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ABARES

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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 records and observer data, fisheries management boundaries
- **Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)**—CCAMLR statistical division boundaries
- **Department of the Environment**—marine protected areas boundaries
- **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

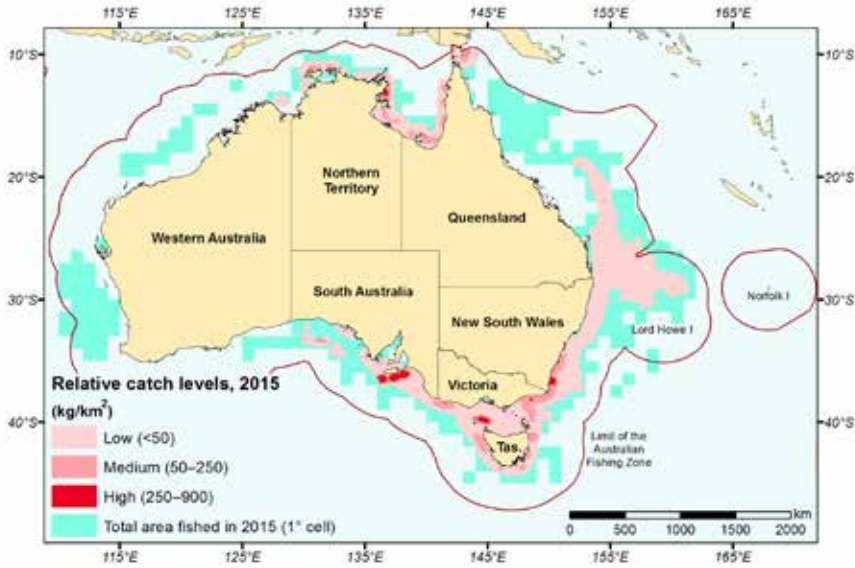
H Patterson, L Georgeson, R Noriega, R Curtotti, F Helidoniotis, J Larcombe, S Nicol and A Williams

The Australian Government's approach to fisheries management is to maintain fish stocks at ecologically sustainable levels and, within this context, maximise 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 2016 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 2015 and over time, against the requirements of fisheries legislation and policy. The reports assess all key commercial species from Australian Government-managed fisheries and 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 catch, 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. In this edition, all stocks in the Small Pelagic Fishery (SPF) have been assessed for two fishing seasons so that the data for the most recent fishing season can be reported. To compare status from year to year, biological and environmental status is presented retrospectively for '2015'. Economic status is presented for the 2014–15 financial year.

FIGURE 1.1 Relative catch levels of Australian Government–managed fisheries, 2015



1.1 Assessing biological status

Assessments of stock status provide an indication of whether the current size of a fish stock is adequate to sustain the stock 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 indicates 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 reflects the level of fishing mortality on a stock in the year being assessed and whether that mortality level 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) in a fishery managed solely or jointly by the Australian Government
- a species or stock previously classified as ‘overfished’ that has not yet recovered to above the limit reference point
- a species previously included in the Fishery Status Reports as a single stock that has been reclassified as multiple stocks to align with species biology or management
- a byproduct species of ecological and/or economic importance, if it meets 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 2015

Fishery status reports 2016 assesses 93 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 28 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 2016*: the toothfish stock—which includes both Patagonian toothfish (*Dissostichus eleginoides*) and Antarctic toothfish (*D. mawsoni*)—in the Commission for the Conservation of Antarctic Marine Living Resources exploratory toothfish fishery in the Amundsen Sea, which was fished by an Australian vessel for the first time in 2015. This is a jointly managed stock because it occurs in the area covered by the Convention on the Conservation of Antarctic Marine Living Resources.

The status of the 93 fish stocks managed solely or jointly by the Australian Government changed slightly in 2015, compared with the previous year (Figures 1.3 and 1.4):

- The number of stocks classified as not subject to overfishing increased to 79 (77 in 2014), and the number of stocks classified as not overfished increased to 69 (66 in 2014). Of these, 66 stocks were both not subject to overfishing and not overfished (63 in 2014)
- The number of stocks classified as subject to overfishing increased to 3 (2 in 2014), and the number of stocks classified as overfished decreased to 11 (12 in 2014). Of these, 1 stock (bigeye tuna [*Thunnus obesus*] in the Eastern Tuna and Billfish Fishery (ETBF)) was both subject to overfishing and overfished (2 in 2014).
- The number of stocks classified as uncertain with [regard to fishing mortality] decreased to 11 (13 in 2014), and the number of stocks classified as uncertain with regard to biomass decreased to 13 (14 in 2014). Of these, 3 stocks were uncertain with respect to both fishing mortality and biomass.

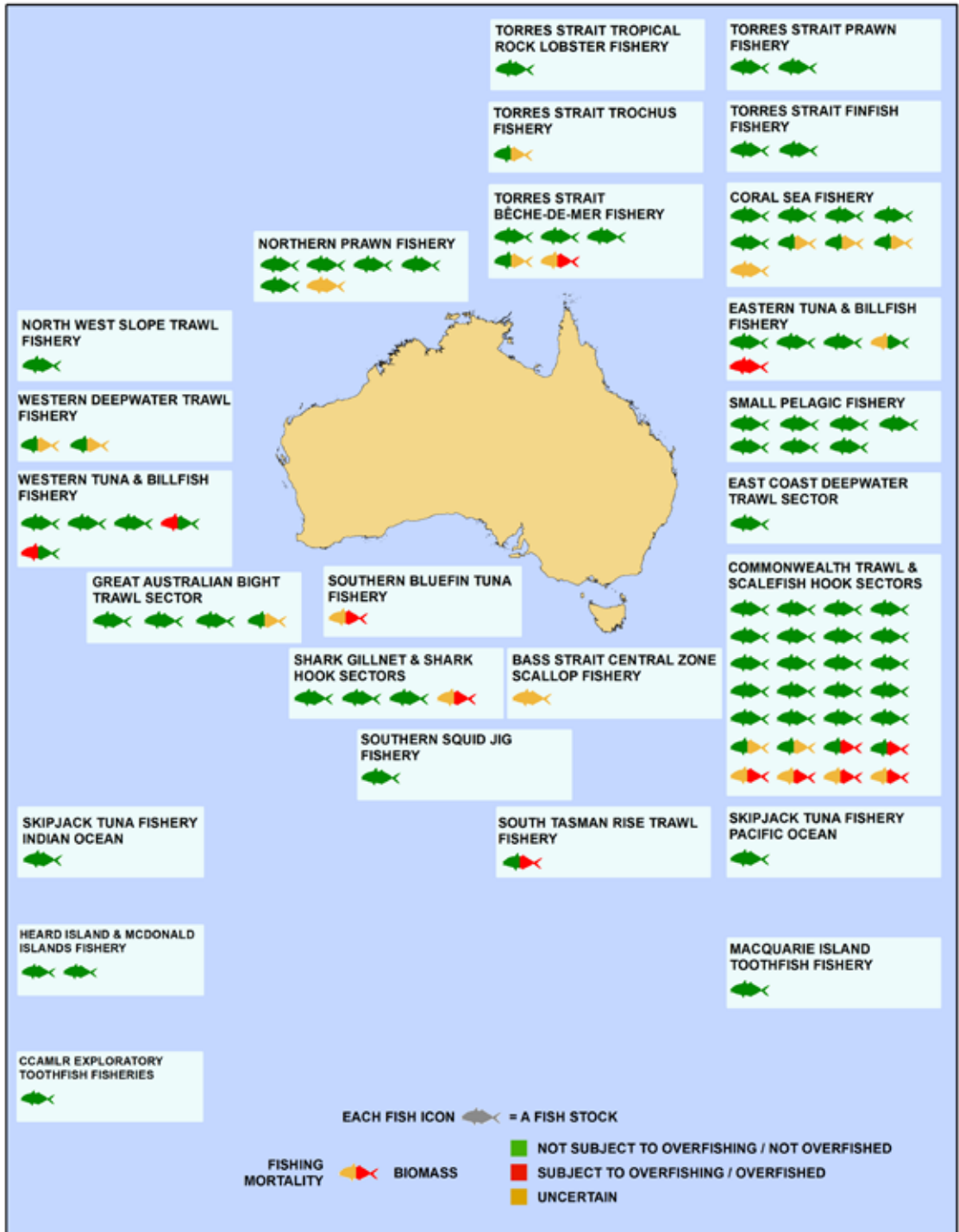
The *Fishery status reports 2016* reports show a continuation of the general trends in improvements of performance in terms of the biological status of fish stocks in Australian Government-managed fisheries; specifically, the increasing number of stocks classified as not subject to overfishing and not overfished (Figures 1.3 and 1.4). Rapid increases came before 2009, with more stocks being classified in the reports and the influence of the 2005 Ministerial Direction and the associated implementation of the HSP (2007) and the Securing our Fishing Future structural adjustment package. These factors also influenced the general reduction in the number of stocks classified as overfished or subject to overfishing (Figures 1.3 and 1.4). The 2016 reports are the third 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 2016 reports show continued improvements in our ability to classify stock status. The number of stocks classified as uncertain, with respect to either biomass or fishing mortality has continued to decline after earlier increases, between 2004 and 2005–07 (Figures 1.3 and 1.4). The increased certainty in stock status has been due to the factors already mentioned above, such as the implementation of the HSP, and also the 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 appears to have plateaued since 2011 (Figure 1.3).



Longline fishing vessel
Matt Daniel, AFMA

FIGURE 1.2 Biological status of fish stocks in 2015, by fishery or sector



The summary of status outcomes are presented 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 1.3 Fishing mortality status (number of stocks), 2004 to 2015

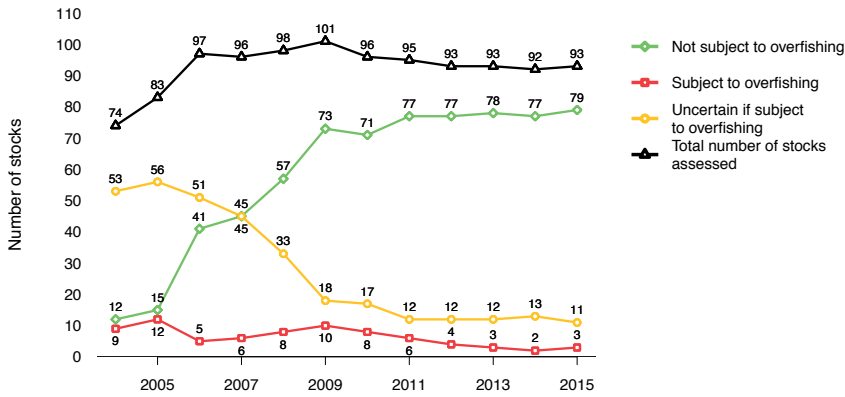
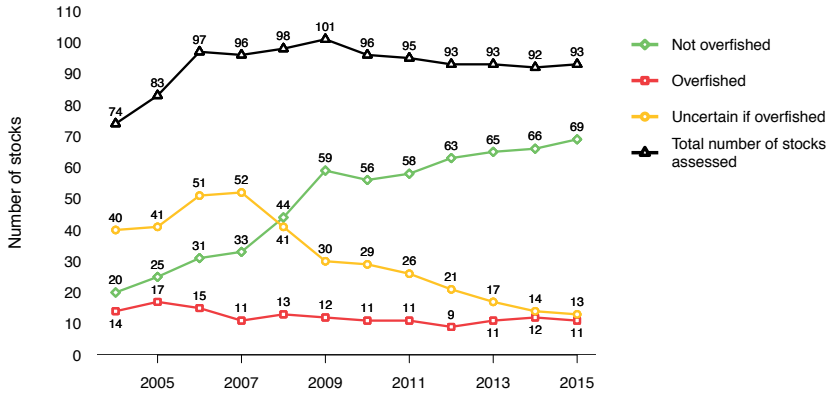


FIGURE 1.4 Biomass status (number of stocks), 2004 to 2015



Stocks that have changed status

The status of three stocks in fisheries solely managed by the Australian Government changed in 2015 (Table 1.1). Two changes reflect increased certainty around the level of fishing mortality, and one reflects increased certainty on biomass.

The level of uncertainty around fishing mortality status of blue-eye trevalla (*Hyperoglyphe antarctica*) in the Southern and Eastern Scalefish and Shark Fishery (SESSF) Commonwealth Trawl Sector (CTS) and Scalefish Hook Sector (SHS) decreased in response to an updated stock assessment (Haddon 2015). The updated assessment indicates that the biomass of the stock was not as depleted as indicated by previous assessments and produced a higher recommended biological catch (RBC). Fishing mortality in the most recent season was constrained to within the RBC and total allowable catch (TAC) for the 2015–16 fishing season, as well as the RBC for 2016–17 produced by the 2015 stock assessment, so the stock was classified as not subject to overfishing in 2015.

The level of uncertainty around fishing mortality of pink ling (*Genypterus blacodes*) in the SESSF CTS and SHS also decreased in response to an updated stock assessment in 2015 (Cordue 2015). The assessment indicated that the eastern pink ling stock should rebuild towards the target under catches of up to 500–550 t per year. Fishing mortality for the eastern stock was constrained to within the constant-catch scenario produced from the 2013 stock assessment (which was used to set the RBC and TAC) for the 2015–16 fishing season, as well as to within the updated constant-catch scenarios produced by the 2015 assessment, so the stock was classified as not subject to overfishing in 2015.

The level of uncertainty around the biomass status of the western stock of redbait (*Emmelichthys nitidus*) in the SPF also changed. While there remains little empirical data on the abundance of the western stock of redbait, ecosystem modelling and management strategy evaluation testing (Giannini et al. 2010; Smith et al. 2015) indicate that the application of the current harvest strategy is unlikely to reduce the stock to an overfished level. This research in combination with the historically low catches are the basis for classifying the stock as not overfished.

TABLE 1.1 Stocks with a changed status in 2015 and their status in 2014

Fishery	Common name (scientific name)	2014		2015	
		Fishing mortality	Biomass	Fishing mortality	Biomass
Stock in fisheries managed solely by the Australian Government					
SESSF: Commonwealth Trawl Sector	Blue-eye trevalla (<i>Hyperoglyphe antarctica</i>)				
SESSF: Commonwealth Trawl Sector	Pink ling (<i>Genypterus blacodes</i>)				
Small Pelagic Fishery a	Redbait west (<i>Emmelichthys nitidus</i>)				
Stocks in fisheries managed jointly by the Australian Government					
Torres Strait Bêche-de-mer Fishery	Sandfish (<i>Holothuria scabra</i>)				
Torres Strait Bêche-de-mer Fishery	Other sea cucumbers (up to 18 species)				
Western Tuna and Billfish Fishery	Striped marlin (<i>Tetrapturus audax</i>)				
Western Tuna and Billfish Fishery	Yellowfin tuna (<i>Thunnus albacares</i>)				

a This stock has been assessed for two years in this report (2014 and 2015), but was previously assessed as uncertain for biomass status; it has been assessed for both 2014 and 2015 as not overfished.

Note: SESSF Southern and Eastern Scalefish and Shark Fishery.

Fishing mortality Not subject to overfishing Subject to overfishing Uncertain

Biomass Not overfished Overfished Uncertain

The status of four stocks in fisheries jointly managed by the Australian Government changed in 2015 (Table 1.1). Status considers the impacts of all fleets on the stocks. In the Torres Strait Bêche-de-mer Fishery, illegal catch of sandfish (*Holothuria* spp.) by Papua New Guinea nationals was detected in 2015. Sandfish in Torres Strait is currently considered to be overfished and is subject to a zero TAC. It is uncertain whether the level of illegal catch detected in 2015 will impede the recovery of the stock. As a result, the stock is classified as uncertain with its regard to fishing mortality. The multi-species stock 'other sea cucumbers' in the Torres Strait Bêche-de-mer Fishery comprises up to 18 species. The 2015 catch (1 t) is not considered to result in overfishing and so the stock was classified as not subject to overfishing in 2015.

In the Indian Ocean, the striped marlin (*Tetrapturus audax*) stock was assessed as overfished and subject to overfishing in 2014, based on stock assessments undertaken by the Indian Ocean Tuna Commission (IOTC 2014). An updated assessment in 2015 (IOTC 2015) indicated that the stock biomass was above the limit reference point of 20 per cent of unfished biomass, and the stock is therefore now considered to be not overfished. However, fishing mortality remains high (above the level that would result in maximum sustainable yield), and the stock remains subject to overfishing. In 2015, an updated assessment of the yellowfin tuna (*Thunnus alalunga*) stock in the Indian Ocean (IOTC 2015) also found that fishing mortality was above the level that would result in maximum sustainable yield. Therefore, the stock is now considered to be subject to overfishing.

Stocks classified as subject to overfishing and/or overfished

Stocks classified as overfished or subject to overfishing remained largely the same as in 2014 (Table 1.2, Table 1.3). Table 1.2 summarises the status determinations and why the stocks are classified as overfished or subject to overfishing; the full details and evidence are provided in the relevant chapters. Briefly, seven stocks in fisheries managed solely by the Australian Government were classified as overfished in 2015 (Table 1.2, Table 1.3). These stocks occur in the SESSF and are subject to stock rebuilding strategies, as required by the HSP. Blue warehou (*Serirolella brama*), eastern gemfish (*Rexea solandri*), orange roughy (*Hoplostethus atlanticus*), gulper sharks (*Centrophorus* spp.) and school shark (*Galeorhinus galeus*) are listed as conservation dependent under the EPBC Act. None of these stocks are classified as subject to overfishing in 2015; however, five are classified as uncertain with respect to fishing mortality status (discussed below).

Five stocks in jointly managed fisheries were classified as either overfished or subject to overfishing in 2015. Classification of these stocks remained largely the same as in 2014 (Table 1.2). Sandfish in the Torres Strait Beche-de-mer Fishery and yellowfin tuna and striped marlin in the Western Tuna and Billfish Fishery (WTBF) were discussed in the previous section.

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 (*Centroberyx affinis*). This has been due to a range of factors, including a lack of data or uncertainty in the catch data and uncertainty in the assessments. These species are subject to rebuilding strategies that 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 may constitute overfishing for the purposes of status determination. There is also some level of discarding of these species, which can be difficult to estimate, is variable between years and is often not available for the most recent season at the time of drafting of these reports. In circumstances 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 due to the uncertainties in discard estimates. This consequently increases the uncertainty about how much influence the incidental catch of the species (and potential overfishing) may have on its rebuilding time frame. Furthermore, the assessment models used to project stock trends use average conditions (e.g. recruitment) for the projection. The purpose of these projections is not to track recovery on an annual basis but to predict an 'on average' expected rebuilding time frame. The failure to detect a trend in the catch data that resembles the trajectory of the projection is not necessarily evidence that the species is not responding but may be reflective of 'non-average' conditions. Moreover, some of these assessments are more than six years old and the evidence for fishing mortality effects are inferred from indicators rather than estimated an assessment model. These models also rarely included ecosystem effects such as changes in trophic interactions that may also influence the effect that fishing mortality has on rebuilding time frames.

Given these realities, it can be unclear if 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 struggle to deliver a concise picture of fishing mortality status for these overfished stocks.

Status of key Australian Fish Stocks reports

On 10 December 2014, the Fisheries Research and Development Corporation released *Status of key Australian fish stocks reports 2014*, the second in the series. The reports provide a national assessment of the status of key wild-capture fish stocks that are managed by the Commonwealth, the states and the Northern Territory. The reports were initiated in 2012 by the Fisheries Research and Development Corporation and ABARES. They are developed collaboratively by ABARES and government fishery research agencies in all states and the Northern Territory, and CSIRO.

The 2014 reports provide stock assessments for 68 key species (or species complexes), 19 more than in the 2012 inaugural edition. These species and their stocks contributed around 85 per cent of the catch volume and 90 per cent of the value of Australian wild-capture fisheries in 2012–13. The reports consider the same biological information as Fishery Status Reports, but interpret that information within a nationally agreed classification system (Appendix A). Of the 93 stocks assessed in *Fishery status reports 2013–14*, 31 stocks are assessed in *Status of key Australian fish stocks reports 2014* and are comparable. This national reporting framework is designed to improve the ability to compare the status of fish stocks.



Bermagui
Lee Georgeson, ABARES

TABLE 1.2 Stocks classified as subject to overfishing and/or overfished in 2015, and their status in 2014

Fishery	Common name (scientific name)	2014		2015		Comments
		Fishing mortality	Biomass	Fishing mortality	Biomass	
Stocks in fisheries managed solely by the Australian Government						
SESSF: CTS and SHS Chapter 9	Blue warehou (<i>Seriolella brama</i>)					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 (<i>Rexea solandri</i>)					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 (<i>Centrophorus harrissoni</i> , <i>C. moluccensis</i> , <i>C. zeehaani</i>)					Populations are likely to be highly depleted, and fishing mortality is uncertain despite low landed catch and protection from closures.
SESSF: CTS Chapter 9	Orange roughy, southern zone (<i>Hoplostethus atlanticus</i>)					Closure of most areas deeper than 700 m and negligible catches. No updated stock assessment.
SESSF: CTS Chapter 9	Orange roughy, western zone (<i>Hoplostethus atlanticus</i>)					Closure of most areas deeper than 700 m and negligible catches. No updated stock assessment.
SESSF: CTS Chapter 9	Redfish, eastern (<i>Centroberyx affinis</i>)					Biomass is below the limit reference point. Catch is above the recommended biological catch and it is unclear if total removals are above the level that will allow rebuilding.
SESSF: SGSHS Chapter 12	School shark (<i>Galeorhinus galeus</i>)					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 2015, and their status in 2014 continued

Fishery	Common name (scientific name)	2014		2015		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 (<i>Hoplostethus atlanticus</i>)					Fishery closed under domestic arrangements since 2007 as a result of stock depletion.
Torres Strait Bêche-de-mer Fishery Chapter 19	Sandfish (<i>Holothuria scabra</i>)					Uncertain impact of illegal foreign catch in recent years. Most recent full survey (2009) indicated that stock was overfished.
ETBF Chapter 21	Bigeye tuna (<i>Thunnus obesus</i>)					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 (<i>Thunnus maccoyii</i>)					The estimate of spawning biomass is well below 20% of unfished biomass. The global total allowable catch, 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 (<i>Tetrapturus audax</i>)					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 (<i>Thunnus albacares</i>)					Most recent estimate of spawning biomass is above the limit reference point. Current fishing mortality exceed the level required for MSY to be realised.

Note: **CTS** Commonwealth Trawl Sector. **MSY** Maximum sustainable yield. **ETBF** Eastern Tuna and Billfish Fishery. **SBTF** Southern Bluefin Tuna Fishery. **SESSF** Southern and Eastern Scalefish and Shark Fishery. **SGSHS** Shark Gillnet and Shark Hook sectors. **SHS** Scalefish Hook Sector. **WTBF** Western Tuna and Billfish Fishery.

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

TABLE 1.3 Biological stock status of all stocks assessed in 2015, 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
		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
Bass Strait Central Zone Scallop Fishery	Commercial scallop (<i>Pecten fumatus</i>)																					
Coral Sea Fishery: Sea Cucumber Sector	Black teatfish (<i>Holothuria whitmaei</i>)																					
Coral Sea Fishery: Sea Cucumber Sector	Prickly redfish (<i>Theleota ananas</i>)																					
Coral Sea Fishery: Sea Cucumber Sector	Surf redfish (<i>Actinopyga mauritiana</i>)																					
Coral Sea Fishery: Sea Cucumber Sector	White teatfish (<i>Holothuria fuscogilva</i>)																					
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 (<i>Panulirus ornatus</i> , possibly other species)																					
Coral Sea Fishery: Line and Trap Sector	Mixed reef fish and sharks																					
Coral Sea Fishery: Trawl and Trap Sector	Numerous fish, shark and crustacean species																					
Northern Prawn Fishery	Red-legged banana prawn (<i>Fenneropenaeus indicus</i>)																					

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2015, 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
		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
Northern Prawn Fishery	White banana prawn (<i>Fenneropenaeus merguensis</i>)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Northern Prawn Fishery	Brown tiger prawn (<i>Penaeus esculentus</i>)	Green	Green	Green	Green	Green	Red	Red	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Northern Prawn Fishery	Grooved tiger prawn (<i>Penaeus semisulcatus</i>)	Green	Green	Green	Green	Green	Red	Red	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Northern Prawn Fishery	Blue endeavour prawn (<i>Metapenaeus endeavouri</i>)	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Northern Prawn Fishery	Red endeavour prawn (<i>Metapenaeus ensis</i>)	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
North West Slope Trawl Fishery	Scampi (<i>Metanephrops australiensis</i> , <i>M. boschmai</i> , <i>M. velutinus</i>)	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
Small Pelagic Fishery	Australian sardine (<i>Sardinops sagax</i>)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green
Small Pelagic Fishery	Blue mackerel, east (<i>Scomber australasicus</i>)	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Small Pelagic Fishery	Blue mackerel, west (<i>Scomber australasicus</i>)	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Small Pelagic Fishery	Jack mackerel, east (<i>Trachurus declivis</i>)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
Small Pelagic Fishery	Jack mackerel, west (<i>Trachurus declivis</i>)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
Small Pelagic Fishery	Redbait, east (<i>Emmelichthys nitidus</i>)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
Small Pelagic Fishery	Redbait, west (<i>Emmelichthys nitidus</i>)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green	Green

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2015, 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
		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
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue-eye trevalla (<i>Hyperoglyphe antarctica</i>)	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue grenadier (<i>Macruronus novaezelandiae</i>)	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Blue warehou (<i>Seriola lalandi</i>)	Yellow	Green	Green	Yellow	Green	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
SESSF: Commonwealth Trawl Sector	Deepwater sharks, eastern zone (18 spp.)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	Deepwater sharks, western zone (18 spp.)	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl Sector	Eastern school whiting (<i>Sillago flindersi</i>)	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 (<i>Platycephalus richardsoni</i> and 4 other spp.)	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gemfish, eastern zone (<i>Rexea solandri</i>)	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gemfish, western zone (<i>Rexea solandri</i>)	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 2015, 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
		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
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Gulper sharks (<i>Centrophorus harrissoni</i> , <i>C. moluccensis</i> , <i>C. zeehaani</i>)																					
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Jackass morwong (<i>Nemadactylus macropterus</i>)																					
SESSF: Commonwealth Trawl Sector	John dory (<i>Zeus faber</i>)																					
SESSF: Commonwealth Trawl Sector	Mirror dory (<i>Zenopsis nebulosa</i>)																					
SESSF: Commonwealth Trawl Sector	Ocean jacket, eastern zone (<i>Nelusetta ayraud</i>)																					
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Ocean perch (<i>Helicolenus barathri</i> , <i>H. percoides</i>)																					
SESSF: Commonwealth Trawl Sector	Orange roughy, Cascade Plateau (<i>Hoplostethus atlanticus</i>)																					
SESSF: Commonwealth Trawl Sector	Orange roughy, eastern zone (<i>Hoplostethus atlanticus</i>)																					
SESSF: Commonwealth Trawl Sector	Orange roughy, southern zone (<i>Hoplostethus atlanticus</i>)																					
SESSF: Commonwealth Trawl Sector	Orange roughy, western zone (<i>Hoplostethus atlanticus</i>)																					

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2015, 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
		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
SESSF: Commonwealth Trawl Sector	Oreodory: smooth, Cascade Plateau (<i>Pseudocyttus maculatus</i>)																					
SESSF: Commonwealth Trawl Sector	Oreodory: smooth, non- Cascade Plateau (<i>Pseudocyttus maculatus</i>)																					
SESSF: Commonwealth Trawl Sector	Oreodory: other (<i>Neocyttus rhomboidalis</i> , <i>Alloctytus niger</i> , <i>A. verrucosus</i>)																					
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Pink ling (<i>Genypterus blacodes</i>)																					
SESSF: Commonwealth Trawl Sector	Redfish, eastern (<i>Centroberyx affinis</i>)																					
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Ribaldo (<i>Mora moro</i>)																					
SESSF: Commonwealth Trawl Sector	Royal red prawn (<i>Haliporoides sibogae</i>)																					
SESSF: Commonwealth Trawl and Scalefish Hook sectors	Silver trevally (<i>Pseudocaranx georgianus</i>)																					
SESSF: Commonwealth Trawl Sector	Silver warehou (<i>Seriolella punctata</i>)																					

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2015, 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	
											Fishing mortality	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass	Fishing mortality	Biomass
SESSF: East Coast Deepwater Trawl Sector	Alfonsino (<i>Beryx splendens</i>)																						
SESSF: Great Australian Bight Trawl Sector	Bight redfish (<i>Centroberyx gerrardi</i>)																						
SESSF: Great Australian Bight Trawl Sector	Deepwater flathead (<i>Platycephalus conatus</i>)																						
SESSF: Great Australian Bight Trawl Sector	Ocean jacket, west (<i>Nelusetta ayraud</i>)																						
SESSF: Great Australian Bight Trawl Sector	Orange roughy (<i>Hoplostethus atlanticus</i>)																						
SESSF: Shark Gillnet and Shark Hook sectors	Elephantfish (<i>Callorhynchus milii</i>)																						
SESSF: Shark Gillnet and Shark Hook sectors	Gummy shark (<i>Mustelus antarcticus</i>)																						
SESSF: Shark Gillnet and Shark Hook sectors	Sawshark (<i>Pristiophorus cirratus</i> , <i>P. nudipinnis</i>)																						
SESSF: Shark Gillnet and Shark Hook sectors	School shark (<i>Galeorhinus galeus</i>)																						
Southern Squid Jig Fishery	Gould's squid (<i>Nototodarus gouldi</i>)																						
Western Deepwater Trawl Fishery	Bugs (<i>Ibacus</i> spp.)																						

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2015, 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	
											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	
Western Deepwater Trawl Fishery	Ruby snapper (<i>Etelis carbunculus</i>)																						
Macquarie Island Toothfish Fishery	Patagonian toothfish (<i>Dissostichus eleginoides</i>)																						
Stocks in fisheries managed jointly by the Australian Government																							
South Tasman Rise Trawl Fishery	Orange roughy (<i>Hoplostethus atlanticus</i>)																						
Torres Strait Finfish Fishery	Coral trout (<i>Plectropomus</i> spp., <i>Variola</i> spp.)																						
Torres Strait Finfish Fishery	Spanish mackerel (<i>Scomberomorus commerson</i>)																						
Torres Strait Tropical Rock Lobster Fishery	Tropical rock lobster (<i>Panulirus ornatus</i>)																						
Torres Strait Prawn Fishery	Brown tiger prawn (<i>Penaeus esculentus</i>)																						
Torres Strait Prawn Fishery	Blue endeavour prawn (<i>Metapenaeus endeavouri</i>)																						
Torres Strait Bêche-de-mer Fishery	Black teatfish (<i>Holothuria whitmaei</i>)																						
Torres Strait Bêche-de-mer Fishery	Prickly redfish (<i>Thelenota ananas</i>)																						
Torres Strait Bêche-de-mer Fishery	Sandfish (<i>Holothuria scabra</i>)																						

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2015, 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
		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
Torres Strait Bêche-de-mer Fishery	White teatfish (<i>Holothuria fuscogilva</i>)																					
Torres Strait Bêche-de-mer Fishery	Other sea cucumbers (up to 18 spp.)																					
Torres Strait Trochus Fishery	Trochus (<i>Trochus niloticus</i>)																					
Eastern Tuna and Billfish Fishery	Striped marlin (<i>Tetrapturus audax</i>)																					
Eastern Tuna and Billfish Fishery	Swordfish (<i>Xiphias gladius</i>)																					
Eastern Tuna and Billfish Fishery	Albacore (<i>Thunnus alalunga</i>)																					
Eastern Tuna and Billfish Fishery	Bigeye tuna (<i>Thunnus obesus</i>)																					
Eastern Tuna and Billfish Fishery	Yellowfin tuna (<i>Thunnus albacares</i>)																					
Skipjack Tuna Fishery: Pacific Ocean	Skipjack tuna (<i>Katsuwonus pelamis</i>)																					
Skipjack Tuna Fishery: Indian Ocean	Skipjack tuna (<i>Katsuwonus pelamis</i>)																					
Southern Bluefin Tuna Fishery	Southern bluefin tuna (<i>Thunnus maccoyii</i>)																					
Western Tuna and Billfish Fishery	Striped marlin (<i>Tetrapturus audax</i>)																					
Western Tuna and Billfish Fishery	Swordfish (<i>Xiphias gladius</i>)																					
Western Tuna and Billfish Fishery	Albacore (<i>Thunnus alalunga</i>)																					
Western Tuna and Billfish Fishery	Bigeye tuna (<i>Thunnus obesus</i>)																					
Western Tuna and Billfish Fishery	Yellowfin tuna (<i>Thunnus albacares</i>)																					

continued ...

TABLE 1.3 Biological stock status of all stocks assessed in 2015, 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
											Fishing mortality Biomass	Fishing mortality Biomass	Fishing mortality Biomass	Fishing mortality Biomass	Fishing mortality Biomass	Fishing mortality Biomass	Fishing mortality Biomass	Fishing mortality Biomass	Fishing mortality Biomass	Fishing mortality Biomass	Fishing mortality Biomass	Fishing mortality Biomass
Heard Island and McDonald Islands Fishery	Mackerel icefish (<i>Champscephalus gunnari</i>)																					
Heard Island and McDonald Islands Fishery	Patagonian toothfish (<i>Dissostichus eleginoides</i>)																					
CCAMLR eExploratory toothfish fisheries	Toothfish (<i>Dissostichus eleginoides</i> , <i>D. mawsoni</i>)																					

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.

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



Electronic monitoring gear on a vessel
 Matt Daniel, AFMA

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. The economic status indicates whether the biomass level is at a point that is consistent with achieving the HSP target reference point—a point consistent with achieving maximum economic yield (MEY). Below this point, the stock is considered to be economically overfished.

Although biomass estimates indicate whether the economic target reference point is being achieved, determination of whether economic overfishing is occurring requires consideration of the annual biomass movement with respect to the target reference point. When biomass is below the target reference point and, over time, moving further away from it, economic overfishing is occurring, and rebuilding of the stock would be required to bring the biomass closer to the reference point.

Determining whether economic performance of a fishery is improving (moving closer to the economic target reference point) or deteriorating (moving away from the economic target reference point) 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 fishery biomass is moving closer to its economic target reference point. 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.

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.

Economic status in 2014–15

Fishery status reports 2016 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 \$348.0 million in 2014–15, contributing 22 per cent of Australia's wild catch fisheries GVP (\$1.6 billion).

The Commonwealth fisheries GVP is dominated by production from four major fisheries that together accounted for 71 per cent of total fishery GVP. In 2014–15, the Northern Prawn Fishery (NPF) was the most valuable fishery, with a GVP of \$106.8 million. The multisector SESSF was the second most valuable Australian Government–managed fishery, with a GVP of \$68.0 million (Figure 1.5). The wild-catch sector of the Southern Bluefin Tuna Fishery (SBTF) and the ETBF also made substantial contributions to fisheries GVP in 2014–15, with values of \$36.8 million and \$35.0 million, respectively.

FIGURE 1.5 Gross value of production of fisheries managed solely or jointly by the Australian Government, 2004–05 to 2014–15

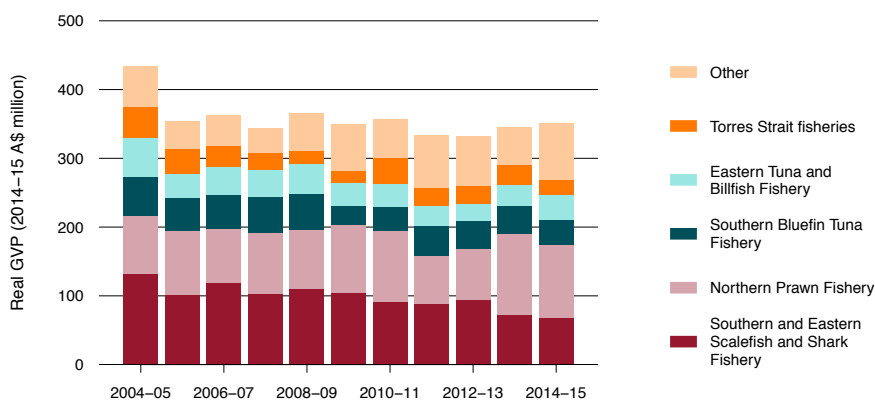


TABLE 1.4 Indicators and summary of economic status of Commonwealth fisheries for 2014–15

Fishery	Performance relative to MEY target	NER trend	Fishing right latency in fishing season	2014–15 fishery GVP (% change from 2013–14)
Bass Strait Central Zone Scallop Fishery	MEY target not specified	Negative in 2009–10 and 2010–11 (–\$1.1 million)	Low uncaught TAC	\$2.8 million (+460%)
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	\$106.8 million (–7%)
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 over 90%, but reduced latency in the 2015–16 fishing season (70%)	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 2014–15 and 2015–16 fishing seasons)	\$38.4 million (–7%)
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 above B_{MEY} target. Deepwater flathead just below B_{MEY} target	Not available but likely to be positive, but have decreased	High uncaught TAC (70%)	\$8.5 million (–24%)
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 2011–14	Low uncaught TAC	\$16.9 million (+7%)
Southern Squid Jig Fishery	MEY target not specified	Not available	High non-participation by licence holders	Confidential
Western Deepwater Trawl Fishery	MEY target not specified	Not available	High non-participation by licence holders	Confidential

2014–15 management costs (% share of GVP)	Primary management instrument	Comments about economic status
0.3 million (9%)	ITQs and spatial management	NER are likely to have improved since 2010–11 when NER were –\$1.1 million, because similar levels of GVP are generated with lower effort levels, and lower management and fuel costs.
\$0.1 million (confidential)	Catch triggers and TACs	Estimates of NER are not available. Catch in the Aquarium Sector declined substantially in 2014–15; however, because of a lack of information about the mix of fish caught, it is unclear how this affected NER. Catch and effort declined in the remainder of the fishery in 2014–15, including in the Sea Cucumber Sector, especially for white teatfish and prickly redfish. 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.
\$2.3 million (2%)	Individual transferable gear units (headrope length)	The Northern Prawn Fishery was surveyed in 2015, which provided estimates of NER for the 2012–13 and 2013–14 financial years. NER were estimated at \$5 million in 2012–13 and continued to improve in 2013–14 to \$12 million as a result of improved prices. In 2014–15, lower fuel prices and improved banana prawn prices indicate positive signs for NER in the fishery.
\$0.09 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.
\$0.6 million (confidential)	ITQs	Estimates of NER are not available for 2014–15 or 2015–16. An increase in the catch in 2014–15 and 2015–16 suggests that GVP is likely to have increased. Changes in NER are uncertain because of a lack of information about changes in cost structures of the industry.
\$3.0 million for CTS (8% of CTS GVP)	ITQs	NER for the CTS were \$4.2 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 million (confidential)	ITQs	A high level of latency indicates low NER.
\$0.6 million (7%)	ITQs	NER are likely to have increased slightly in 2014–15, because the positive impacts of lower effort and lower fuel price are likely to have offset the negative impact of falling GVP.
\$2.3 million for GHTS (15% 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 above the level associated with MEY, the management of non-target species and marine mammal interactions has likely contributed to a fall in NER in recent years.
\$0.07 million (confidential)	Individual transferable gear units (jig machines)	Latent effort in the fishery remains high, but has decreased in the 2015 fishing season. The increased effort and higher catch levels in the 2015 fishing season suggest that NER may have improved.
\$0.02 million (confidential)	Limited entry	No fishing activity occurred in the fishery during the 2015 fishing season. Estimates of NER for previous years are not available, but decline in effort and a low number of active fishing permits in recent years indicate that NER have been low.

continued ...

TABLE 1.4 Indicators and summary of economic status of Commonwealth fisheries for 2014–15 continued

Fishery	Performance relative to MEY target	NER trend	Fishing right latency in fishing season	2014–15 fishery GVP (% change from 2013–14)
Torres Strait Finfish Fishery	Not applicable ^c	Not available	Not applicable	\$1.1 million (-26%)
Torres Strait Tropical Rock Lobster Fishery	Not applicable ^c	Not available	Low uncaught TAC	\$12.2 million (-42%)
Torres Strait Prawn Fishery	Not applicable ^c	Negative	High unused effort	\$9.5 million (+64%)
Torres Strait Bêche-de-mer and Trochus fisheries	Not applicable ^c	Not available	Low uncaught quota for teatfish; high for all other stocks	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 and yellowfin tuna; high for albacore and bigeye tuna	\$35.0 million (+12%)
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	\$36.8 million (-7%)
Western Tuna and Billfish Fishery	MEY target not specified	Not available	High uncaught TAC (greater than 95% in the 2014 and 2015 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

2014–15 management costs (% share of GVP)	Primary management instrument	Comments about economic status
Not available	Non-tradeable quota	Estimates of NER are not available. Economic performance in 2014–15 remains uncertain because the effect on revenue of lower prices received and lower catch may have been offset by lower fishing costs.
Not available	Limited entry, size limits, gear limits and bag limits	NER are likely to have declined in 2014–15, as effort applied to the fishery increased but GVP declined. The fishery is meeting its objective to provide commercial opportunities for Traditional Inhabitants, but it is uncertain whether its objective to optimise value is being met.
\$0.3 million (3%, AFMA costs only)	Tradeable effort units (nights)	NER for the fishery were negative in 2012–13, at –\$2.3 million. No estimates of NER are available for 2013–14 or 2014–15. Increases in catch and GVP, and lower fuel prices suggest that NER in 2014–15 increased. However, substantial latency in the fishery suggests that NER are below potential.
Not available	TACs	Estimates of NER are not available.
\$1.4 million (4%)	ITQs	NER remained positive in 2013–14 (preliminary estimate) after a long period of negative NER (2001–02 to 2009–10). NER for 2014–15 are likely to have increased as a result of higher GVP and lower fuel prices. The move to individual transferable quotas and a new harvest strategy may be supporting increases in NER; however, neither have been implemented long enough to determine whether there has been a positive effect.
\$0.06 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.
\$0.9 million (2%)	ITQs	NER are expected to have remained positive. The overfished status of the stock poses a risk to future NER. Economic status will improve if the stock can be rebuilt under the management procedure.
\$0.3 million (confidential)	ITQs	Latency remained high in 2015, with only a small proportion of the total allowable commercial catch caught, suggesting low NER.
\$1.6 million (confidential)	ITQs	Estimates of NER are not available but were most likely positive in 2013–14 and 2014–15 because the TACs for mackerel icefish and Patagonian toothfish were mostly caught.
\$0.4 million (confidential)	ITQs	Estimates of NER are not available but were most likely positive in 2013–14 and 2014–15 because the TAC for Patagonian toothfish was mostly caught.

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. CTS Commonwealth Trawl Sector. GHTS Gillnet, Hook and Trap Sector. GVP Gross value of production. ITQ Individual transferable quota. MEY Maximum economic yield. NER Net economic returns. SESSF Southern and Eastern Scalefish and Shark Fishery. TAC Total allowable catch. The South Tasman Rise Trawl Fishery is not shown because it has been closed since 2007.

Fisheries managed solely by the Australian Government

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 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, 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, because only explicit costs and revenues are considered in deriving estimates of profits.

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 the MEY objectives. Together, they accounted for 48 per cent of the GVP of all Australian Government-managed fisheries in 2014–15.

The NPF is explicitly managed to an MEY target for the tiger prawn (*Penaeus esculentus*) component of the fishery, using a bio-economic model to set effort levels that are estimated to produce MEY. NER in the NPF increased to \$12 million in 2013–14 and continued to improve in 2014–15 as a result of improved prices (Bath & Green 2016). The bio-economic modelling for tiger prawn has allowed this component of the fishery to improve its economic performance. The identification and application of effort levels that achieve MEY from fishing for tiger prawns has led to an increase in spawning stock levels and reduced fishing costs.

In the CTS and the GHTS, MEY is targeted through the application of proxies for B_{MEY} . 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 NER can be improved by fishing down stocks to the B_{MEY} target. 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 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 indicate biomass levels are above the B_{MEY} target and NER can be improved by increased fishing effort.

The TAC for the Herd Island and Macdonald Islands Fishery (HIMIF) was almost fully caught in the 2013–14 and 2014–15 fishing seasons, mainly as a result of improved sea conditions. This suggests that NER is likely to be positive for the fishery.

Low catch-and-effort levels in the other fisheries (Bass Strait Central Zone Scallop Fishery, Coral Sea Fishery, East Coast Deepwater Trawl Sector, North West Slope Trawl Fishery, SPF, Southern Squid Jig Fishery and Western Deepwater Trawl Fishery) indicate low NER in these fisheries in 2014–15.

Jointly managed fisheries

Of the fisheries jointly managed by the Australian Government, major fisheries in value terms include the SBTF, the ETBF and the Torres Strait Tropical Rock Lobster Fishery (TSTRLF). In 2014–15, these fisheries generated GVP of \$36.8 million, \$35.0 million and \$12.2 million, respectively. Combined, these three fisheries accounted for 24 per cent of the GVP of all Australian Government–managed fisheries in 2014–15.

Estimates of NER are not available for the SBTF. However, the fishery provides fish to South Australia’s southern bluefin tuna aquaculture industry (generating a GVP of \$131 million). 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 the most recent estimates, in 2010–11, NER were positive for the first time since 2000–01 (George & New 2013). In 2011–12, NER are estimated to have increased to \$3.0 million, with a decrease in operating costs outweighing a decline in revenue. The NER estimates for 2012–13 are not available and are uncertain. The fishery’s move to individual transferable quotas in 2011 and a new harvest strategy may result in further improvement in economic performance.

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 2014–15, 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, then fishers their economically profitable opportunities are being foregone as, 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 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 introduction of a factory vessel into the SPF of a factory trawler has led to reduced latency in that fishery in the 2015–16 fishing season. For some fisheries managed solely by the Australian Government the reasons for a high degree of latency to persist remain unclear and warrant further investigation.

For example, a number of species in the SESSF fishery have increasingly been under caught in terms of their TAC in recent seasons and the reasons for the under catch require investigation so that appropriate management responses can be undertaken.

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 redundant
- 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. As well, 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 2015

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.

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
- development of a threat abatement plan for the incidental catch (or bycatch) of seabirds during pelagic longline fishing operations in the ETBF, the 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, from 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.

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 programmes in several fisheries and subfisheries to improve logbook reporting and for logbook verification of interactions with protected species. Indeed, 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 e-monitoring was introduced, indicating that fishers are recording data in their logbooks more accurately than before e-monitoring was implemented (Larcombe et al. 2016).

Electronic 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. Electronic 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 electronic monitoring can be found on the AFMA website.¹

¹ www.afma.gov.au/monitoring-enforcement/electronic-monitoring-program

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 2013a) and the Commonwealth Policy on Fisheries Bycatch 2000 (DAFF 2013b). 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.

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Chapter 2

Bass Strait Central Zone Scallop Fishery

N Marton and R Green

FIGURE 2.1 Area and relative fishing intensity in the Bass Strait Central Zone Scallop Fishery, 2015

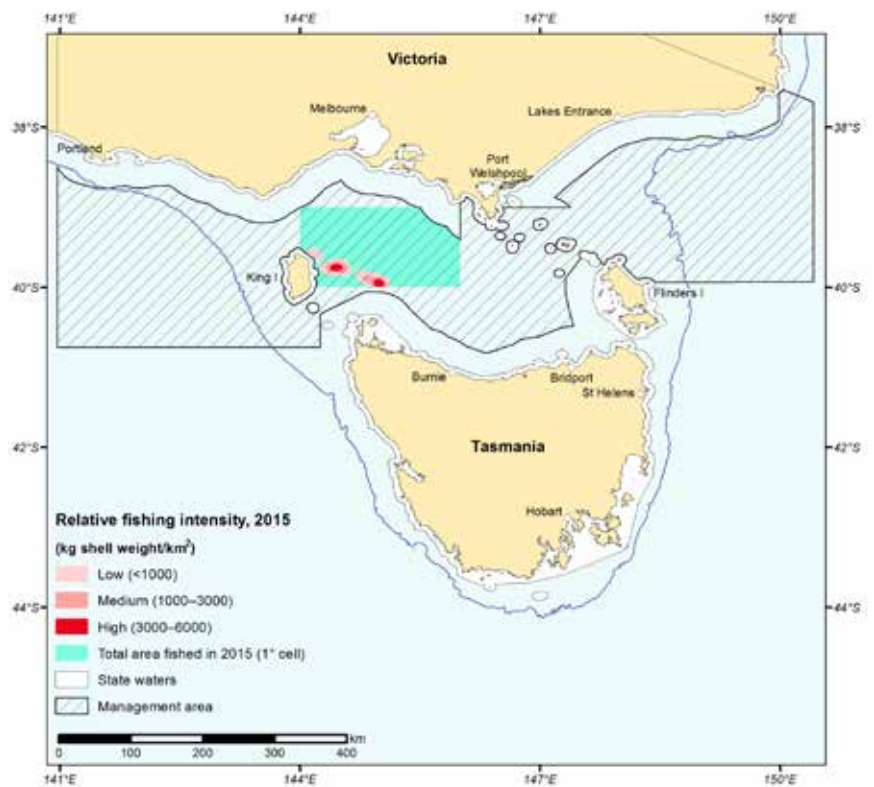


TABLE 2.1 Status of the Bass Strait Central Zone Scallop Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Biological status Commercial scallop (<i>Pecten fumatus</i>)					Limited evidence of successful recent recruitment in eastern Bass Strait. No robust estimate of total biomass.
Economic status	NER are likely to have improved since 2010–11 when NER were –\$1.1 million, because similar levels of GVP are generated with lower effort levels, and lower management and fuel costs.				

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 2015, fishing was permitted throughout the management area, with the exception of three scallop beds (Figure 2.1). Fishing was concentrated on beds east of King Island. This was a similar area to that fished in 2014.

Fishing methods and key species

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

Management methods

The fishery is managed through a range of input controls (seasonal and area closures) and output controls (total allowable catch [TAC]), together with quota statutory fishing rights and individual transferable quota controls. A TAC of 100 t also exists for doughboy scallops (*Chlamys asperrima*). However, with the exception of one year (2003), this species is either not retained or only retained in very small amounts, because of a lack of a market.

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 2014a) and updated in 2015 for clarity (AFMA 2015a).

Management methods have changed considerably since the fishery reopened in 2009. The changes include a reduction in the 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 2014 and 2015 harvest strategy used a tiered management approach, whereby a 150 t TAC is initially set as a ‘default opening’, covering the whole BSCZSF management area, to allow operators to search widely for scallop beds (AFMA 2015a). 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, this exploratory aspect of the harvest strategy has had limited success—in 2014, only the King Island beds were located (Figure 2.1), and, in 2015, the exploratory period was skipped altogether in favour of returning to the known, and presumed good-quality, 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 2015 fishery operated under tier 2 of the harvest strategy.

Fishing effort

The fishery has a history of boom and bust, with the peaks (1982–83, 1994 to 1996, 2003, 2009 and 2014) 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 has since decreased, to 11 vessels in 2015. 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. Dredge-hours increased in 2014 and again in 2015, to 4 116.

TABLE 2.2 Main features and statistics for the BSCZSF

Fishery statistics a	2014 fishing season b			2015 fishing season c		
	TAC (t)	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t)	Real value (2014–15)
Commercial scallop	1 500 (+150, +260) d	1 418	\$0.5 million	2 500 (+36) d	2 260	\$2.8 million
Doughboy scallop	100	<0.1	na	100	0.2	na
Total fishery	2 010	1 418	\$0.5 million	2 636	2 260	\$2.8 million
Fishery-level statistics						
Effort	2 739 hours dredged			4 116 hours dredged		
Fishing permits	64			65		
Active vessels	11			11		
Observer coverage	0 days			0 days		
Fishing methods	Scallop dredge					
Primary landing ports	Queenscliff and Apollo Bay (Victoria); 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 2014–15 dollars. b Fishing season was 9 June to 31 December 2014. c Fishing season was 8 July to 31 December 2015. d A research quota also exists for commercial scallop (260 t in 2014 and 36 t in 2015). In addition, an exploratory fishing TAC of 150 t was set in 2014.

Notes: ITQ Individual transferable quota. na Not available. SFR Statutory fishing right. TAC Total allowable catch.

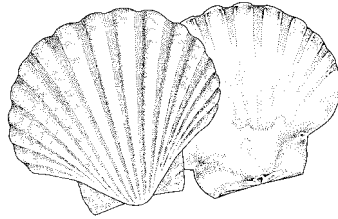


Scallops

Jayson Semmens, University of Tasmania

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). Substantial historical catches were reported from the western part of the fishery, including through the 1990s. However, between 2000 and 2013, the fishery was centered on the eastern region because of the higher costs of operating in the more remote western region and a lack of recent evidence of commercially viable beds in the west (Harrington & Semmens 2010). Since 2014, the fishery has returned to the western part of the central Bass Strait area. A TAC of 2 500 t was set in 2009, of which 2 413 t (97 per cent) was caught, following expansion of open areas to maintain catch rates. A TAC of 3 000 t was set for the fishery in 2010. However, scallops were in poor condition for much of the season, and industry reported that a widespread die-off had occurred. This resulted in only 2 110 t (70 per cent of the TAC) being landed (Figure 2.2). A TAC of 2 000 t was set in 2011; however, poor catch rates were reported in the open area (AFMA 2012b). In addition, a further die-off was reported to have occurred between the survey and opening of the fishery. In response, most of the area opened in July 2011 was subsequently closed, and a larger area surrounding it was opened in August 2011. Catch rates remained low (less than 200 kg/hour) in the new area, and only 365 t (18 per cent) of the TAC was taken (AFMA 2012b).

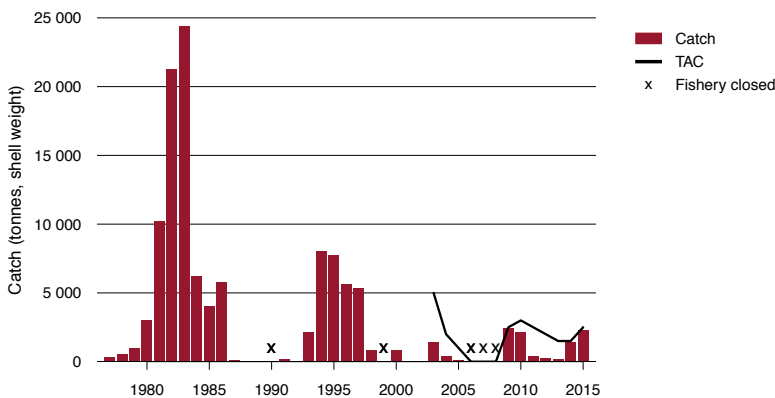
A TAC of 2 000 t was set for the 2012 season; however, scallops were reported to be in poor condition, and catch rates were low. A small number of vessels remained in the BSCZSF and reported finding some good-quality scallops later in the season. However, most operators with Tasmanian Scallop Fishery licences moved to the Tasmanian Scallop Fishery (DPIPWE 2012); 244 t (12 per cent) of the 2 000 t TAC was taken.

A TAC of 1 500 t was set for the 2013 season, with two areas sequentially opened through the season; 182 t (12 per cent) of the TAC was taken. The fishery was affected by an outbreak of paralytic shellfish toxin, and one of the areas was subsequently closed.

Following a survey of beds north-east of Flinders Island in eastern Bass Strait, the 2014 fishery opened with a 150 t default opening TAC. The fishery quickly focused on a bed east of King Island in western Bass Strait, which was reported to be in good condition (AFMA 2015b). Two additional scallop beds were found close to the primary King Island bed, with both reported to be in similarly good condition. These beds were not surveyed before the 2014 season, so information on biomass estimates and length-frequency data before commercial fishing in the area restarted are not available. The TAC was initially set at 1 000 t on 8 August 2014, and was increased to 1 500 t on 17 October (AFMA 2014b). The fishery closed on 31 December 2014 with 1 418 t (95 per cent) of the 1 500 t TAC taken.

The three beds found and fished in 2014 east of King Island were surveyed before the 2015 season. Together, they were estimated to contain 9 300 t of scallops larger than 85 mm (Knuckey et al. 2015). The 2015 fishery opened on 30 June 2015 with a starting TAC of 2 001 t. Fishing focused on the same areas as the 2014 season, and operators reported scallops in good condition. The TAC was increased on 14 November to 2 500 t, of which 2 260 t (90 per cent) had been taken when the fishery closed on 31 December 2015.

FIGURE 2.2 Catch and TAC of commercial scallop in the BSCZSF, 1977 to 2015



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; 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). A weight-of-evidence approach is used to determine stock status.

Recruitment of commercial scallops in Bass Strait (Young et al. 1992) and elsewhere (for example, Port Phillip Bay; Coleman 1998) has been historically variable; however, recent recruitment in eastern Bass Strait appears to have been consistently lower than average, even in the context of this variability. There has been little evidence of recruitment in eastern Bass Strait since surveys in 2009 identified large numbers of small scallops north-east of Flinders Island (Harrington & Semmens 2010). Surveys in 2015 identified small scallops adjacent to Flinders Island (Knuckey et al. 2015) that were again detected in greater amounts in 2016 (Knuckey et al 2016).

In terms of western Bass Strait, in 2009, a biomass survey around King Island found only seven individual scallops (Harrington & Semmens 2010). Exploratory fishing in 2014 found commercially viable quantities of scallops east of King Island in the area where surveys in 2009 failed to detect scallops, indicating that some recruitment had occurred in western Bass Strait since 2009. This finding, together with indications of recruitment in eastern Bass Strait after the 2006 to 2009 closure, appears to support the original (2007) harvest strategy approach of rotational fishing and 'resting' beds for a number of years before revisiting them.

Biomass surveys were not conducted around King Island in 2014; however, three beds in the area were surveyed before the 2015 season and were together estimated to contain 9 300 t of scallops larger than 85 mm (Knuckey et al. 2015). Seven beds around King Island (including the three surveyed in 2015) were surveyed in June 2016. The 2016 survey estimated the biomass of scallops larger than 85 mm in these beds at 16 500 t (Knuckey et al. 2016). An additional 3 800 t of scallops larger than 85 mm was estimated from two beds adjacent to Flinders Island in the same area as the 2015 survey (Knuckey et al. 2015). Because of the dredge gear, juvenile scallops will be undersampled in both surveys and commercial fishing. However, even in this context, biomass surveys around King Island have only detected juvenile scallops in two of the seven beds (Knuckey et al. 2016). Industry members have, however, reported additional beds around King Island that are thought to contain juvenile scallops (AFMA 2016).

The reduction in the minimum size limit decision rule from 90 mm to 85 mm since 2012, and reversal of spatial management arrangements from closing most areas to opening most areas have allowed greater flexibility for management and operators, but these arrangements are somewhat less precautionary (for example, AFMA 2012c). Despite generally high beach prices, catches had been falling each year since the fishery reopened, and the management changes were not able to arrest the fall; catches continued to fall until the discovery of beds around King Island in 2014. Although previous management arrangements allowed operators to fish the King Island beds if they had been surveyed, more flexible management arrangements in 2014 gave operators a stronger incentive to explore and fish unsurveyed areas.

To set a TAC higher than 150 t, industry-based biomass surveys must be undertaken. Known beds are typically surveyed, with some exploratory fishing on the way to and from the known beds. The costs of surveying, together with the highly patchy distribution of scallops, make fishery-wide surveys impractical. As a result, the surveyed area has been limited, and the extent of survey effort has been influenced by the nature of the fishing season—for example, poor fishing seasons generally result in limited participation in surveys. Because of recent die-off events, it is unclear how well results from previous surveys reflect the current biomass across the whole of the fishery area.

Stock status determination

Recent concerning signs in the eastern part of the fishery, including limited evidence of recruitment, reduced fishing area and reduced catch, indicate that these areas are supporting a substantially reduced biomass and density of scallops compared with historical levels.

Following revisions to the harvest strategy in 2014, three scallop beds were found in the western part of the fishery (in an area unfished for more than a decade), all of which were reported to be in good condition. Encouragingly, these areas again yielded good catches in 2015 and 2016 surveys estimated that a substantial biomass remains.

Because surveys and fishing activity in recent years have focused on and around known beds, there is a lack of recent information from large parts of the historically fished area. Additionally, recent die-off events (2010 and 2011) mean that confidence in previous biomass surveys drops with time.

The stock is classified as **uncertain** with regard to the level of biomass because of the lack of information for most of the fishery, including areas previously fished. The level of fishing effort and catch increased in 2014 and 2015, from a very low level, with 2015 approaching the highest catch and effort since the fishery reopened in 2009. Given the uncertainty in biomass and the potential that biomass remains substantially reduced across the fishery, the impact of this catch on biomass rebuilding is unclear. As a result, the stock is classified as **uncertain** with regard to the level of fishing mortality. Survey results from 2015 and 2016 estimate a larger biomass than has been seen in recent years, with recruitment having occurred after the 2009 surveys. If this trend of increasing biomass and evidence of recruitment continues, it may provide confidence that, even while biomass status is uncertain, fishing mortality is at a level that is not preventing rebuilding.

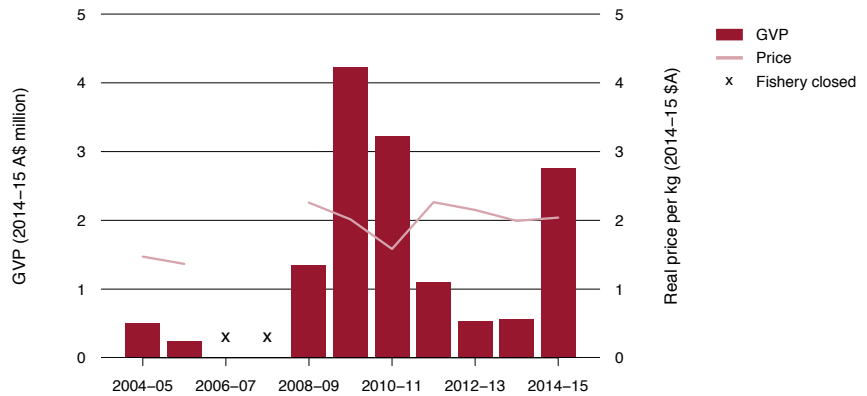
2.3 Economic status

Key economic trends

In 2011, an economic survey of the BSCZSF for the 2009–10 and 2010–11 financial years 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 (2014–15 dollars; George et al. 2012). These results are comparable with those from the previous survey of the fishery, for the 1997–98 and 1998–99 financial years, when real NER were –\$1.7 million and –\$1.0 million, respectively (Galeano et al. 2001). The timing of fishing seasons means that the financial year may sometimes span two fishing seasons.

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, real GVP was \$0.5 million in 2004–05 and \$0.2 million in 2005–06 (2013–14 dollars). Since the fishery’s reopening, higher GVPs of \$1.3 million and \$4.1 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 \$0.5 million in 2012–13. Most of the fall in real GVP in 2010–11 was a result of poor-quality scallops and low beach prices.

FIGURE 2.3 Real GVP and real prices received for catch in the BSCZSF, by financial year, 2004–05 to 2014–15



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.

NER are likely to have improved from the $-\$1.1$ million recorded in 2010–11. Increased catch in 2014–15 led to a GVP of $\$2.8$ million, comparable with the $\$3.2$ million GVP in 2010–11. However, whereas the 2010 fishing season comprised nearly 5 000 dredge-hours, the 2014 season comprised just over 2 700 dredge-hours. The lower input costs from this lower effort, combined with a 10 cent fall in the average real price of fuel and a nearly $\$240\ 000$ fall in real management costs since 2010–11, should have contributed to improved NER.

Management arrangements

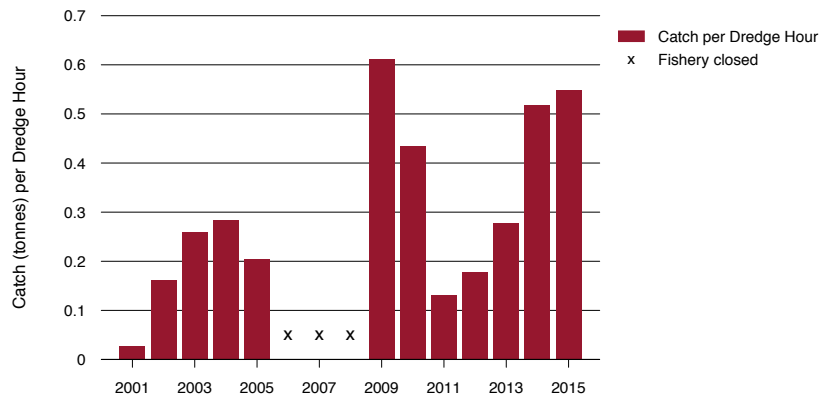
The BSCZSF harvest strategy was first developed following the Australian Government's Securing our Fishing Future structural adjustment programme in 2006, which removed 22 licences from the fishery. The harvest strategy was implemented in 2009, following three years (2006 to 2008) with a zero TAC. It 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 Harvest Strategy Policy (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. There is uncertainty about how the stock compares with its historical condition and therefore about how observed variability relates to natural factors as opposed to stock depletion. This uncertainty makes it difficult to develop appropriate target reference points for MSY and MEY (AFMA 2015a).

The 2015 BSCZSF harvest strategy (AFMA 2015a) recognises the difficulties associated with managing the fishery using a biomass target that is relative to virgin biomass. Since 2014 the harvest strategy uses 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 relation to 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.

There are indications that the current process that began in the 2014 BSCZSF harvest strategy, through its survey mechanism, has allowed fishers to focus on identified and viable scallop beds, meaning that fewer dredge-hours are used in areas of low availability. Catch per dredge-hour is now the highest it has been since the fishery reopened in 2009 (Figure 2.4), allowing a given volume to be caught with lower inputs. This, along with lower fuel prices and management costs, is likely to have improved NER, although it is uncertain whether NER are now positive. Reduced quota latency is also an indication that economic incentives have improved under the revised harvest strategy.

FIGURE 2.4 Catch per dredge-hour in the BSCZSF, 2001 to 2015

2.4 Environmental status

The BSCZSF was accredited against parts 10, 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999* in April 2013. The accreditation was accompanied by several recommendations, including that the observer programme be reviewed, that the Australian Fisheries Management Authority ensure improvements to the monitoring and analysis of bycatch and byproduct, and that issues identified in an (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 2015.

2.5 References

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Scallops
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Chapter 3

Coral Sea Fishery

S Hansen and K Mazur

FIGURE 3.1 Area fished within the Coral Sea Fishery, 2014–15

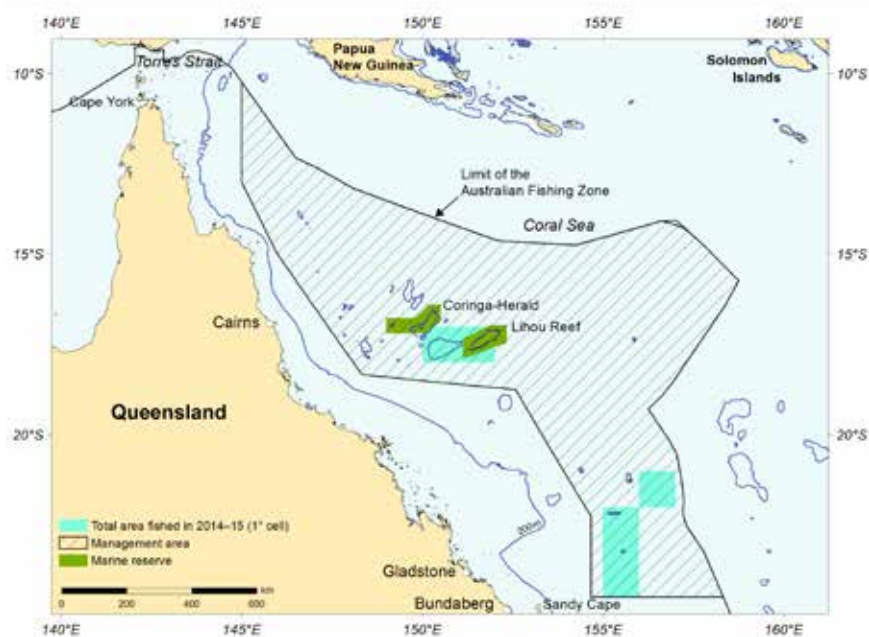


TABLE 3.1 Status of the Coral Sea Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Black teatfish (<i>Holothuria whitmaei</i>)					Negligible take in 2014–15; historical catch is less than plausible sustainable yield.
Prickly redfish (<i>Theleota ananas</i>)					Negligible take in 2014–15; historical catch is less than plausible sustainable yield.
Surf redfish (<i>Actinopyga mauritiana</i>)					Negligible take in 2014–15; historical catch is less than plausible sustainable yield.
White teatfish (<i>Holothuria fuscogilva</i>)					No current assessment to determine fishing mortality or biomass state.
Other sea cucumber species (~11 species)					Negligible take in 2014–15; 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 (<i>Panulirus ornatus</i>)					No take in 2014–15; 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 declined substantially in 2014–15; however, because of a lack of information about the mix of fish caught, it is unclear how this affected NER. Catch and effort declined in the remainder of the fishery in 2014–15, including in the Sea Cucumber Sector, especially for white teatfish and prickly redfish. A high degree of latent effort in the non-aquarium part of the fishery suggests low NER.				

Note: NER Net economic returns.

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 currently undertaking a review of the individual sector harvest strategies for likely completion in early 2017. It is expected that the updated harvest strategies will identify the key commercial species for each sector, which was not done previously.

Fishing effort

In 2014–15, five vessels were active in the fishery: two in the Line and Trap Sector, two in the Aquarium Sector and one in the Sea Cucumber Sector.

Catch

Approximately 14.7 t of finfish and echinoderms (excluding the Aquarium Sector, where catch is recorded as the number of individuals) was taken in the CSF during 2014–15, a decline from the 17.3 t taken in the 2013–14 season (Table 3.2).

TABLE 3.2 Main features and statistics for the CSF

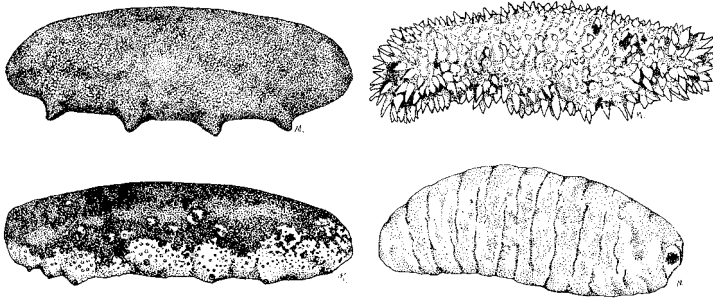
Fishery statistics a	2013–14 fishing season			2014–15 fishing season		
	Stock	TAC (t) or catch trigger	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t)
Aquarium Sector	40 000 individuals b	28 708 individuals	Confidential	40 000 individuals b	19 421 individuals	Confidential
Black teatfish	1	0.52	Confidential	1	0.52	Confidential
Greenfish and lollyfish	10	0	0	10	0	0
Other sea cucumbers	10	0.24	Confidential	10	0.23	Confidential
Prickly redfish	20	3.2	Confidential	20	0.57	Confidential
Sandfish	1	0	0	1	0	0
Surf redfish	10	0.21	Confidential	10	0.001	Confidential
White teatfish	4	4.04	Confidential	4	3.3	Confidential
Total sea cucumbers	150	8.2	Confidential	150	4.6	Confidential
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)	–	9.11	Confidential	–	10.1	Confidential
Total fishery	–	17.3 c	Confidential	–	14.7 c	Confidential
Fishery-level statistics						
Effort	Sea Cucumber: 270 dive-hours Lobster: 0 dive-hours Aquarium: 1 342 dive-hours Line and Trap, and Trawl and Trap: 70 719 hooks, 0 trap lifts, 0 trawl hours			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		
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	7			5		
Observer coverage	Sea Cucumber: 0 Lobster: 0 Trochus: 0 Aquarium: 8 days Line and Trap, and Trawl and Trap: 1 day			Sea Cucumber: 0 Lobster: 0 Trochus: 0 Aquarium: 0 Line and Trap, and Trawl and Trap: 0		
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	Mooloolaba, Innisfail, Bowen					
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	<i>Management arrangements booklet 2014—Coral Sea Fishery</i> (AFMA 2014) <i>Management arrangements booklet 2015—Coral Sea Fishery</i> (AFMA 2015)					

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 assess each separately, and they are managed as a group. Therefore, their status is also reported as a group.



Prickly redfish
Tim Skewes, CSIRO

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. Subsequently (since 2003–04), the annual sea cucumber catch has fluctuated between 1.9 t and 9.2 t. Annual catches since 2007–08 have generally been less than 3 t, but increased to 8.2 t in 2013–14 before declining to 4.6 t in 2014–15.

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. 2004, 2003). 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 the 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, with 1 kg caught in 2014–15, well below historical peaks that exceeded 4 t per season. Catches of surf redfish have been less than the median estimate of MSY (879 kg) for 13 of the 17 seasons since 1997–98 (including the 2013–14 season). Therefore, surf redfish is classified as **not overfished** and **not subject to overfishing**. Catch of white teatfish declined to 3.35 t in 2014–15 (from 4.04 t in 2013–14) and remains well below the historical peak of 19.7 t in 1999–2000. As a result of data limitations, a plausible initial biomass estimate could not be established for white teatfish, and the status of this stock remains **uncertain** with respect to both biomass and fishing mortality. Since stock status classification is at the fishery level, caution is required when considering status at the level of an individual reef. Historical catch at some reefs has been high, and 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 the catch from the multispecies stock was low (only 225 kg) in 2014–15, 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

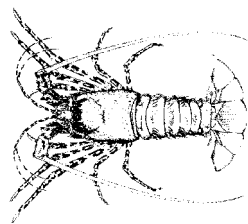
The ABARES assessment of the Aquarium Sector (Leatherbarrow & Woodhams 2015), based on data up to the 2008–09 fishing season, indicated that fishing in the sector was unlikely to be having an adverse impact on the stock. Under current permit conditions, operators can only fish about 7 per cent of suitable 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 trigger of 40 000 individuals was exceeded during the 2012–13 season, the current level of effort is considered unlikely to have a detrimental impact on the stock. However, the CSF aquarium expert group recommended exploring options to develop and implement monitoring practices, which include reporting catches at the species level—specifically for goby (Gobiidae) and damselfish (Pomacentridae) species. This information would improve future assessment and management of fishing impacts (AFMA 2013).

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. versicolour*; 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 2013–14 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 10.1 t in 2014–15, an increase from 9.11 t in 2013–14. No trap effort has been recorded since 2010–11, and no trawl effort has been recorded since 2006–07. The number of hooks deployed decreased to 65 300 in 2014–15, from 70 719 in 2013–14 (Table 3.2). Most of the 2013–14 catch was caught by auto-longline (9.8 t) operations.

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 fishery was considered as a whole. No new stock assessments are available.

At the fishery level, the total line catch in 2014–15 was less than the conservative estimates of all-species sustainable yield (82 t) (Larcombe & Roach 2015).

In 2014–15, flame snapper (*Etelis coruscans*) constituted approximately 58 per cent of auto-longline catch. Flame snapper, in conjunction with bar rockcod (*Epinephelus ergastularius* and *E. septemfasciatus*), amberjack (*Seriola dumerili*) and ruby snappers (*Etelis* spp.) constituted approximately 80 per cent of auto-longline catch. Auto-longline and dropline catch in 2014–15 did not exceed species-specific sustainable yield estimates (Larcombe & Roach 2015).

In some fishing seasons, sharks have comprised a large component of the total catch for these sectors—for example, blacktip sharks were more than 50 per cent of the total line catch in 2005–06. However, no data are currently 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 in 2013–14 was 259 kg, and 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 2014–15 was unlikely to constitute overfishing, and there were no trawl or trap fishing operations. Therefore, 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 supported trawl operations. Therefore, the Line and Trap, and Trawl and Trap sectors are classified as **uncertain** with regard to their biomass status.

3.3 Economic status

Key economic trends

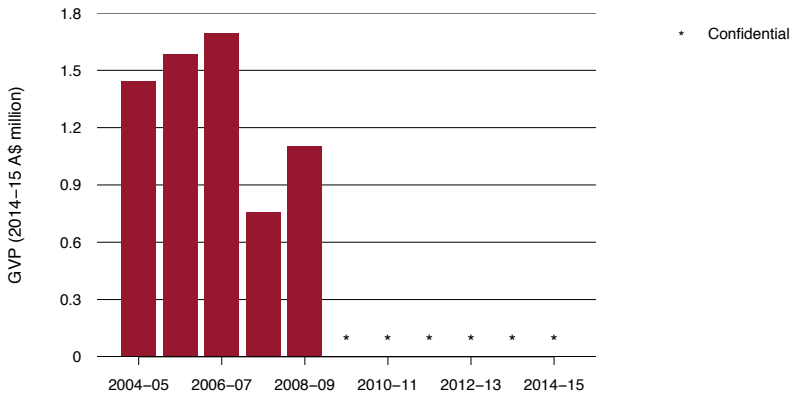
The Aquarium Sector is likely to have contributed most of the value of the CSF in recent years. The sector's gross value of production (GVP) is difficult to estimate because catch is reported as the number of fish rather than the weight of fish. As well, prices are different for different species, and 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 2014–15, these exports were valued at \$1.9 million (compared with \$2 million in 2013–14), of which exports from Queensland accounted for 81 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 decreased from 70 719 in 2013–14 to 65 300 in 2014–15 (Table 3.2). The line sector catch increased from 9.11 t in 2013–14 to 10.1 t in 2014–15. The GVP from these sectors also declined, but cannot be reported because of the small number of operators (Figure 3.2).

The Sea Cucumber Sector catch declined from 8.2 t in 2013–14 to 4.6 t in 2014–15, and dive effort declined substantially from 270 hours in 2013–14 to 84 hours in 2014–15 (Table 3.2). Although GVP is confidential for this sector, about 72 per cent of the 2014–15 catch was made up of white teatfish, a relatively high-value sea cucumber species. Catch of white teatfish, however, declined from 4 t in 2013–14 to 3.3 t in 2014–15, which is likely to have had a negative influence on GVP.

No lobster catch or trawl effort occurred in 2013–14 or 2014–15, and therefore these sectors did not generate any net economic returns (NER).

FIGURE 3.2 Real GVP for the CSF (excluding the Aquarium Sector), 2004–05 to 2014–15



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

Low NER in the non-aquarium part of the fishery are indicated by the existence of latent available effort units in some CSF sectors. For example, only a small number of vessels have been active in the Line and Trap Sector in recent years (two vessels in 2014–15), despite eight permits being available. This suggests that fishers have had a low incentive to participate in this part of the fishery, reflecting expectations of low profits. Despite the decline in fishing effort and catch for this part of the fishery during the past year, the change in NER is uncertain. Similarly, lack of information about the mix of fish caught in the Aquarium Sector means that changes in NER remain uncertain, despite the decline in catch (from 28 708 individuals in 2013–14 to 19 421 individuals in 2014–15) and dive effort (from 1 342 hours in 2013–14 to 925 hours in 2014–15).

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.

3.4 Environmental status

The CSF was reaccredited under parts 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999* until 17 November 2016. 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.

Eight level 1 (Scale, Intensity, Consequence Analysis) ecological risk assessments were completed for the CSF in 2007, covering a broad suite of species and associated habitats. A qualitative risk assessment was then undertaken in 2009 for protected species and chondrichthyans (AFMA 2009). A level 2 ecological risk assessment for all protected species and chondrichthyan species was submitted to AFMA in 2012; however, no CSF species or habitats were assessed at level 2 using Productivity Sensitivity Analysis. 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 2015.

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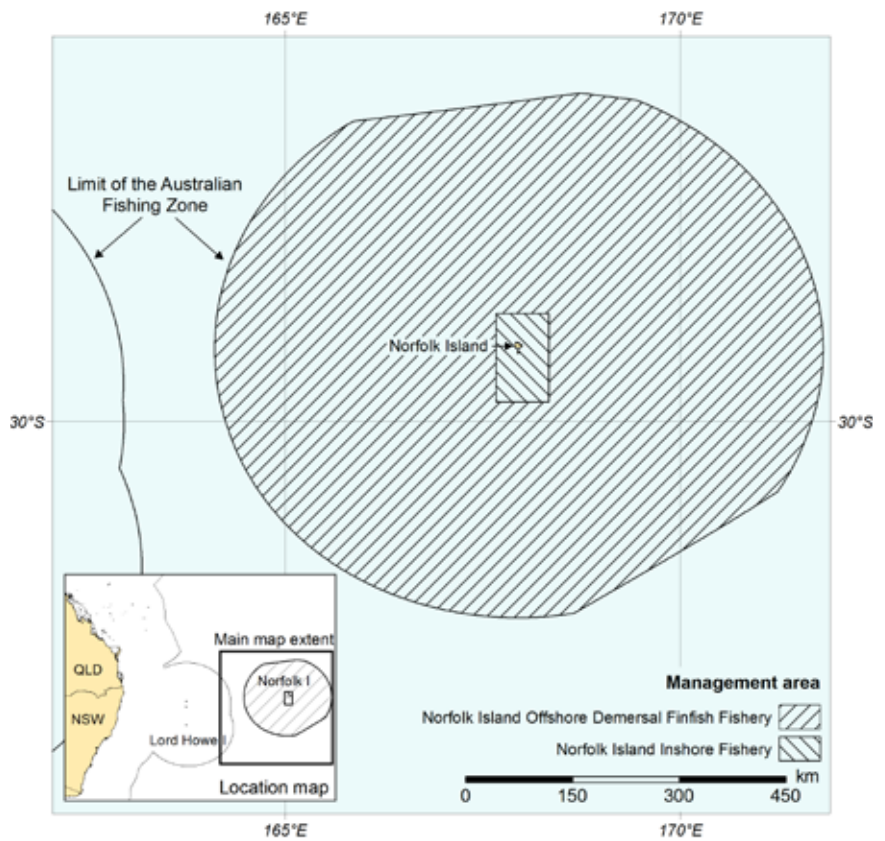
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Chapter 4

Norfolk Island Fishery

S Hansen

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 (*Hyperglyphe 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 2015, no interactions with protected species were reported.

4.5 References

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Chapter 5

Northern Prawn Fishery

J Larcombe, A Bath and R Green

FIGURE 5.1 Relative fishing intensity in the Northern Prawn Fishery, 2015

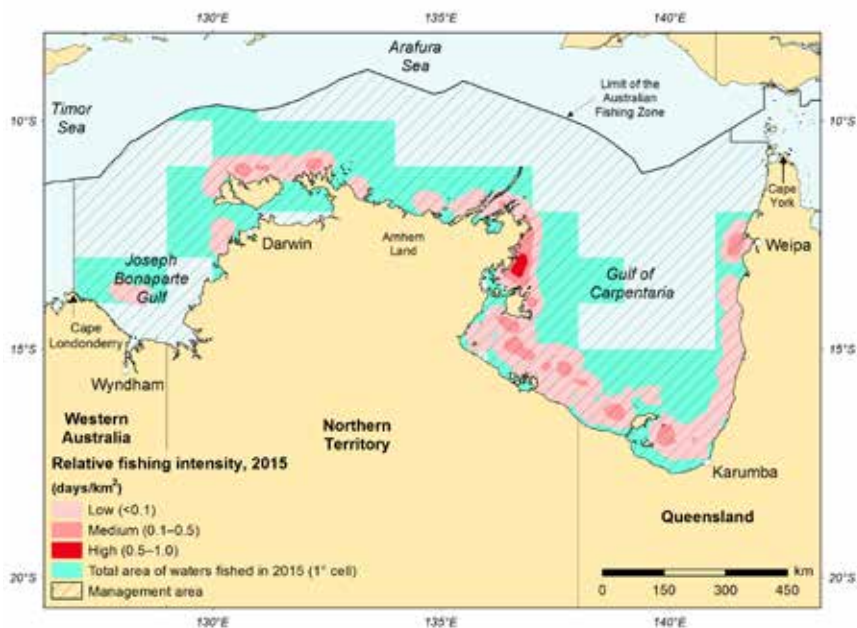


TABLE 5.1 Status of the Northern Prawn Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Red-legged banana prawn (<i>Fenneropenaeus indicus</i>)	■	■	■	■	Recent catches are below MSY estimates. Biomass is estimated to be above the TRP.
White banana prawn (<i>Fenneropenaeus merguensis</i>)	■	■	■	■	High natural recruitment variability is primarily linked to environmental factors. Harvest strategy aims to provide for adequate escapement.
Brown tiger prawn (<i>Penaeus esculentus</i>)	■	■	■	■	Effort is below E_{MSY} and catch is below MSY. Spawner stock size is above the LRP of $0.5S_{MSY}$.
Grooved tiger prawn (<i>Penaeus semisulcatus</i>)	■	■	■	■	Effort is near E_{MSY} and catch is below MSY. Spawner stock size is above the LRP of $0.5S_{MSY}$.
Blue endeavour prawn (<i>Metapenaeus endeavouri</i>)	■	■	■	■	Catch is below the estimate of MSY. Spawner stock biomass is above the LRP of $0.5S_{MSY}$.
Red endeavour prawn (<i>Metapenaeus ensis</i>)	■	■	■	■	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. In 2014–15, lower fuel prices and improved banana prawn prices indicate positive signs for NER in the fishery.				

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. TRP Target reference point.

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 merguianensis*) 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 (*Penaeus 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 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. 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 (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 7 500 days of effort and 52 vessels. This restructuring of the fishery was achieved through a series of structural adjustment and buyback programmes, 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 2015 was 7 825 t, comprising 7 696 t of prawns and 129 t of byproduct species (predominantly bugs, squid 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.

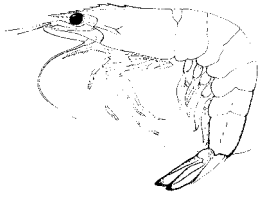
TABLE 5.2 Main features and statistics for the NPF

Fishery statistics a	2014 fishing season b		2015 fishing season b	
	Catch (t)	Real value (2013–14)	Catch (t)	Real value (2014–15)
Stock				
Banana prawns	6 245	\$69.1 million	3 931	\$62.0 million
Tiger prawns	1 688	\$40.6 million	3 168	\$34.4 million
Endeavour prawns	677	\$5.5 million	554	\$8.5 million
Other catch (prawns)	11	\$0.4 million	43	\$0.5 million
Other catch (not prawns)	86	\$1.6 million	129	\$1.5 million
Total fishery	8 707	\$117.2 million	7 825	\$106.8 million
Fishery-level statistics				
Effort	Banana season: 2 476 boat-days Tiger season: 5 624 boat-days		Banana season: 2 249 boat-days Tiger season: 5 940 boat-days	
Fishing permits	52		52	
Active vessels	52		52	
Observer coverage	Crew member observers: 843 days (10.4%) Scientific observers: 117 days (1.4%)		Crew member observers: 1058 (12.9%) Scientific observers: 159 days (1.94%)	
Fishing methods	Otter trawl			
Primary landing ports	Cairns, Darwin, Karumba. Much of the catch is offloaded onto mother ships 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 for banana prawns: 1 April to 15 June; for tiger prawns: 1 August to 29 November.

5.2 Biological status

Red-legged banana prawn (*Fenneropenaeus indicus*)



Line drawing: FAO

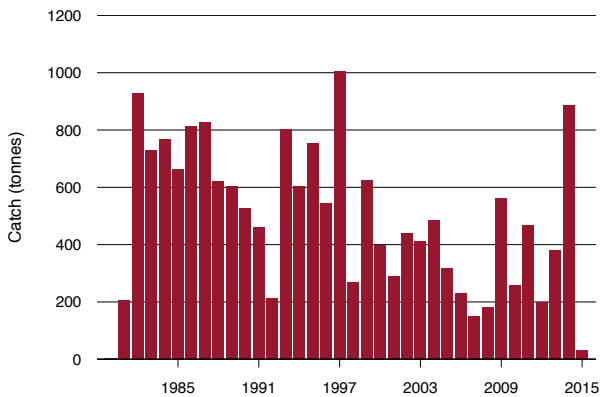
Stock structure

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

Catch history

The bulk 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 in 2015 to 56 t (Figure 5.2).

FIGURE 5.2 Red-legged banana prawn catch, 1980 to 2015



Source: CSIRO

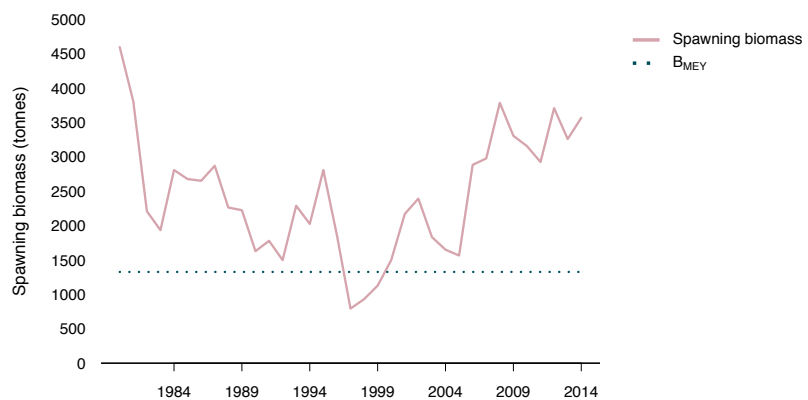
Stock assessment

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 aspect 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.

The 2015 season saw very low levels of effort in Joseph Bonaparte Gulf (76 days) and corresponding very low levels of catch (30 t in Joseph Bonaparte Gulf and 56 t in total). 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 2015, the model was not able to provide reliable estimates of stock status. One explanation for the low levels of catch and effort in 2015 is the more favourable tiger prawn fishing in the Gulf of Carpentaria, which experienced unusually high catch rates in 2015—this explanation was accepted by the Northern Prawn Fishery Resource Assessment Group (NPRAG) as a contributing factor. Another explanation is that recruitment or availability was lower in 2015 as a result of anomalous environmental factors, including strong El Niño conditions and considerably reduced tidal flows—this possibility was acknowledged by NPRAG. Under the harvest strategy, when effort is below 100 days in one year, the fishery remains open in both seasons of the following year. However, given the uncertainties around status, NPRAG agreed to additional data collection and analysis during the first season of 2016, to provide early indications of stock status before an assessment update is undertaken in early 2017.

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

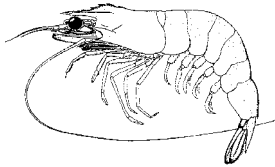


Source: Buckworth et al. 2015

Stock status determination

The 2015 red-legged banana prawn catch of 56 t was substantially lower than in recent years and well below the estimated long-term average MSY range (750–900 t; Buckworth et al. 2015). Given this low catch and the high estimated spawning biomass level in 2014, the stock is classified as **not subject to overfishing**. The most recent estimate of biomass (2014) was well above the target reference point. However, there was no assessment in 2015 following low catch and effort levels, and there is uncertainty and some concern about the cause of these lower catch levels. Noting the importance of additional monitoring and assessment planned for 2016 and 2017, the red-legged banana prawn stock is classified as **not overfished**.

White banana prawn (*Fenneropenaeus merguensis*)



Line drawing: FAO

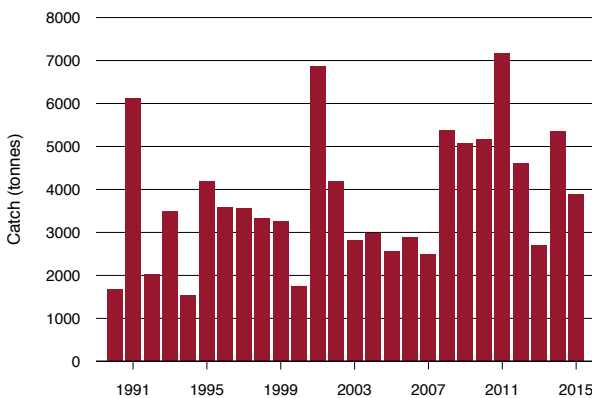
Stock structure

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 2015 was 3 901 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 2015



Source: CSIRO

Stock assessment

The environmentally driven variability of this resource means that a robust stock–recruitment relationship cannot be determined and that annual sustainable yields are largely dependent on annual recruitment. Consequently, 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 the model cannot accurately predict catch levels in some years, particularly in recent years (Buckworth et al. 2013).

Harvest rates for white banana prawn in the fishery are understood to have been high (>90 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 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. The catch-rate trigger level for the closure of the banana prawn season is being reviewed from the perspective of its performance in achieving economic objectives and stock sustainability (allowing sufficient escapement).

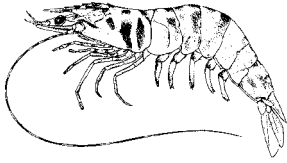
Stock status determination

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



Deploying the gear
Austral Fisheries

Brown tiger prawn (*Penaeus esculentus*)



Line drawing: FAO

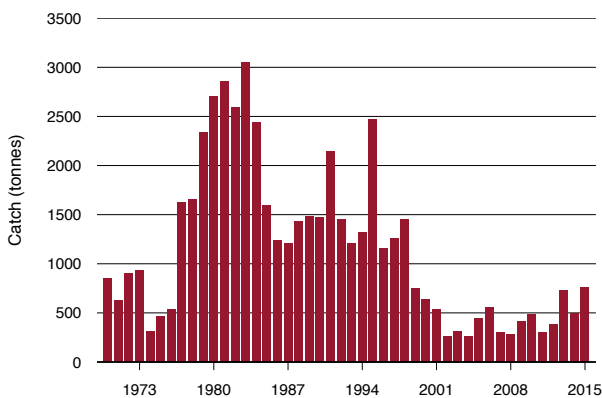
Stock structure

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 2015 was 763 t (Figure 5.5). This was an increase from 2014 and similar to 2013 catch levels.

FIGURE 5.5 Brown tiger prawn catch, 1970 to 2015



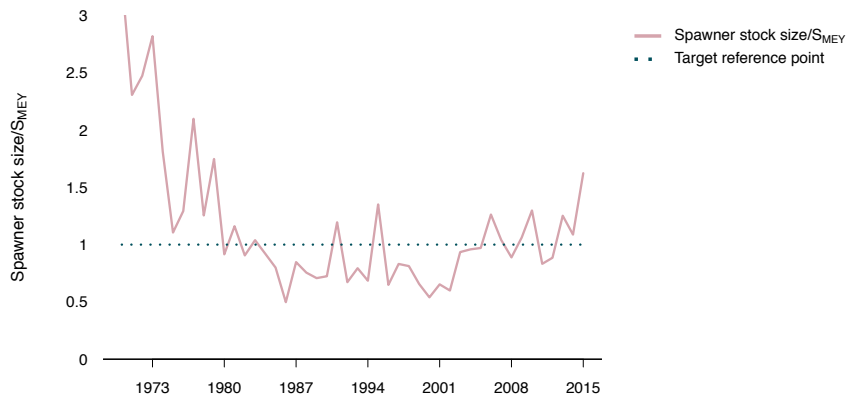
Source: CSIRO

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. Assessments are conducted every two years. For the most recent assessment (Buckworth 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 (range across sensitivities 32–34 per cent). The estimate of effort in 2015 as a percentage of effort at MEY (E_{2015}/E_{MEY}) was 35 per cent (32–43 per cent). Catch of brown tiger prawn was 492 t in 2014 and 763 t in 2015 (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

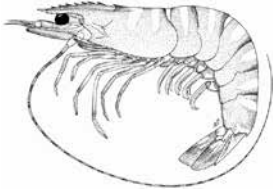


Source: Buckworth 2016

Stock status determination

Effort in recent years has been less than the level associated with MSY, catches in recent years have been less than MSY, and the estimate of biomass 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

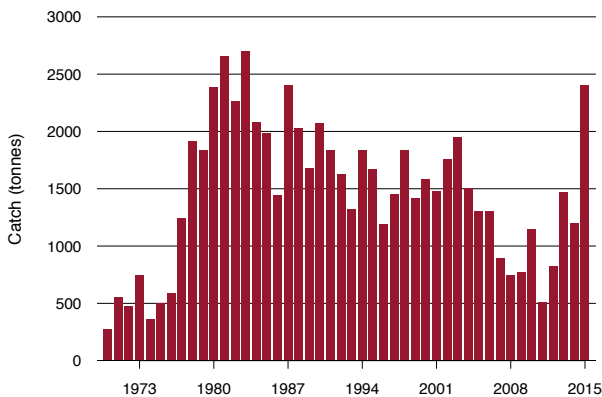
Stock structure

Grooved tiger prawn ranges across northern Australian waters, the Indo-West Pacific and the Mediterranean. 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 2015 was 2 405 t, which was a substantial increase from the 2014 catch of 1 196 t, and the highest catch of this species since the early 1980s.

FIGURE 5.7 Grooved tiger prawn catch, 1970 to 2015



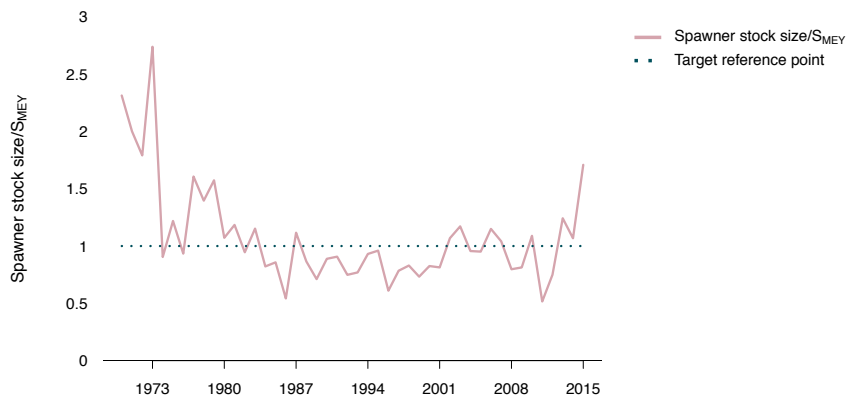
Source: CSIRO

Stock assessment

For the most recent assessment (Buckworth 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 (50–90 per cent). The estimate of effort in 2015 as a percentage of effort at MEY (E_{2015}/E_{MEY}) was 101 per cent (98–122 per cent). The catch of grooved tiger prawn in 2015 was 2 405 t (Figure 5.7), which was more than 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

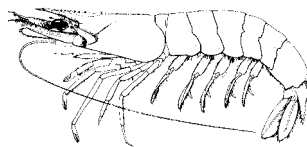


Source: Buckworth 2016

Stock status determination

Although the catch of grooved tiger prawn in 2015 exceeded the estimated long-term MSY, this catch was supported by higher than average levels of recruitment in 2015. Additionally, effort in 2015 was estimated to be less than the level associated with MSY and close to the level associated with MEY. 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

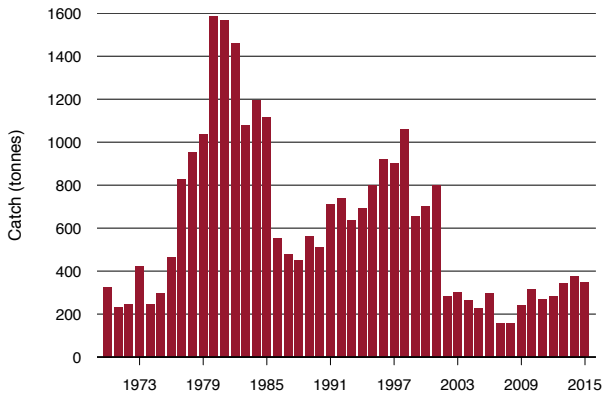
Stock structure

Blue endeavour prawn ranges across northern Australia waters and parts of the Indo-West Pacific. 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 2015 catch was 348 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 2015



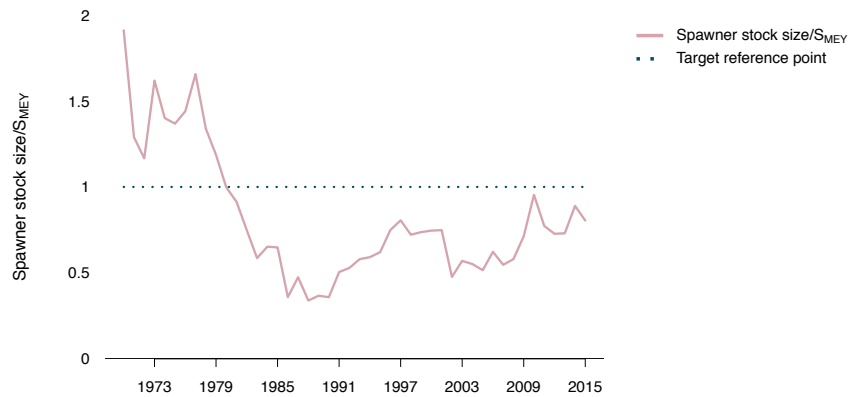
Source: CSIRO

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 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 377 t in 2014 and 348 t in 2015 (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

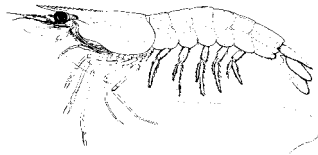


Source: Buckworth 2016

Stock status determination

The catch in 2015 was well under the estimated MSY, and the estimate of spawner stock size 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. 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. Since 1998, catches have been below 400 t, and the 2015 catch was 206 t. Red endeavour prawn is a byproduct of the tiger prawn fishery.

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 a fall in fishing effort directed at tiger prawn rather than any indication of a fall in red endeavour prawn biomass.

Stock status determination

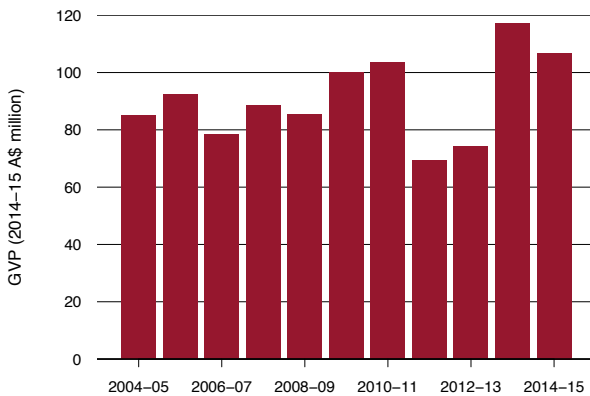
Given the absence of information on the sustainability of catches or the state of the biomass, this stock is classified as **uncertain** with regard to the level of fishing mortality and biomass.

5.3 Economic status

Key economic trends

The gross value of production (GVP) in the NPF fluctuated during the decade to 2014–15, peaking at \$117 million (in 2014–15 dollars) in 2013–14 and reaching a low of \$69 million in 2011–12 (Figure 5.11). The GVP in the fishery declined to \$107 million in 2014–15, but this still represented one of the highest value years in the fishery during the past decade.

FIGURE 5.11 GVP for the NPF, 2004–05 to 2014–15



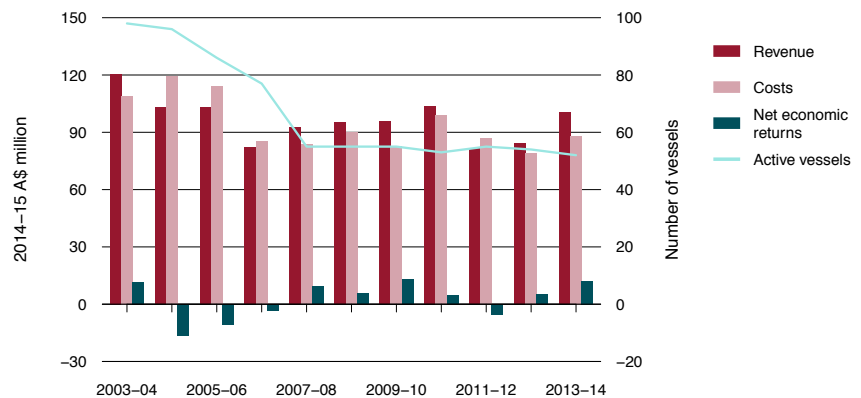
Notes: GVP Gross value of production. 2014–15 data are preliminary.

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 provides survey-based estimates of NER for the 2012–13 and 2013–14 financial years (Bath & Green 2016).

The level of real NER in the NPF has varied considerably during the past 15 years (Figure 5.12). In 2000–01, real NER were estimated at \$86 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 onwards, the fishery began targeting MEY in the tiger prawn component of the fishery and the Securing our Fishing Future (SOFF) structural adjustment programme (which concluded in 2006–07) was implemented. Management changes that allowed the adoption of quad gear trawl configuration also occurred in this period. Together, these changes are likely to have assisted in improving the economic performance of the fishery since 2014–05

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, real NER in the fishery have been positive each year, apart from 2011–12, peaking at \$13 million in 2009–10, while active vessel numbers have declined slightly, to 52 active vessels in the 2015 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 more than \$10 million to –\$5 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. Real unit prices improved in 2014–15, with banana prawn prices increasing from \$11.96 per kg in 2013–14 to \$13.58. Together with lower fuel prices, this indicates positive signs for NER in the fishery for 2014–15.

FIGURE 5.12 Real revenue, costs, NER and active vessel numbers for the NPF, 2003–04 to 2013–14



Notes: NER Net economic returns. NER include management costs.

Source: Bath & Green 2016

Total factor productivity 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; Figure 5.13 and 5.14). 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 (Figure 5.15); however, targeting MEY of 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, rather than just changes in efficiency measures and technology adopted by fishers.

Banana prawn catch per vessel has fluctuated since 2010–11, including a sharp reduction in 2011–12 and 2012–13, which contributed to negative NER in 2011–12 but was offset by higher prices for banana prawns in 2012–13. Higher landed catches in 2013–14 led to improved growth in total factor productivity. Other factors that are likely to have improved productivity include the structural adjustment buyback and, more recently, many vessels moving to quad trawl gear, which is more fuel-efficient.

Inputs have proved stable, despite variation in seasonal conditions. If fewer inputs were used in less abundant fishing seasons, total factor productivity and NER would be higher overall and more stable. Recent management changes, including the introduction of an MEY catch trigger for banana prawns, seek to address this, but it is too early to assess the impact of these changes on total factor productivity.

FIGURE 5.13 Total factor productivity index, 2004–05 to 2013–14

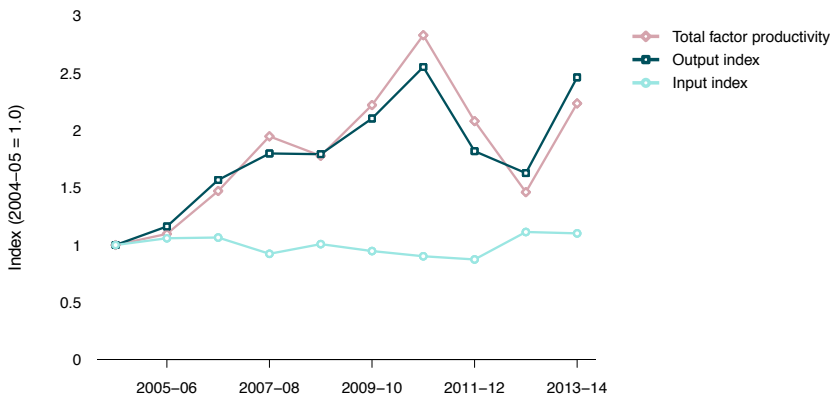


FIGURE 5.14 Terms of trade index, 2004–05 to 2013–14

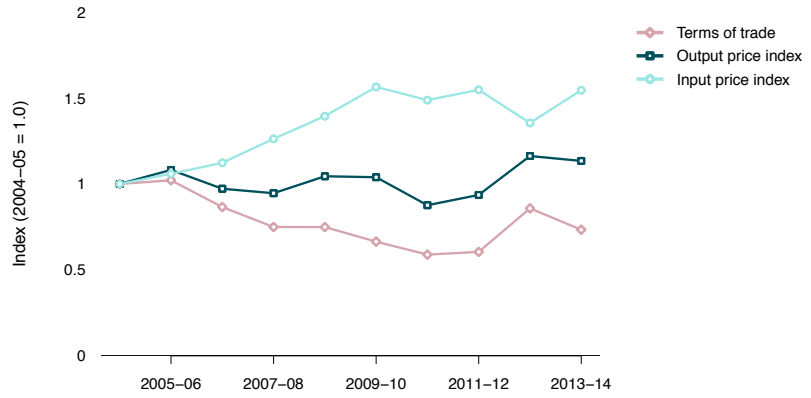
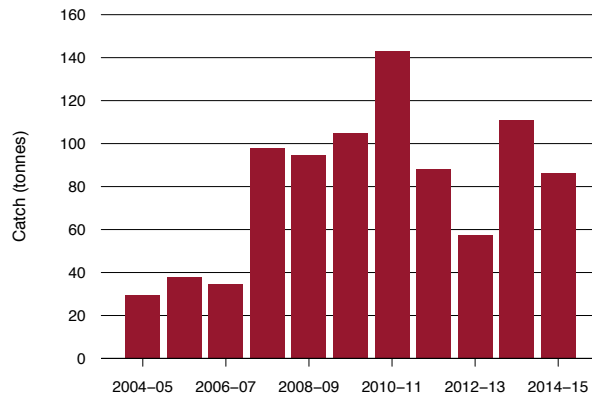


FIGURE 5.15 Average banana prawn catch per vessel, 2004–05 to 2014–15



Source: Skirtun et al. 2014

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). It is too early to disentangle the effect of these changes from other factors.

Performance against economic objective

The tiger prawn component of the fishery (tiger and endeavour prawns) has explicit MEY targets (three species-level biomass MEY targets), and a bio-economic model is used to estimate annual fishing effort required to move towards spawning stock sizes at MEY (S_{MEY}) across the stocks. Stock assessments are undertaken every two years. Spawning stock size 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 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 highly variable. For white banana prawn, recruitment is associated with rainfall in some areas, and so 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 and will be refined over subsequent seasons (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.

The targeting of MEY in the fishery is consistent with the economic objective of maximising economic returns and could be expected to increase NER in the fishery. MEY targeting of the tiger prawn component of the fishery began in 2004–05. Despite declining terms of trade over 2004–05 to 2010–11, productivity and NER improved. Although the targeting of MEY over the 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 *Harpisquilla stephensoni*).

AFMA publishes quarterly reports of logbook interactions with protected species on its website. In the NPF in the 2014 calendar year, 60 turtle interactions were reported, and all turtles were released alive; 476 sawfish were caught, of which 326 were released alive, 9 were injured and the remainder were dead; and 7 682 sea snakes were caught, of which 6 324 were released alive, 7 were injured, 322 had an unknown life status and the remainder were dead. Reports also indicate that 28 seahorses or pipefish were caught—21 were dead and 7 were released alive.

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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, 2014–15

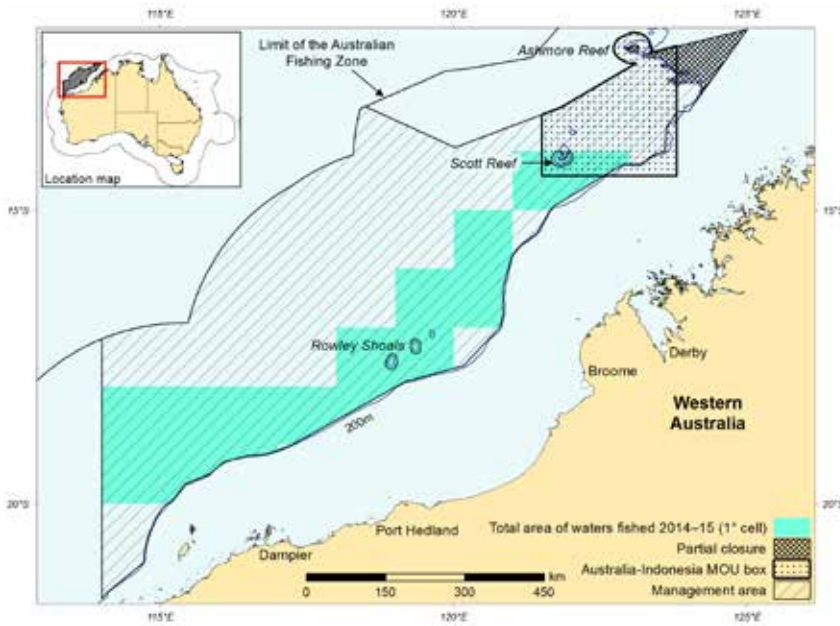


TABLE 6.1 Status of the North West Slope Trawl Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Scampi (<i>Metanephrops australiensis</i> , <i>M. boschmai</i> , <i>M. velutinus</i>)					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



Scampi
AFMA

6.1 Description of the fishery

Area fished

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

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, and mixed snappers (Lutjanidae) have been an important component of the catch in some years. 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.

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. It has since decreased to stabilise at one or two vessels each year since 2008–09. Historical effort, in trawl hours, in the fishery largely follows the trend in the number of active vessels (Figure 6.2).

TABLE 6.2 Main features and statistics for the NWSTF

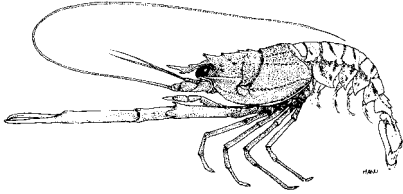
Fishery statistics a	2013–14 fishing season			2014–15 fishing season		
	TAC (t)	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t)	Real value (2014–15)
Scampi (<i>Metanephrops australiensis</i> , <i>M. boschmai</i> , <i>M. velutinus</i>)	–	33.3	Confidential	–	33.4	Confidential
Total fishery	–	45.7	Confidential	–	49.1	Confidential
Fishery-level statistics						
Effort	119 days; 2 191 trawl hours			115 days; 2 137 trawl hours		
Fishing permits	6			4		
Active vessels	1			1		
Observer coverage	12 days (10.1%)			–		
Fishing methods	Demersal trawl					
Primary landing ports	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	<i>North West Slope Trawl Fishery and Western Deepwater Trawl Fishery statement of management arrangements (AFMA 2012)</i>					

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

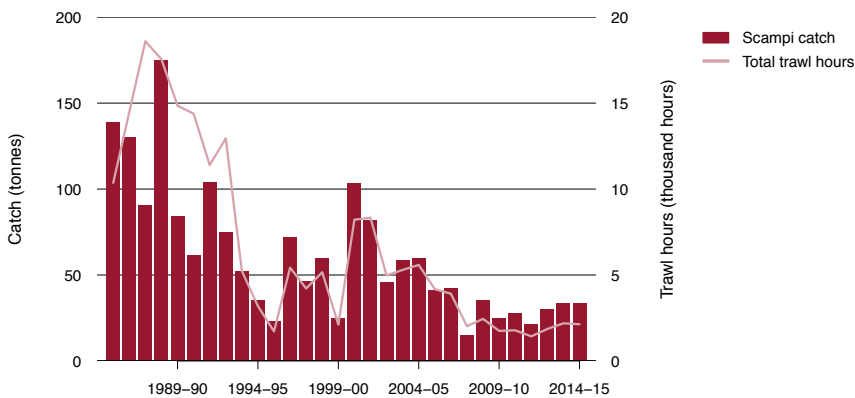
Stock structure

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 is 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). Catch in recent years has primarily consisted of scampi, with the exception of 2011–12, when mixed snapper accounted for most of the catch (32 t).

FIGURE 6.2 Catch and effort for scampi in the NWSTF, 1985–86 to 2014–15



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 is 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 remains 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 is 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 fewer than five vessels have been active in the fishery. Only one vessel has been active in the fishery since the 2012–13 fishing season. The 2014–15 fishing season had four fishing permits issued, indicating latent effort in the fishery and suggesting potentially low net economic returns (NER), because fishers are not fully using their right to fish. Although more catch was landed in total during 2014–15, catch of the high-value scampi species remained largely unchanged from 2013–14. The share of total catch that was scampi decreased from 73 per cent in 2013–14 to 68 per cent in the 2014–15 fishing season. This movement away from high-value scampi to lower-value species suggests that NER may have declined in the 2014–15 fishing season.

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 was reaccredited under parts 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) until 25 November 2016. As well as standard requirements that apply to demersal trawl fisheries, the reaccreditation recommends a review of the ecological risk assessment (ERA) for the fishery if fishing effort in waters shallower than 200 m exceeds 2011 levels.

Chondrichthyans and teleosts caught in the NWSTF and the WDTF have been assessed to level 3 of the AFMA ERA (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 2015.

6.5 References

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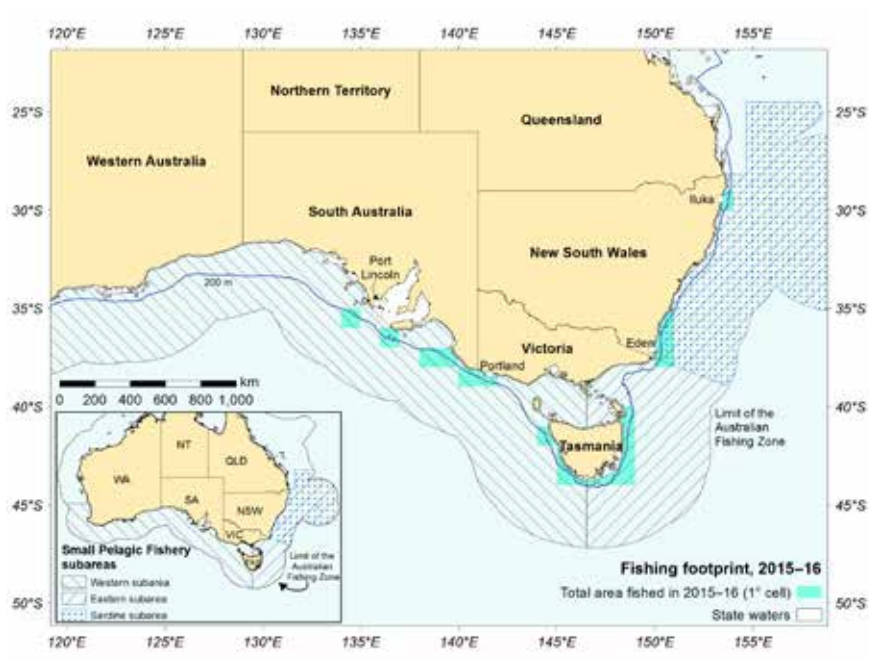
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Chapter 7

Small Pelagic Fishery

A Moore and K Mazur

FIGURE 7.1 Area fished in the Small Pelagic Fishery, 2015–16



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

TABLE 7.1 Status of the Small Pelagic Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Australian sardine (<i>Sardinops sagax</i>)					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 (<i>Scomber australasicus</i>)					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 (<i>Scomber australasicus</i>)					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 (<i>Trachurus declivis</i>)					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 (<i>Trachurus declivis</i>)					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 (<i>Emmelichthys nitidus</i>)					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 (<i>Emmelichthys nitidus</i>)					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 2014–15 or 2015–16. An increase in the catch in 2014–15 and 2015–16 suggests that GDP is likely to have increased. Changes in NER are uncertain because of a lack of information about changes in cost structures of the industry.				

Notes: **GVP** Gross value of production. **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 red bait (*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 to set recommended biological catches (RBCs) and total allowable catches (TACs) for the 2014–15 and 2015–16 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 in excess of 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 2. Exploitation rates under tier 2 are now 10 per cent of estimated spawning biomass for Australian sardine, 7.5 per cent for blue mackerel, 6 per cent for jack mackerel and 5 per cent for redbait. 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 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; Fulton et al. 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 used to set RBCs and TACs for the 2015–16 fishing season.

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. In this chapter, spawning biomass estimates are generally presented with the 95 per cent confidence interval of the range of possible estimates. This confidence interval 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, a high level of precaution needs to be applied 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 and 2015–16 with the introduction 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 introduction of a factory trawler vessel in 2014–15 and 2015–16 has led to increased catches. Total Commonwealth catch in the 2014–15 season was 644 t, representing 2 per cent of the total TAC of 34 820 t. Total Commonwealth catch in 2015–16 increased to 12 004 t, representing 30 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 (that is, last year's reports assessed the 2013–14 fishing season, not the 2014–15 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 are predominantly from Commonwealth fisheries. The catch for blue mackerel by Commonwealth vessels increased in the 2015–16 fishing seasons to the extent that the Commonwealth catch was larger than the state catch. Commonwealth catches of jack mackerel also increased by an order of magnitude in the 2015–16 season. Stock status is now reported for the 2014–15 and 2015–16 seasons because of the trend of increasing Commonwealth catch for these two species, which necessitates more up-to-date status assessments. The status determination for 2015–16 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

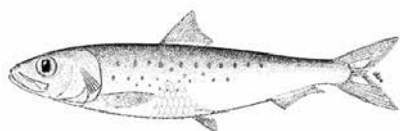
Fishery statistics a	2014–15 fishing season			2015–16 fishing season	
	Stock name	TAC (t)	Catch (t) b	Real value (2014–15)	TAC (t)
Australian sardine	560	152	Confidential	1 880	118
Blue mackerel, east	2 630	202	Confidential	2 630	2 164
Blue mackerel, west	6 500	0	0	6 200	1 007
Jack mackerel, east	10 230	311	Confidential	18 670	6 585
Jack mackerel, west	5 000	0	0	3 600	631
Redbait, east	5 000	0	0	3 310	289
Redbait, west	5 000	0	0	2 880	1 210
Total fishery	34 920	665	Confidential	39 170	12 004
Fishery-level statistics					
Effort	Purse seine: 102 search-hours Midwater trawl: 48 shots			Purse seine: 128 search-hours Midwater trawl: 316 shots	
Fishing permits	33 entities held quota SFRs in 2014–15			32 entities held quota SFRs in 2015–16	
Active vessels	Purse seine: 2 Midwater trawl: 1			Purse seine: 2 Midwater trawl: 1	
Observer coverage	Purse seine: 3 shots (5.3%) Midwater trawl: 100%			Purse seine: 0 shots (0%) Midwater trawl: 100%	
Fishing methods	Purse seine, midwater trawl				
Primary landing ports	Triabunna (Tasmania); Port Lincoln (South Australia); Eden, Iluka (New South Wales); 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 2015–16. b Catch data are derived from the Australian Fisheries Management Authority's 'Catchwatch' records and do not include state catches.

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

Stock structure of Australian sardine in Australia is not well defined. Two studies indicate genetic structuring (Dixon et al. 1993; Yardin et al. 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. Australian sardine within the SPF is assessed and managed as a single east coast stock (Figure 7.1).

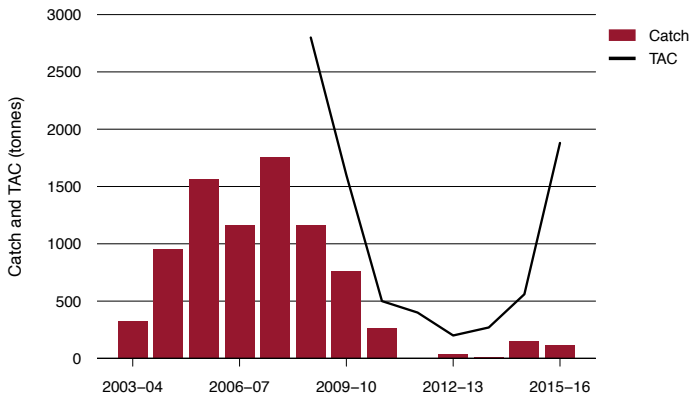


Smoked Eden sardines
Lee Georgeson, ABARES

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 steadily decreased to 893 t in 2014–15—its lowest level since 2001–02. The Commonwealth catch for 2015–16 was 117 t (Figure 7.2). State catches are not available for 2015–16.

FIGURE 7.2 Commonwealth Australian sardine catch and TAC in the SPF, 2003–04 to 2015–16



Note: TAC Total allowable catch.

Stock assessment

The 2014–15 and 2015–16 RBCs and TACs were based on a DEPM survey in 2004. This survey estimated the spawning biomass for Australian sardine off eastern Australia during July 2004 to be 28 809 t (95 per cent confidence interval [CI] 9 161 to 58 673 t) (Ward et al. 2007). The then SPF 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 2014–15 was set using the tier 2 decision rule (using 7.5 per cent of the 2004 biomass estimate), which resulted in an RBC of 3 000 t (AFMA 2014b). After deductions for expected state catches, the Australian Fisheries Management Authority (AFMA) set the 2014–15 Commonwealth TAC at 560 t.

After the 2014–15 fishing season TAC had been set, 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 (95 per cent CI 8 000 to 15 000 t; Ward et al. 2015b).

The 2015–16 RBC and TAC were set using the 2014 harvest strategy control rules, because the results of the 2014 DEPM survey were not available at the time and the revised harvest strategy was not released until April 2015. Consequently, after application of the tier 2 decision rule, the 2015–16 RBC was the same (3 000 t) as in 2014–15. After deductions for expected state catches, the 2015–16 fishing season TAC was set at 1 880 t.

In 2012, SPFRAG noted concerns about the lack of larger, commercial-sized sardines off southern New South Wales, with industry representatives suggesting that this was linked to oceanographic conditions (AFMA 2014b). Available length-frequency and age data showed a decrease in the number of larger fish sampled in 2012–13 and 2013–14. However, there was no evidence of a lack of larger fish in the 2014–15 length-frequency data.

Total (Commonwealth plus state) catch in 2014–15 was 2 per cent of the August to September 2014 biomass estimate (Ward et al. 2015a) and 30 per cent of the RBC. Total Commonwealth catch in 2015–16 was less than 1 per cent of the 2014 biomass estimate and 4 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 and length-frequency data show no trends of concern.

MSE testing has been conducted for Australian sardine (Giannini et al. 2010; Smith et al. 2015). These models suggest that the current 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).

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 2014–15 and 2015–16 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

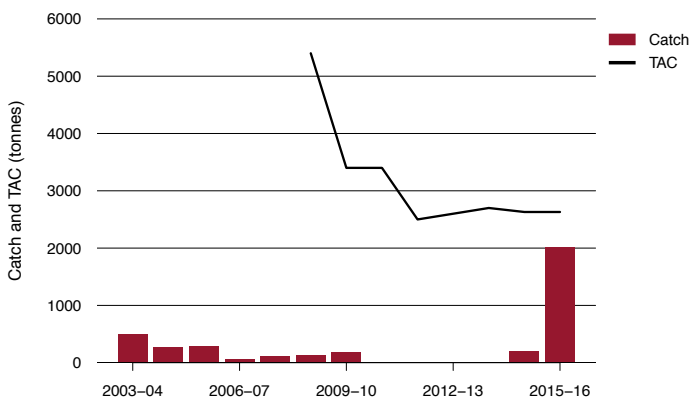
The stock structure of blue mackerel is uncertain. Genetic analysis of samples from southern Queensland, Western Australia and New Zealand indicates population subdivision. Genetic differences were detected between Western Australia and Queensland, and between Western Australia and New Zealand, but not 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

The majority of the blue mackerel (east) catch has historically been taken in state fisheries, with a peak combined state catch of 1 036 t in 2003–04. Total state and Commonwealth catch was 442 t in 2014–15. Commonwealth catch in 2015–16 increased to 2 164 t (state catches are not available for 2015–16) (Figure 7.3).

FIGURE 7.3 Commonwealth eastern blue mackerel catch and TAC, 2003–04 to 2015–16



Note: TAC Total allowable catch.

Stock assessment

The 2014–15 and 2015–16 RBCs and TACs for blue mackerel (east) were based on a DEPM survey in 2004. 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 then 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 2014–15 and 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 2015b, 2014b). After deducting expected state catches, the Commonwealth TAC was set at 2 630 t for 2014–15 and 2015–16. Since setting the 2014–15 and 2015–16 TACs, results from a DEPM survey for blue mackerel (east) in 2014 estimated spawning biomass to be 83 304 t (95 per cent CI 35 100 to 165 000 t) (Ward et al. 2015b).

Total (Commonwealth and state) blue mackerel (east) catch in 2014–15 was less than 1 per cent of the 2014 spawning biomass estimate, 15 per cent of the RBC and 17 per cent of the TAC. The Commonwealth catch in 2015–16 was 3 per cent of the 2014 spawning biomass estimate, 72 per cent of the RBC and 82 per cent of the TAC.

MSE testing has been conducted for blue mackerel (east) (Giannini et al. 2010; Smith et al. 2015). These models suggest that the current 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.

Stock status determination

The peak harvest from the stock was 3 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. Current fishing mortality remains a small proportion of biomass and below the 2014–15 and 2015–16 RBCs. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Blue mackerel, west (*Scomber australasicus*)

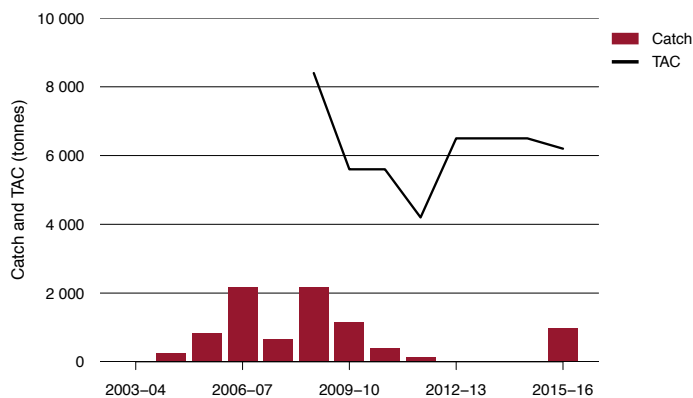
Stock structure

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 increased to 1 007 t in 2015–16 (state catches are not available for 2015–16) (Figure 7.4).

FIGURE 7.4 Commonwealth western blue mackerel catch and TAC, 2003–04 to 2015–16



Note: TAC Total allowable catch.

Stock assessment

The 2014–15 and 2015–16 RBCs and TACs for blue mackerel (west) were based on a DEPM survey conducted in 2005. This survey estimated the spawning biomass to be 56 228 t (95 per cent CI 10 993 to 293 456 t) (Ward & Rogers 2007). 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 2014–15 (AFMA 2014b) and 2015–16 fishing seasons. Since there were no deductions for state catches or discards, the Commonwealth TAC was set at 6 500 t for the 2014–15 season. The Commonwealth TAC was reduced to 6 200 t for the 2015–16 fishing season (AFMA 2015b).

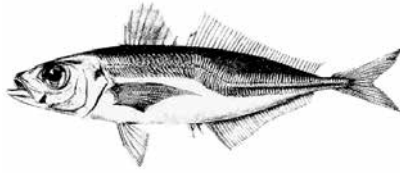
Total landings (Commonwealth and state) peaked in 2008–09 at 2 168 t, which is 4 per cent of the spawning biomass estimated by the 2005 DEPM survey. No catch was reported for 2014–15. Commonwealth catch in 2015–16 (1 007 t) represented 16 per cent of the 2015–16 TAC and 15 per cent of the RBC. Available age and length-frequency data show no trends of concern.

MSE testing has been conducted for blue mackerel (west) (Giannini et al. 2010; Smith et al. 2015). These models suggest that the current 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.

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 biomass. Although this biomass estimate is dated, this level of fishing mortality 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 2014–15 and 2015–16 RBCs. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Jack mackerel, east (*Trachurus declivis*)



Line drawing: FAO

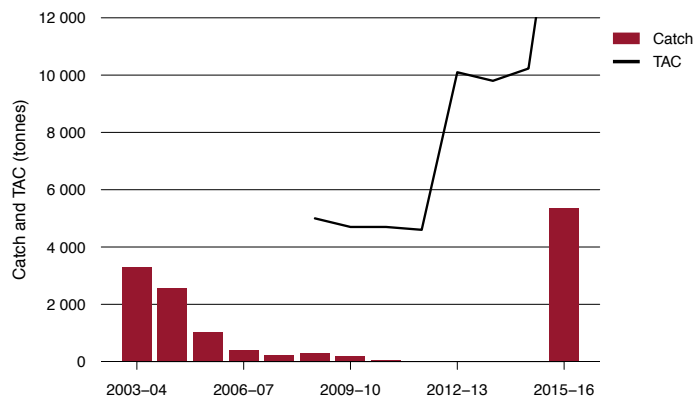
Stock structure

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) between 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 developed 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. Total landings (state and Commonwealth) of jack mackerel (east) in 2014–15 were 317 t. Commonwealth catch increased from 311 t in 2014–15 to 6 585 t in 2015–16 (state catches are not available for 2015–16) (Figure 7.5).

FIGURE 7.5 Commonwealth eastern jack mackerel catch and TAC, 2003–04 to 2015–16



Note: TAC Total allowable catch.

Stock assessment

The most recent DEPM survey for jack mackerel was in January 2014 off eastern Australia (Ward et al. 2015a) and estimated spawning biomass to be 157 805 t (95 per cent CI 59 570 to 358 731 t). Because the 2014 DEPM survey had not been conducted before the 2014–15 fishing season, the RBC for the 2014–15 season was set using the tier 2 decision rule (using 7.5 per cent of the 2002 estimate), resulting in an RBC of 10 600 t (AFMA 2014b). After deduction of expected state catches, the 2014–15 Commonwealth TAC was set at 10 230 t. Using the tier 1 decision rule under the 2014 harvest strategy, the 2014 DEPM survey (Ward et al. 2015a) was used to estimate an RBC of 18 900 t for the 2015–16 fishing season. After deduction of expected state catches, the 2015–16 TAC was set at 18 670 t.

Total catch (Commonwealth and state) in 2014–15 was less than 1 per cent of the 2014 spawning biomass estimate, and 3 per cent of the RBC and TAC. Commonwealth catch in 2015–16 was 6 585 t, representing 4 per cent of the 2014 spawning biomass estimate, and 35 per cent of the RBC and TAC. Total catch peaked at 1 508 t in 2009–10, which is less than 1 per cent of the spawning biomass estimated from the 2014 DEPM survey. The length-frequency and age structures of the eastern stock show no signs of concern (Ward & Grammer 2016).

MSE testing has been conducted for jack mackerel (Giannini et al. 2010; Smith et al. 2015). These models suggest that the current 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.

Stock status determination

The peak harvest during the past 30 years in this fishery was 4 per cent of the 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. 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 2014–15 and 2015–16 RBCs. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Jack mackerel, west (*Trachurus declivis*)

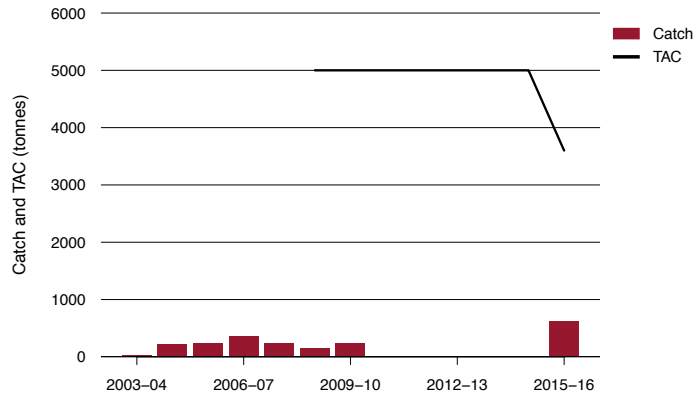
Stock structure

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 631 t in 2015–16 (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 2015–16



Note: TAC Total allowable catch.

Stock assessment

No DEPM survey or estimate of spawning biomass has been conducted for jack mackerel (west). 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. The 1970s estimate was used with the tier 2 decision rule to derive an RBC of 5 000 t for the 2014–15 and 2015–16 fishing seasons (AFMA 2015b, 2014b). The RBC has been set at this level since 2008–09. The 5 000 t RBC is supported by Atlantis-SPF estimates of spawning biomass of 62 000 t (AFMA 2015b). There have been negligible state catches; the Commonwealth TAC was set at 5 000 t for the 2014–15 fishing season and 3 600 t for the 2015–16 fishing season.

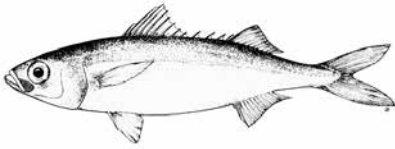
The peak total catch in 2006–07 was less than 1 per cent of the 1970s biomass estimate and 7 per cent of the RBC. There was no reported catch for 2014–15. Catch in 2015–16 increased to 631 t, which is 17 per cent of the RBC and TAC.

MSE testing has been conducted for jack mackerel (Giannini et al. 2010; Smith et al. 2015). These models suggest that the current 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. 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.

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 this biomass estimate is 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 2014–15 and 2015–16 RBCs. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Redbait, east (*Emmelichthys nitidus*)



Line drawing: FAO

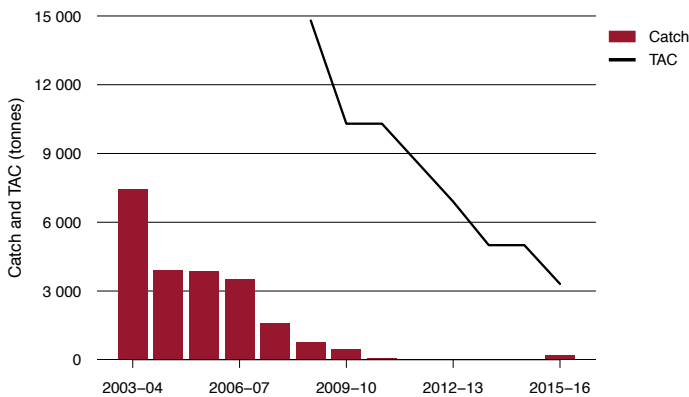
Stock structure

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 until 2015–16, when Commonwealth catch increased to 289 t (Figure 7.7). State catches have been negligible since 2010–11.

FIGURE 7.7 Commonwealth eastern redbait catch and TAC, 2003–04 to 2015–16



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 5 200 t for 2014–15 and 2015–16, using the tier 2 decision rule (using 7.5 per cent of the spawning biomass estimate) (AFMA 2015b, 2014b).

State catch of this stock is negligible; the Commonwealth TAC was set at 5 000 t for the 2014–15 fishing season and 3 310 t for the 2015–16 fishing season. 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 289 t, which is less than 1 per cent of the spawning biomass estimate, 5 per cent of the RBC and 9 per cent of the TAC.

MSE testing has been conducted for redbait (east) (Giannini et al. 2010; Smith et al. 2015). These models suggest that the current 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.

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 this 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 2014–15 and 2015–16 RBCs. The stock is therefore classified as **not subject to overfishing** for both years assessed.

Redbait, west (*Emmelichthys nitidus*)

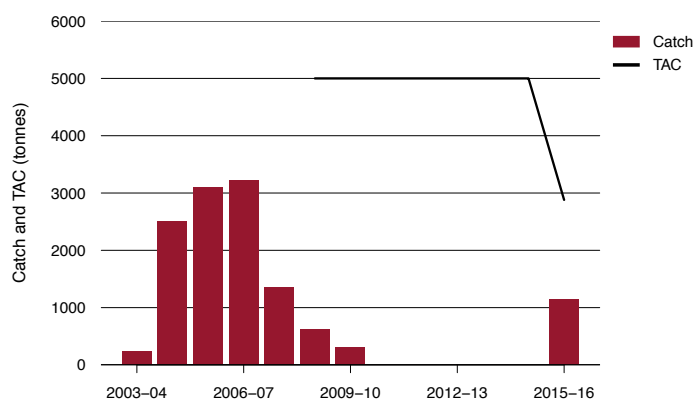
Stock structure

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 from 2009–10 until 2014–15. However, 1 210 t was caught in the Commonwealth fishery in 2015–16 (Figure 7.8) (state catches are not available for 2015–16).

FIGURE 7.8 Commonwealth western redbait catch and TAC, 2003–04 2015–16



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 tier 2 decision rule was used to produce an RBC of 5 000 t for the 2014–15 fishing season and 2 900 t for the 2015–16 fishing season (AFMA 2015b, 2014b). These estimates are supported by Atlantis-SPF estimates of spawning biomass of 62 000 t (AFMA 2015b). However, there is little empirical data on abundance or biomass. There is no state catch; the AFMA Commission set the Commonwealth TAC at 5 000 t for the 2014–15 fishing season and 2 880 t for the 2015–16 fishing season.

MSE testing has been conducted for redbait (west) (Giannini et al. 2010; Smith et al. 2015). These models suggest that the current 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.

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.



Blue mackerel
AFMA

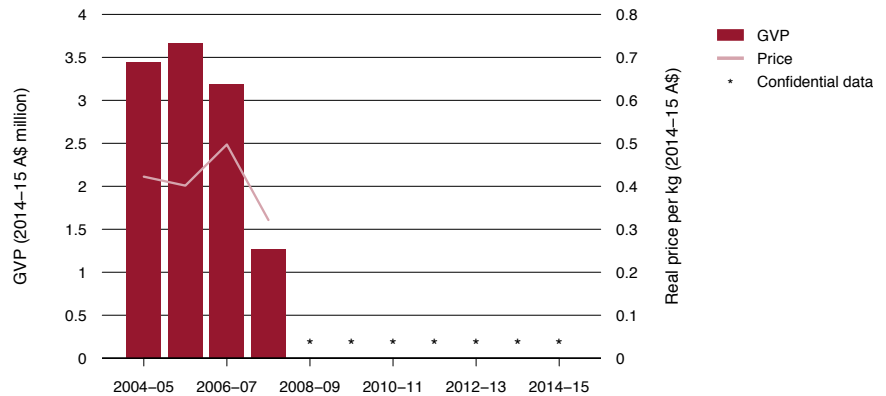
7.3 Economic status

Key economic trends

The gross value of production (GVP) in the SPF was estimated to be \$1.3 million in 2007–08 (2014–15 dollars). This was 65 per cent lower than the estimate for 2005–06 (\$3.6 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 81 per cent between 2013–14 and 2014–15 (from \$0.4 million to \$0.8 million). The number of vessels remained steady at three in 2015–16. A significant increase in the level of catch, from 78 t in 2013–14 to 665 t in 2014–15, and to 12 004 t in 2015–16, suggests that GVP has increased substantially. However, changes in NER are uncertain because of a lack of information about the change in the cost structure of the fishery as a result of introduction of a factory trawler towards the end of the 2014–15 fishing season. The factory trawler operated for the full 2015–16 season, which resulted in a significant increase in catch and GVP.

FIGURE 7.9 Real GVP for the SPF, 2004–05 to 2014–15



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 2014–15 fishing season, 33 statutory fishing rights were held in the fishery; there were 32 in 2015–16. Of the combined TACs for small pelagic species that were available in 2014–15, 98 per cent were uncaught. However, the percentage of TACs uncaught declined substantially in the 2015–16 fishing season, to 69 per cent.

Performance against economic objective

A meaningful biomass target to provide maximum economic yield 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. However, it is clear from the low catches, high levels of latent effort and high levels of unfished TAC that this fishery has not been achieving its maximum economic yield. The operation of a factory trawler during the full 2015–16 season has resulted in significantly lower quota latency, indicating that economic performance of the fishery may have improved. Despite lower latency, changes in NER are uncertain because of the lack of information about changes in cost structures of the industry as a result of the introduction of the factory trawler in the latter part of the 2014–15 financial year.

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.

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. No interactions with protected species were reported in the fishery in the 2014 calendar year. A total of 51 interactions with protected species were reported in the SPF during the 2015 calendar year: 3 shy albatross (*Thalassarche cauta*; dead), 1 albatross (unclassified) (injured), 9 common dolphins (*Delphinus delphis*; dead), 3 Australian fur seals (*Arctocephalus pusillus doriferus*; dead), 12 seals (unclassified) (dead) and 23 shortfin mako (*Isurus oxyrinchus*; 10 released alive, 13 dead).

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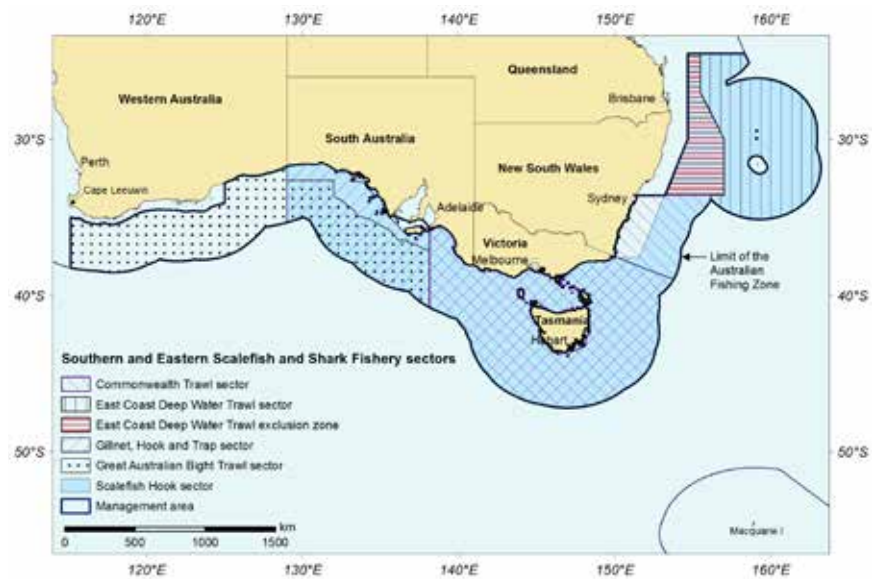
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Chapter 8

Southern and Eastern Scalefish and Shark Fishery

L Georgeson, R Green 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 2014a).

The SESSF remained the largest Commonwealth fishery in terms of volume produced in the 2015–16 fishing season. In 2014–15, the SESSF was the second-largest Commonwealth fishery in terms of production value, accounting for 20 per cent of the gross value of production (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 daemeli*), trip limits for certain species (for example, snapper—*Chrysophrys auratus*), codes of conduct, 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 2015–16, landings in the Commonwealth Trawl Sector (CTS) and the Scalefish Hook Sector (SHS) were 9 025 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 GVP was \$68 million in the 2014–15 financial year, a decrease from \$72.2 million in 2013–14.

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 the 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 for the remaining participants in the fishery (Vieira et al. 2010).

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 Gillnet, Hook and Trap Sector (GHTS).

The status of the stocks taken in these sectors is presented in Chapters 9, 10, 11 and 12, respectively. The GHTS includes the 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 harvest strategy framework (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 all species under quota, and is described in AFMA (2014b). The HSF uses three tiers (1, 3 and 4; tier 2 has been phased out), which have been developed to accommodate different levels of data quality or knowledge about stocks (AFMA 2014b). Tier 1 assessments are quantitative, model-based stock assessments that are conducted for stocks with the highest quality of data or information. The tier 3 assessment methodology primarily involves catch-curve analyses of age (or size) composition data, and information on size at maturity and selectivity to estimate fishing mortality rates. Tier 4 involves an assessment of trends in standardised catch rates, and is undertaken for stocks for which only catch-and-effort data are available.

The target and limit reference points for each tier reflect those 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 2014b). 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 level of precaution applied in RBCs is intended to increase from tier 1 to tier 4, reflecting the increasing level of uncertainty in assessments. Therefore, 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. The SESSF 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 or five years. 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. In 2014, the HSF was amended to remove the catch-per-unit-effort multiplier rule and to provide further guidance on multiyear TACs, the deduction of discards from TACs and the application of discount factors.

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 typically allocates incidental catch allowances to cover catches 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 or quantitative stock assessment models to estimate the quantities of species taken as bycatch when fishing for other species. These data feed into advice on the appropriate setting of incidental catch allowances. 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), shifts in the ecological relationships between stocks and their environment ('regime shifts'), or changes in other environmental variables.

The performance of the SESSF HSF against the economic objective of maximum economic yield (MEY) has improved. Indications are that NER increased in the CTS and the GHTS in the years immediately after implementation of the SESSF HSF and the Securing our Fishing Future structural adjustment package (George & New 2013; Ward et al. 2013).

Most quota species caught in the CTS and the GHTS are currently managed towards a B_{MEY} (biomass at MEY) target, although these targets are not 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 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) have 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 (*Callorhynchus 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. Recent research (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 fishery may need updating to better reflect changes to cost and profit input parameters.

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 2015:

- 32 stocks (86 per cent) were classified as not subject to overfishing
- 0 stocks (0 per cent) were classified as subject to overfishing
- 5 stocks (14 per cent) were classified as uncertain with regard to the level of fishing mortality.

For biomass status:

- 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 (Figures 8.2 and 8.3).

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. However, 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 2015 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 2015 are blue warehou, eastern gemfish, gulper sharks, redfish and school shark.

FIGURE 8.2 Fishing mortality status for all stocks in the SESSF, 2004 to 2015

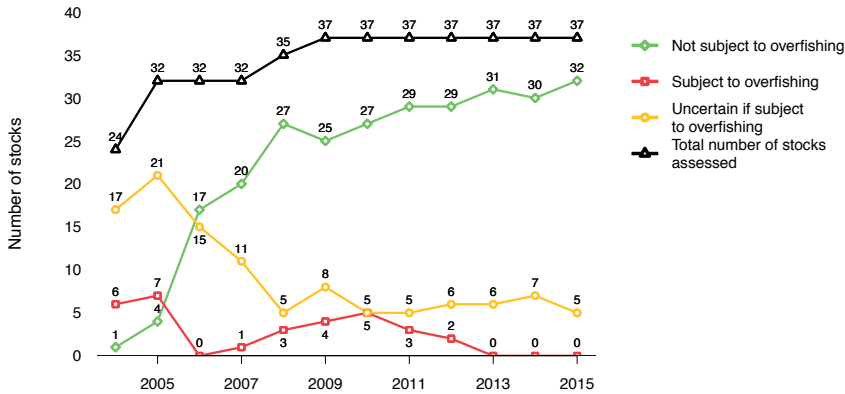
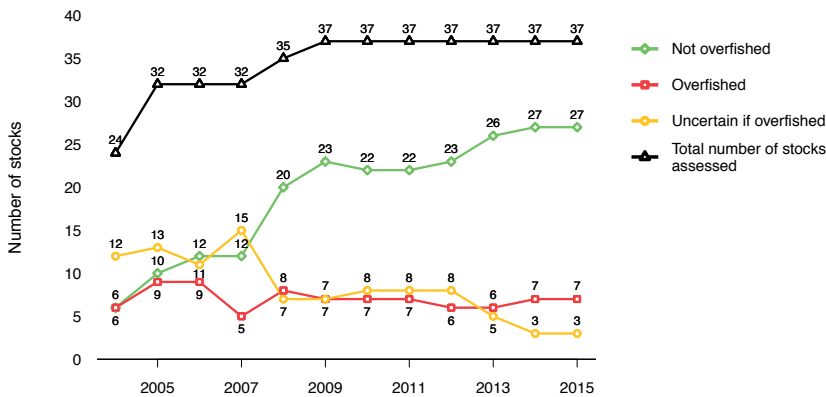


FIGURE 8.3 Biomass status for all stocks in the SESSF, 2004 to 2015



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, $0.48B_0$). When this information is combined with indicators of profitability and efficiency, the economic status of SESSF sectors can be assessed in terms of whether they are moving towards or away from MEY.

Scalefish catches in the CTS and the SHS accounted for 55 per cent of SESSF GVP in 2014–15 (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 programme; the SHS is surveyed as part of the GHTS. The NER for the CTS followed a positive trend from 2004–05 to a peak in 2010–11 of \$7.3 million. NER declined in 2011–12 and 2012–13, but remained positive. The estimated biomass of three of the sector's most valuable species (blue grenadier—*Macruronus novaezelandiae*, silver warehou—*Seriola punctata*, and tiger flathead—*Neoplatycephalus richardsoni*) remained above or close to their 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 catches approached TACs for other species. This may require some adjustment to proxy target reference points or cost-effective estimates of B_{MEY} for some of the more valuable species in the sector. Based on preliminary estimates, NER for the sector declined in 2013–14. This result is 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.

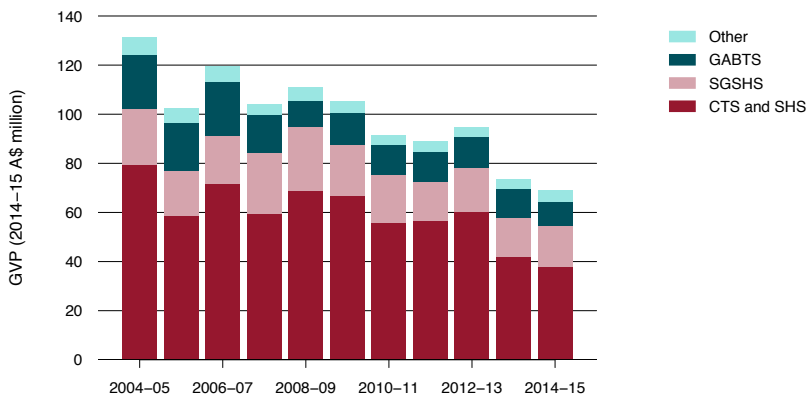
Historically, orange roughy has contributed substantially to the CTS GVP. The rebuilding of orange roughy stocks over the longer term should improve the sector's economic status, although sustainable harvests of this species are likely to be lower than peak historical levels. The recommencement of fishing for orange roughy in the eastern zone will boost GVP in 2015–16. Likewise, the blue grenadier catch was substantially lower than the allowed TAC in 2013–14 and 2014–15, 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 75 per cent of GVP in the GHTS in 2014–15. For the decade preceding 2009–10, estimates of NER in the GHTS had been positive. Estimates became negative (–\$0.5 million) in 2009–10 and have remained negative since then. This is despite biomass levels of gummy shark (*Mustelus antarcticus*), the sector's main target species, being close to or above the stock's target reference point (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 their impacts on gummy shark catches. A key challenge for the sector is rebuilding of the school shark stock; this could lead to increases in NER in the future but is associated with adjustment costs to avoid the species in the rebuilding phase.

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 2013–14 to be above the B_{MEY} target (Klaer 2012, 2011, 2010), potentially allowing increased profits from the species as 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 SSSF by sector, 2004–05 to 2014–15



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 SSSF.

Overall, the current economic status of the SSSF is mixed. The negative change in economic performance in the GHTS has occurred at the same time as positive NER in the CTS, while the GABTS now pursues 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 significant implications for a fishery’s economic performance, and such factors should be taken into account when attempting to meet bycatch management objectives. The SSSF HSF will continue to make an important contribution to the fishery’s economic performance 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, 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) fishery and the GABTS, and Danish-seining account for the greatest volume of bycatch in the Commonwealth fisheries examined. This largely reflects the high level of fishing activity in these sectors and fisheries. Bycatch and discards largely comprise small fish species with little or no commercial value, but also include crustaceans, sharks, molluscs and, more rarely, marine mammals, reptiles and seabirds.

Data collected by the Integrated Scientific Monitoring Program (ISMP) over 20 years have shown a reduction in the volume of trawl discards since the mid 2000s. 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 fishery, and 40–60 per cent in the GABTS (Tuck et al. 2013). Commercial species are discarded for various reasons, but the majority of 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 fishery 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 fishery 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 fishery 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 GHFS, 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). 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 and almost 80 per cent for 4 inch mesh (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 benthos 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 benthos 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, Harrison'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 mitigation measures 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 protected species interactions are also difficult to interpret with confidence because the ISMP was originally designed only to provide estimates of the retained and discarded proportions of fish catch in the SESSF. A review of the ISMP in 2009 sought to facilitate better estimates of 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. 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 2015. 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 the 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.

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).



Sorting the catch
AFMA

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 will remain in place until 18 June 2017.

Increased onboard observer coverage or camera monitoring is important for obtaining reliable data on interaction rates. 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.

Comparisons between logbook and observer data suggest that there is still some level of under-reporting of pinniped interactions. In 2015, 134 pinniped interactions were reported in CTS and GHTS logbooks: 1 with an Antarctic fur seal, 2 with Australian sea lions, 3 with New Zealand fur seals, 88 with Australian fur seals and 40 with seals of unknown species. This is a decrease from the 167 interactions reported in 2014 and the 259 interactions reported in 2013. Of the 134 reported pinniped interactions, the Antarctic fur seal, the 2 Australian sea lions, 2 of the 3 New Zealand fur seals, 74 of the 88 Australian fur seals and 25 of the 40 unspecified seals were reported to be dead.

In the CTS, 87 per cent of all pinniped interactions in 2015 were reported from bottom-trawling operations, and the remainder of interactions (14) were reported from Danish-seine or midwater trawl operations. Of the 30 pinniped interactions reported in logbooks or by observers in the GHTS in 2014, 27 (90 per cent) were reported from gillnet operations and 3 from longline 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 km² 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 2015, interactions were reported with 29 dolphins in the GHTS fishery, all of which were reported to be dead. This is an increase from the 19 interactions reported in 2014 and the 10 interactions reported in 2013. The increase in 2015 is likely to reflect the introduction of electronic monitoring in the GHTS. No dolphin interactions were reported in the CTS in 2015.

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 programme to improve seabird avoidance measures, and undertook a trial of 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.

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 2015, 49 seabird interactions were reported in logbooks or by observers in the SESSF: 45 in the GHTS fishery and 4 in the CTS. This is an increase from 41 seabird interactions reported in 2014 but significantly lower than the 90 seabird interactions reported in 2013. Of the 49 interactions, 26 were reported as unclassified petrels, prions and shearwaters, 22 of which were reported to be dead; 9 were with white-chinned petrels (*Procellaria aequinoctialis*), 5 of which were reported to be dead; 6 were with shy albatross (*Thalassarche cauta*), 4 of which were reported to be dead; 4 were with unclassified albatrosses, 2 of which were reported to be dead; 2 were with Wilson’s storm petrels (*Oceanites oceanicus*), both of which were reported to be alive; and 2 were with cormorants, both of which were reported to be dead.

Sharks

In 2015, 166 interactions with protected sharks were reported in logbooks: 153 in the GHTS (143 of which were dead) and 13 in the CTS (all of which were dead). The most prevalent shark was shortfin mako, with 90 interactions reported. Of these, all were reported to be dead. The second most prevalent was longfin mako (*Isurus paucus*), with 57 interactions reported. Of these, all were reported to be dead. Fifteen white sharks were reported—all in the GHTS; 10 were released alive, and 5 were reported to be dead. Three porbeagle sharks were reported, all of which were dead, and one basking shark (*Cetorhinus maximus*) was reported in the CTS, 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 Harrison'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 Harrison'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 2015.

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Chapter 9

Commonwealth Trawl and Scalefish Hook sectors

L Georgeson, S Nicol, A Moore and R Green

FIGURE 9.1 Relative fishing intensity (a) in the Commonwealth Trawl Sector and (b) by Danish-seine operations, 2015–16 fishing season

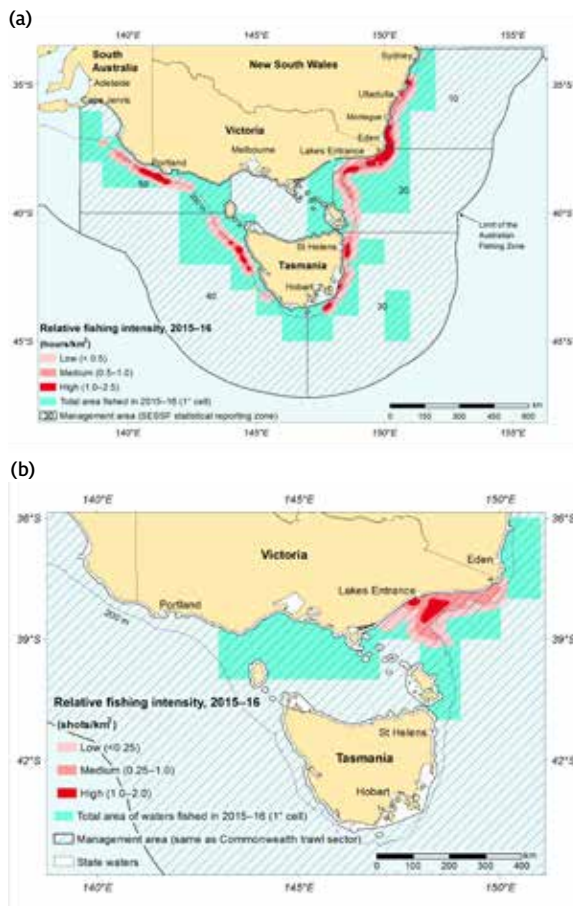


FIGURE 9.2 Relative fishing intensity in the Scalefish Hook Sector, 2015–16 fishing season



TABLE 9.1 Status of the Commonwealth Trawl and Scalefish Hook sectors

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Blue-eye trevalla (<i>Hyperoglyphe antarctica</i>)	Yellow	Green	Green	Green	CPUE is between the limit and target reference points. Fishing mortality is below the most recent RBC.
Blue grenadier (<i>Macruronus novaezelandiae</i>)	Green	Green	Green	Green	Estimated spawning biomass was above target in 2012. Total removals have remained below the long-term RBC.
Blue warehou (<i>Seriolella brama</i>)	Yellow	Red	Yellow	Red	Total removals are below the incidental catch allowance. There is no evidence that the stock is rebuilding.
Deepwater sharks, eastern zone (multiple species)	Green	Yellow	Green	Yellow	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)	Green	Yellow	Green	Yellow	Substantial areas where historical catch was taken are closed. Multispecies nature of stock makes CPUE potentially unreliable as the index of abundance.
Eastern school whiting (<i>Sillago flindersi</i>)	Green	Green	Green	Green	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 (<i>Platycephalus richardsoni</i> and 4 other species)	Green	Green	Green	Green	Recent estimates of biomass are above the target reference point, and current catches are below the RBC.
Gemfish, eastern zone (<i>Rexea solandri</i>)	Yellow	Red	Yellow	Red	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	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Gemfish, western zone (<i>Rexea solandri</i>)					Estimated spawning biomass is above the target reference point. Catches have been stable in recent years and well below the RBC.
Gulper sharks (<i>Centrophorus harrissoni</i> , <i>C. moluccensis</i> , <i>C. zeehaani</i>)					Populations are likely to be highly depleted, and fishing mortality is uncertain, despite low landed catch and protection from closures.
Jackass morwong (<i>Nemadactylus macropterus</i>)					Estimates of spawning biomass are above the limit reference point. Total removals have declined and remain below the RBC.
John dory (<i>Zeus faber</i>)					Catches and fishing mortality rates are low. Assessment indicates that biomass is likely to be above the limit reference point.
Mirror dory (<i>Zenopsis nebulosa</i>)					Recent CPUE is above the limit reference point. It is likely that total mortality is below RBCs for eastern and western stocks.
Ocean jacket (<i>Nelusetta ayraud</i>)					History of stable CPUE, increasing in recent years.
Ocean perch (<i>Helicolenus barathri</i> , <i>H. percoides</i>)					Recent CPUE (including discards) is above target for both species and has remained near target for offshore ocean perch for the past decade.
Orange roughy, Cascade Plateau (<i>Hoplostethus atlanticus</i>)					Most recent estimate of spawning biomass (2008) is above the target reference point. Catches since the last estimate have been well below the RBC.
Orange roughy, eastern zone (<i>Hoplostethus atlanticus</i>)					Most recent stock assessment estimated biomass to be between the limit and target reference points. Fishing mortality constrained to within RBC and TAC.

continued ...

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

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Orange roughy, southern zone (<i>Hoplostethus atlanticus</i>)					Negligible catches. Closure of most areas deeper than 700 m. No updated stock assessment.
Orange roughy, western zone (<i>Hoplostethus atlanticus</i>)					Negligible catches. Closure of most areas deeper than 700 m. No updated stock assessment.
Smooth oreodory, Cascade Plateau (<i>Pseudocyttus maculatus</i>)					Low recent catches. CPUE is above the target reference point.
Smooth oreodory, non-Cascade Plateau (<i>Pseudocyttus maculatus</i>)					Closure of most areas deeper than 700 m. Recent CPUE is above the target reference point. New assessment shows catch is below levels that would be expected to result in depletion.
Other oreodories (<i>Alloctytus niger</i> , <i>A. verrucosus</i> , <i>Neocyttus rhomboidalis</i> , <i>Neocyttus</i> 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 (<i>Genypterus blacodes</i>)					Total mortality for both stocks has been constrained to within appropriate thresholds. Western stock is above target. Biomass of eastern stock is above the limit reference point but needs further rebuilding towards the target.
Redfish (<i>Centroberyx affinis</i>)					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 (<i>Mora moro</i>)					Standardised CPUE has remained stable and well 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	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Royal red prawn (<i>Haliporoides sibogae</i>)					Recent average CPUE is above the limit reference point, and catches have been below the RBC in recent years.
Silver trevally (<i>Pseudocaranx georgianus</i>)					Recent average CPUE is close to the target, and recent catches have been well below the RBC.
Silver warehou (<i>Seriolella punctata</i>)					Spawning biomass is close to the target reference point. Total removals are well below the RBC.
Economic status	NER for the CTS were \$4.2 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.				

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

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



Trawl vessel
Lee Georgeson, ABARES

9.1 Description of the fishery

Area fished

The Commonwealth Trawl Sector (CTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF) extends from east of Sydney southwards through Bass Strait and around Tasmania to Cape Jervis in South Australia, where it abuts the Great Australian Bight Trawl Sector (GABTS; Chapter 11; Figure 9.1). To the north, the CTS adjoins the East Coast Deepwater Trawl Sector (Chapter 10) at 24°30'S off Queensland. From the same boundary, the Scalefish Hook Sector (SHS) extends around south-eastern Australia to the border of South Australia and Western Australia (Figure 9.2). The SHS is managed as part of the Gillnet, Hook and Trap Sector (GHTS) of the SESSF, but is reported in this chapter because it shares many target species with the CTS. The CTS and the SHS are major domestic sources of fresh fish for the Sydney and Melbourne markets. In contrast to several Commonwealth fisheries, CTS and SHS landings are rarely exported to overseas markets, with the exception of orange roughy (*Hoplostethus atlanticus*), some of which was exported to Asia after fishing recommenced in the eastern zone in 2015–16.

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. Eighteen stocks were on multiyear TACs in the SESSF in 2015–16.

The move towards the use of multiyear TACs for a number of tier 4 stocks (see Chapter 8 for an explanation of the SESSF tiers) means that a tier 4 assessment, which would be required to estimate a new recommended biological catch (RBC), was not required for some stocks for the 2015–16 fishing season. The updating of tier 4 assessments with new data can result in minor changes to annual values in the standardised catch-per-unit-effort (CPUE) series because the method scales the CPUE series relative to its reference period. This may change the limit and target reference points, and recent CPUE averages. For this reason, only CPUE series that were used for tier 4 assessments are included in this chapter, except where any patterns in other standardised CPUE, which may include updated data, are of particular relevance to assigning a stock status determination.

A total of 20 983 t of quota was allocated in the CTS and the SHS across all quota species or species groups for the 2015–16 fishing season (1 May 2015 to 30 April 2016). This was an increase of 2 091 t from 2014–15 (Table 9.2), following an 804 t increase from 2013–14. Most of the 2015–16 quota (20 570 t) was for target species. A further 413 t was allocated as ‘incidental catch allowances’ to cover incidental catches of eastern gemfish (*Rexea solandri*), blue warehou (*Seriolella brama*), orange roughy (southern and western zones¹) and redfish (*Centroberyx affinis*). Most of the overall quota increase resulted from increased TACs for blue grenadier (*Macruronus novaezelandiae*) (+1 996 t), and smaller increases for orange roughy (eastern zone; +381 t), ribaldo (*Mora moro*) (+103 t), silver warehou (*Seriolella punctata*) (+88 t), royal red prawn (*Haliporoides sibogae*) (+42 t) and jackass morwong (*Nemadactylus macropterus*) (+30 t). These increases were partly offset by TAC decreases for mirror dory (*Zenopsis nebulosa*; -371 t), and smaller decreases for flathead (*Platycephalus richardsoni* and 4 other species), gemfish (western zone), pink ling (*Genypterus blacodes*), school whiting (*Sillago flindersi*), john dory (*Zeus faber*), redfish, ocean perch (*Helicolenus barathri*, *H. percoides*), other oreodories (*Allocyttus niger*, *Neocyttus rhomboidalis*, *A. verrucosus*, *Neocyttus* spp.) and silver trevally (*Pseudocaranx georgianus*).

1 The orange roughy southern zone TAC contains both ‘incidental’ and ‘target’ quota as a result of the apportioning of quota resulting from the orange roughy eastern zone stock assessment, which includes orange roughy from Pedra Branca in the southern zone as part of the assessed eastern stock.

Fishing effort

In 2015–16, trawlers reported 54 078 hours of fishing effort—a slight decrease from the 55 172 hours in 2014–15 (Figure 9.3). The number of active trawlers increased from 35 in 2014–15 to 38 in 2015–16 (Table 9.2). Danish-seine effort increased from 9 912 shots in 2014–15 to 10 660 shots in 2015–16, and the number of vessels increased from 15 in 2014–15 to 16 in 2015–16. Fishing effort in the SHS increased from 2.830 million hooks in 2014–15 to 3.097 million hooks in 2015–16 (Figure 9.4).

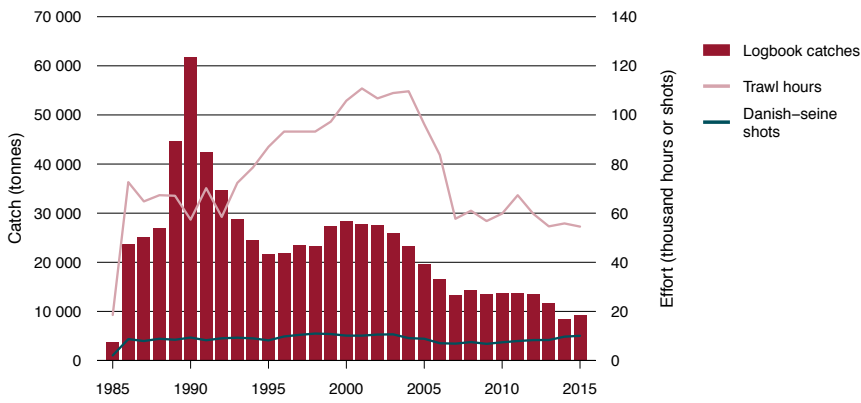
Catch

The total landings of all species managed under TACs from the CTS in 2015–16 were 8 057 t. Flathead, blue grenadier, pink ling, eastern school whiting and orange roughy (eastern zone) accounted for approximately 79 per cent of the catch. Flathead catches increased from 2 317 t in 2013–14 to 2 829 t in 2014–15 and 2 908 t in 2015–16, with 2015–16 catch representing about 102 per cent of the quota (within the 10 per cent overcatch provision). Catches of blue grenadier decreased significantly from 3 887 t in 2013–14 to 1 375 t in 2014–15 and 1 745 t in 2015–16, representing around 20 per cent of the quota in the two most recent seasons. The large reduction in blue grenadier catch can be largely attributed to one factory vessel not fishing the winter spawning aggregation in the 2014–15 and 2015–16 fishing seasons. The total scalefish landings from the GHTS (of which the SHS comprises the primary component reported in this chapter) in the 2015–16 fishing season were estimated to be 656 t, similar to the 639 t landed in the 2014–15 fishing season. Total catch for both sectors reported in this chapter (quota stocks and ocean jackets—non-quota stock) was 9 025 t in 2015–16, which was an increase from the 8 264 t landed in 2014–15. Approximately 42 per cent of quota was caught across the two sectors in both 2014–15 and 2015–16.

In the 2014–15 financial year, scalefish catches in the CTS accounted for 49 per cent of the gross value of production (GVP) in the SESSF. Scalefish GVP in the CTS decreased 9 per cent, from \$36 million in 2013–14 to \$33 million in 2014–15. The GVP in the SHS decreased by 20 per cent, from \$5.7 million in 2013–14 to \$4.6 million in 2014–15. Overall, the total scalefish GVP in 2014–15 for both sectors was \$37.7 million (Table 9.2).

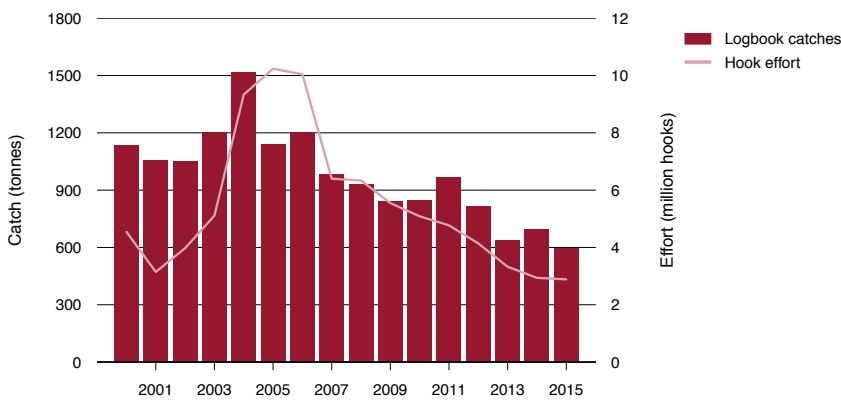
Flathead was the dominant species in GVP terms in 2014–15, valued at \$15.4 million (Table 9.2); this was an increase of 13 per cent from \$13.7 million in 2013–14. Blue grenadier accounted for \$1.9 million, which was 72 per cent lower than in 2013–14 (\$6.6 million) and 89 per cent lower than in 2012–13 (\$15.9 million). This was the result of lower prices and lower catch. The GVP of pink ling increased slightly (4 per cent), from \$4.3 million in 2013–14 to \$4.6 million in 2014–15, while the GVP of silver warehou decreased 44 per cent to \$0.5 million. The GVP of orange roughy increased 94 per cent to \$1.5 million—its highest level in real terms since 2009–10 (\$3.4 million).

FIGURE 9.3 Total catch and fishing effort for the CTS, 1985 to 2015



Source: Australian Fisheries Management Authority

FIGURE 9.4 Total catch and fishing effort for the SHS, 2000 to 2015



Source: Australian Fisheries Management Authority

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

Fishery statistics b	2014–15 fishing season			2015–16 fishing season	
	TAC (t) c	Catch (t) (CTS, GHTS)	Real value (2013–14)	TAC (t) c	Catch (t) (CTS, GHTS)
Blue-eye trevalla	335	270 (38, 232)	\$2.4 million	335	298 (20, 278)
Blue grenadier	6 800	1 384 (1 375, 9)	\$1.9 million	8 796	1 754 (1 745, 9)
Blue warehou	118 d	16 (16, <1)	<\$0.1 million	118 d	2 (2, <1)
Deepwater sharks, eastern zone	47	25 (22, 3)	na	47	22 (21, 1)
Deepwater sharks, western zone	215	79 (76, 3)	na	215	68 (67, 1)
Eastern school whiting	809	795 (792, 3)	\$2.5 million	747	733 (733, 0)
Flathead (several species)	2 878	2 829 (2 829, <1)	\$15.4 million	2 860	2 908 (2 908, <1)
Gemfish, eastern zone	100 d	37 (31, 6)	<\$0.1 million	100 d	30 (27, 3)
Gemfish, western zone e	199	72 (65, 7)	\$0.1 million	183	81 (76, 5)
Jackass morwong	568	123 (122, 1)	\$0.4 million	598	136 (135, 1)
John dory	221	66 (65, <1)	\$0.6 million	169	86 (86, <1)
Mirror dory	808	226 (226, 0)	\$0.8 million	437	252 (252, 0)
Ocean perch	195	188 (172, 16)	\$0.5 million	166	169 (154, 15)
Orange roughy, Cascade Plateau	500	<1	\$0 million	500	2
Orange roughy, eastern zone	25	6 (6, 0)	\$1.1 million	465	436 (436, 0)
Orange roughy, southern zone	35	17 (17, 0)	\$0.2 million	66	57 (57, 0)
Orange roughy, western zone	60	29 (29, 0)	\$0.2 million	60	22 (22, 0)
Smooth oreodory, Cascade Plateau	150	0	na	150	1
Smooth oreodory, non-Cascade Plateau	23	<1 (<1, 0)	<\$0.1 million	23	21 (21, 0)
Other oreodories	132	116 (116, <1)	<\$0.1 million	128	141 (140, <1)
Pink ling	996 (349 east, 647 west)	CDR: 967 (622, 345) Logbook: 873 (568 [300 east, 268 west], 305 [72 east, 233 west]) f	\$4.6 million	980 (337 east, 643 west)	CDR: 825 (519, 306) Logbook: 699 (449 [207 east, 242 west], 250 [73 east, 177 west]) f
Redfish	138	78 (78, 0)	\$0.2 million	100 d	49 (49, <1)
Ribaldo	252	134 (71, 63)	\$0.2 million	355	90 (54, 36)
Royal red prawn	344	146 (146, 0)	\$0.5 million	386	183 (183, 0)
Silver trevally	615	93 (93, 0)	\$0.4 million	602	72 (72, <1)
Silver warehou	2 329	370 (370, 0)	\$0.5 million	2 417	276 (275, 1)

continued ...

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

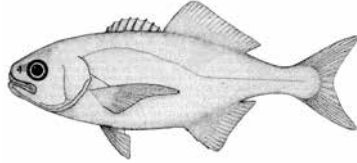
Fishery statistics ^b	2014–15 fishing season			2015–16 fishing season	
Non-quota species					
Gulper sharks	na	<1 (<1, 0)	na	na	<1 (<1, 0)
Ocean jacket ^g	na	307	\$0.6 million	na	312
Total	18 892	8 264	\$37.7 million	20 983	9 026
Fishery statistics					
Effort					
Otter trawl	55 172 trawl hours			54 078 trawl hours	
Danish-seine	9 912 shots			10 660 shots	
Scalefish hook	2.830 million hooks			3.097 million hooks	
Boat statutory fishing rights	57 trawl 37 scalefish hook			57 trawl 37 scalefish hook	
Active vessels	35 trawl; 15 Danish-seine; 15 scalefish hook			38 trawl; 16 Danish-seine; 16 scalefish hook	
<i>Observer coverage</i>					
CTS	Trawl: 130 fishing-days Danish-seine: 22 fishing-days			Trawl: 144 fishing-days Danish-seine: 20 fishing-days	
Auto-longline (scalefish)	78 fishing-days			12 sea-days	
Fishing methods	Trawl, Danish-seine, hook (dropline, demersal longline), trap (minor)				
Primary landing ports	Eden, Sydney, Ulladulla (New South Wales); Lakes Entrance, Portland (Victoria); Hobart (Tasmania)				
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 2015–16 financial year at the 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 (e.g. flathead) may slightly exceed agreed TACs. ^d Incidental catch allowance. ^e Not including the Great Australian Bight Trawl Sector. ^f CDR and logbook data are provided because the east–west split is unavailable for CDR data. There appears to have been significant under-reporting of pink ling catches in logbooks in 2014–15 and 2015–16. ^g Catch figures are combined for the trawl and non-trawl sectors.

Notes: CDR Catch disposal records. 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

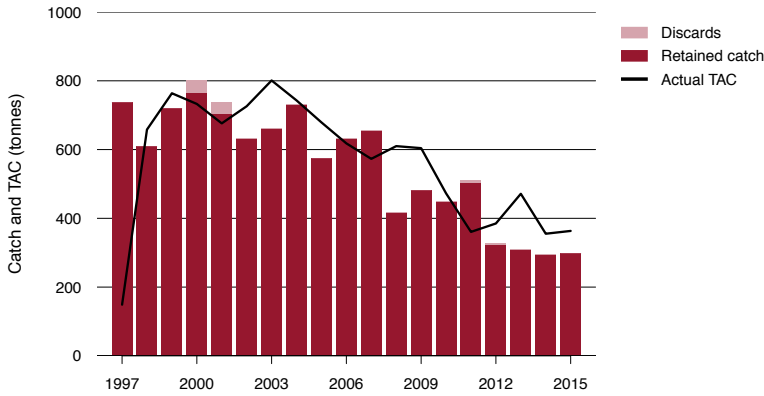
A single biological stock of blue-eye trevalla (incorporating the continental shelf, seamounts and the Cascade Plateau) is assumed for the Australian Exclusive Economic Zone (EEZ). For management purposes, it and the New Zealand stock(s) are considered to be separate.

Genetic studies have found no evidence of population structuring between different regions in the SESSF (Robinson et al. 2008). However, preliminary stock structure studies have suggested some structuring, principally between the East Coast Deepwater Trawl Sector and the New Zealand region (which appear to form one group), and the rest of Australia's SESSF (Hindell et al. 2006). CSIRO is attempting to use otolith microchemistry and ocean circulation models to better determine the subpopulation structure of blue-eye trevalla, especially between the SESSF, the East Coast Deepwater zone and the area outside Australia's EEZ. The results are expected to be published in 2016.

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 764 t in 2000 (Figure 9.5). Commonwealth landed catch in the 2015–16 fishing season was 298 t, with 93 per cent of this taken in the SHS.

FIGURE 9.5 Blue-eye trevalla annual catches (CTS, SHS and states) and fishing season TACs, 1997 to 2015



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

Stock assessment

Blue-eye trevalla is assessed as a tier 4 stock under the SESSF HSF, using catch-and-effort data for the auto-longline and dropline fisheries. The Slope Resource Assessment Group (SlopeRAG) noted concerns that catch and CPUE of blue-eye trevalla have been negatively affected by the presence of killer whales (*Orcinus orca*) near fishing operations, and exclusions from historical fishing grounds following closures implemented to rebuild gulper shark stocks (SlopeRAG 2014a). Industry representatives believe that these two factors have directly reduced CPUE, or have resulted in shifts in fishing effort that have reduced catch and CPUE.

The 2013 tier 4 assessment used separate indices for blue-eye trevalla east and west of Bass Strait because of differences in the trends in each CPUE series (Haddon 2013a). The assessment estimated that the four-year average standardised CPUE was slightly below the target in the west, but near the limit in the east. The combined RBC for these two areas was estimated at 269 t for the 2014–15 and 2015–16 fishing seasons. SlopeRAG considered these estimates to be conservative because the potential effects of orca depredation and closures were not accounted for in the CPUE standardisation and subsequent tier 4 analysis. Following industry submissions aimed at minimising the economic impact of reduced quota, AFMA agreed to implement a phased TAC reduction over three years: the TAC was set at 335 t for the 2014–15 season, 282 t for 2015–16 and 229 t for 2016–17, after deduction of state catches and discards.

In January 2014, the South East Management Advisory Committee (SEMAC) asked SlopeRAG to provide advice on any recommended revision to this TAC reduction schedule (SEMAC 2014). In October 2014, SlopeRAG discussed additional work that reviewed data used to establish the early part of the blue-eye trevalla CPUE series. The review indicated that the dropline catch rates that used a catch-per-day instead of a catch-per-hook metric had inflated the early part of the CPUE series (SlopeRAG 2014a). Based on the updated analysis, SlopeRAG recommended that, because of the conservative RBC and the additional work that was needed to consider the effect of closures and orca depredation on CPUE, the proposed TAC step-down be delayed and the 2014–15 TAC be maintained for the 2015–16 season at 335 t (SlopeRAG 2014a).

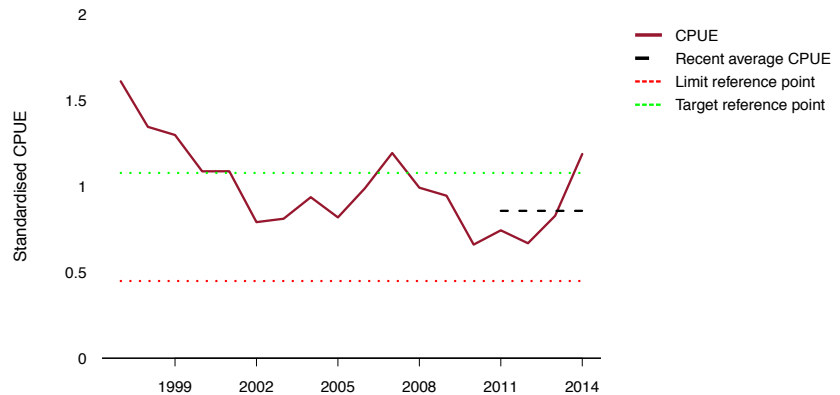
The most recent tier 4 assessment in 2015 (Haddon 2015a) used the revised catch-per-hook series in the CPUE analyses. Because the auto-longline CPUE series does not include a period when the stock was thought to be near-virgin biomass, it was necessary to use combined dropline and auto-longline series that were normalised to their averages for the overlap period (2002 to 2006).

A sensitivity that included orca depredation was undertaken. This indicated that depredation, when considered as a 'discard', would act to bias actual fishing mortality, and result in a higher CPUE and a higher RBC. The estimate of orca depredation was based on data from a single vessel, and extrapolating this to the fleet would add a large degree of uncertainty (Haddon 2015a); consequently, this scenario was not accepted by SlopeRAG (SlopeRAG 2015a).

The accepted assessment estimated four-year average CPUE for the combined east and west components to be between the limit and the target (Figure 9.6), and produced an RBC of 444 t for the 2016–17 fishing season. SlopeRAG recommended that the tier 4 discount factor not be applied because of the protection afforded by closures and because this RBC was more conservative than that derived from the assessment that included orca depredation as a sensitivity (SlopeRAG 2015a).

The 2015–16 landed catch was 298 t, which was approximately 89 per cent of the TAC of 335 t (Figure 9.5).

FIGURE 9.6 Standardised auto-longline and dropline CPUE index for blue-eye trevalla to the east and west of Tasmania, 1997 to 2014



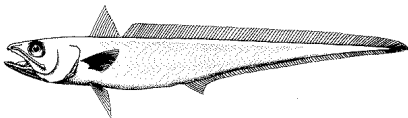
Note: CPUE Catch-per-unit-effort.
Source: Haddon 2015a

Stock status determination

The primary indicators for status determination for this stock are the information provided by the 2015 tier 4 assessment and recent catch. The 2015 assessment indicated that the previously reported decline in CPUE in the east was inflated by the use of catch-per-day rather than catch-per-hook data records. The RBC estimate from the 2015 assessment has a level of precaution built in, because it does not take into account the impact of closures, and the influence of orca depredation on catch rates and fisher behaviour. The stock is classified as **not overfished** because the index of abundance is between the limit and the target reference points.

The 2016–17 RBC is a more useful indicator of the sustainable catch level than the RBC estimate produced by the 2013 tier 4 assessment. Considering fishing mortality in the 2015–16 fishing season against the 335 t TAC and in the context of the updated 2016–17 RBC of 444 t produced by the 2015 tier 4 assessment, the stock is classified as **not subject to overfishing**.

Blue grenadier (*Macrurus novaezelandiae*)



Line drawing: Rosalind Poole

Stock structure

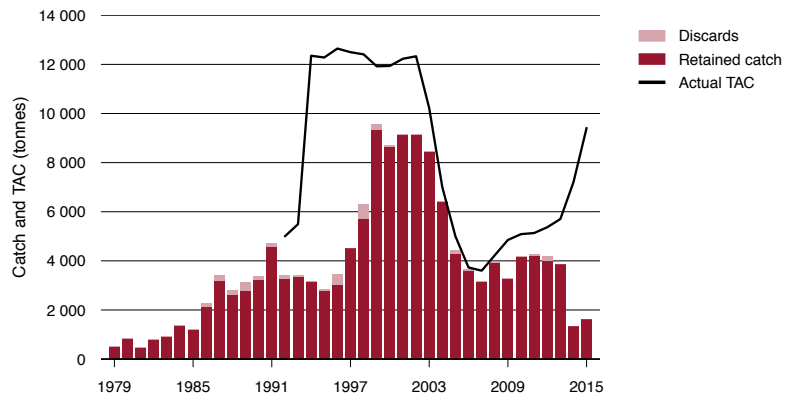
Blue grenadier is assessed as a single stock. There are two defined subfisheries: the winter spawning fishery off western Tasmania and the widely spread catches of the non-spawning fishery.

A stock structure study using otolith chemistry and otolith shape (Hamer et al. 2009) has suggested 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 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. Only 20 per cent of the 2014–15 and 2015–16 TAC was caught; this can be attributed to one factory vessel not fishing the winter spawning aggregations in those fishing seasons. Catch in 2015–16 was 1 754 t.

FIGURE 9.7 Blue grenadier annual catches (CTS and SHS) and fishing season TACs, 1979 to 2015



Note: TAC Total allowable catch. Data for 2013 to 2015 do not include discards and state catch.

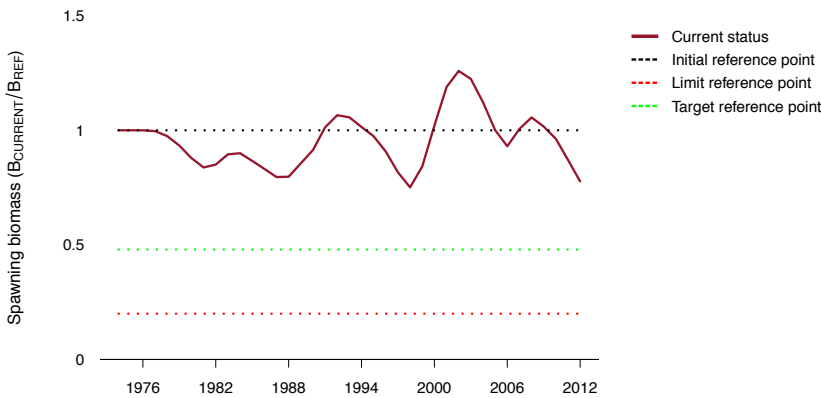
Source: Tuck 2013; Australian Fisheries Management Authority catch disposal records (2013 to 2015 data)

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 consideration of industry's preference for a cautious approach to increasing the TAC, to promote economic stability (SEMAC 2014). The multiyear TAC increased to 8 796 t in the 2015–16 season. Reported landings in 2015–16 were 1 754 t. Discard estimates have been variable: between 6 per cent in 2012 and 32 per cent in 2014 (Upston & Thomson 2015). Discard estimates were not available for 2015 at the time of writing.

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



Source: Tuck 2013

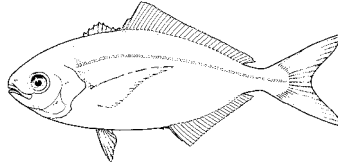
Stock status determination

Blue grenadier remains classified as **not overfished** because the most recent assessment (2013) indicated that the spawning biomass was above the target reference point. Total removals have been less than the long-term RBC since 2005. As a result, blue grenadier remains classified as **not subject to overfishing**.



Fishing vessel
Andrew Sampaklis, ABARES

Blue warehou (*Seriolella brama*)



Line drawing: Rosalind Poole

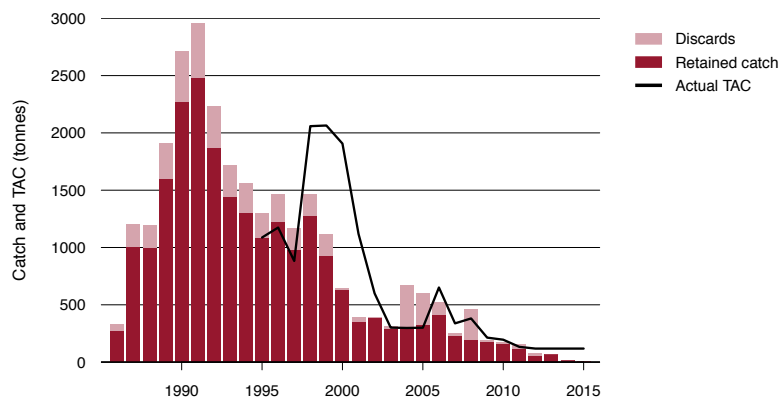
Stock structure

Blue warehou is assumed to have a separate eastern stock (southern New South Wales to eastern Tasmania) and western stock (western Tasmania to western Victoria) (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 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. Blue warehou is also taken in state fisheries and recreationally—an estimated 15.4 t was harvested by recreational fishers in Tasmania during 2012–13 (Lyle et al. 2014).

FIGURE 9.9 Blue warehou annual catches (CTS, SHS and state combined) and fishing season TACs, 1986 to 2015



Notes: TAC Total allowable catch. Data for 2013 to 2015 do not include discards and state catch.

Source: Haddon 2013b; Australian Fisheries Management Authority catch disposal records (2013 to 2015 data)

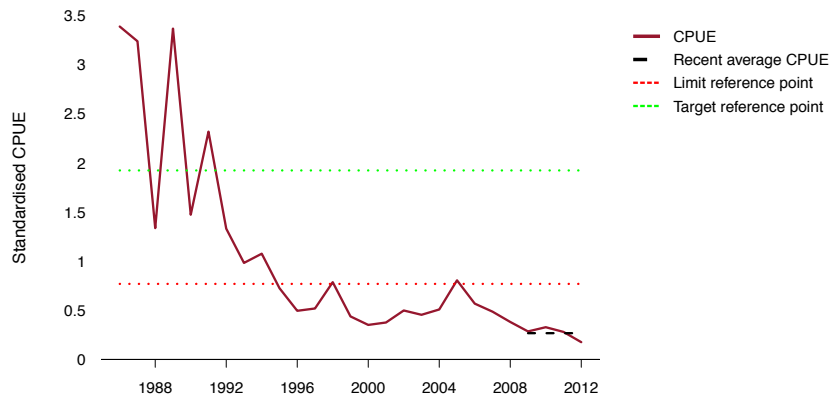
Stock assessment

Blue warehou has been classified as overfished since 1999. 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 2013b). For the eastern stock, CPUE has been below the limit reference point since 1998. For the western stock, CPUE has been below the limit reference point for 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. 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.

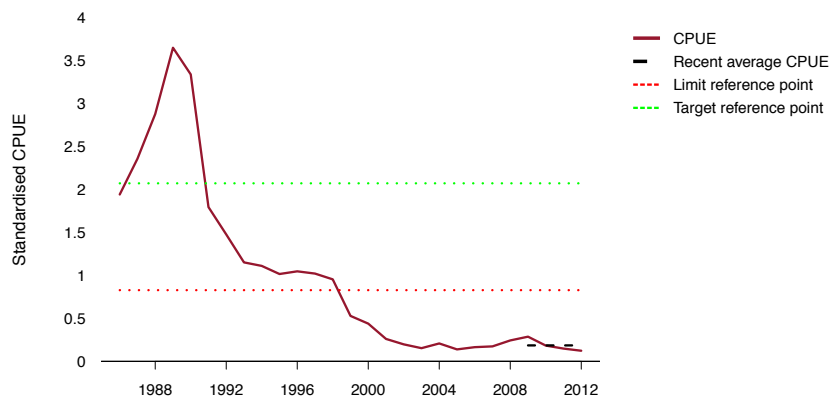
AFMA set an annual incidental catch allowance of 133 t for blue warehou for 2011–12, which was reduced to 118 t for the 2012–13 and subsequent fishing seasons. The incidental catch allowance includes triggers of 27 t in the east and 91 t in the west. These triggers are intended to alert AFMA and the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

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. In September 2015, ShelfRAG discussed whether the rebuilding strategy for blue warehou was meeting its objectives (ShelfRAG 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 2013b

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.

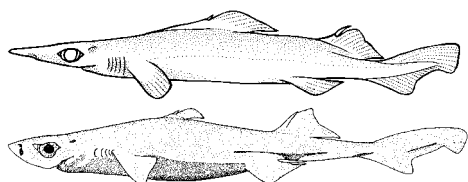
Source: Haddon 2013b

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. Only 2 t was landed across both stocks in 2015–16. The deterioration of CPUE as an index of abundance is a concern for blue warehou.

Despite catches being at record lows, the level of fishing mortality that will allow the stock to rebuild is unknown. A change in recruitment success and overall reproductive productivity could be an explanation for the failure to recover, but there is currently no mechanism to investigate whether this is the case. As a result, blue warehou is classified as **uncertain** with regard to the level of fishing mortality.

Deepwater sharks, eastern and western zones (multiple species)



Line drawing: FAO and Anne Wakefield

Stock structure

The deepwater shark stock comprises multiple species of deepwater sharks: 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 2013b).

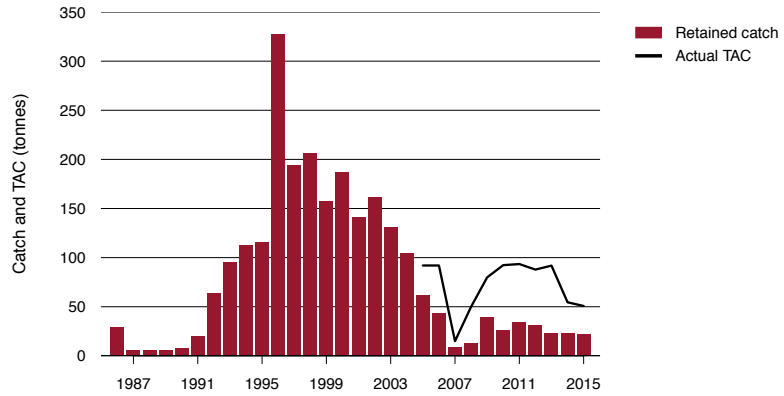
Little is known about the stock structure of these deepwater sharks. They are benthopelagic species that have been sampled in oceanic environments over the abyssal plains, and are distributed widely across ocean basins, and along the middle and lower continental shelves. The management boundary between 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. 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 2015–16 season was 22 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 2015–16 fishing season was 68 t, below the western TAC of 215 t (Figure 9.13).

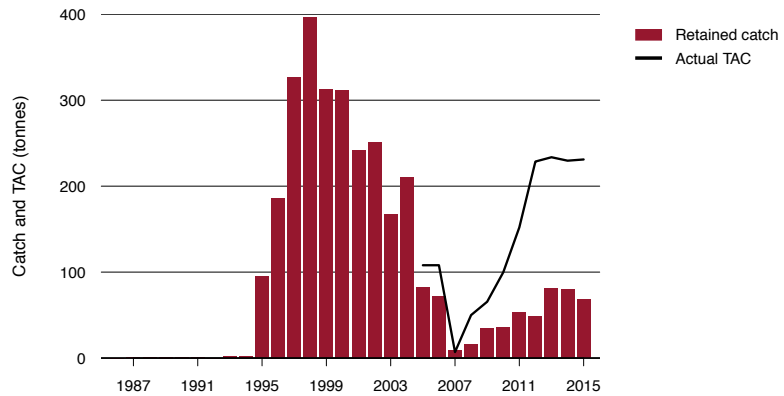
TACs for the deepwater shark multispecies stock are set separately for the eastern and western areas, and cover all deepwater shark species taken in those areas. In 2015–16, platypus sharks (mixed), roughskin dogfishes (mixed) and sleeper sharks (mixed) accounted for most of the catch in the east, and platypus sharks (mixed), longsnout dogfish and sleeper sharks (mixed) accounted for most of the catch in the west.

FIGURE 9.12 Deepwater shark annual catches (CTS) and fishing season TACs, eastern zone, 1986 to 2015



Notes: TAC Total allowable catch. Data for 2011 to 2015 include catch disposal records from the CTS and the SHS. Source: Haddon 2013b; Australian Fisheries Management Authority catch disposal records (2011 to 2015 data)

FIGURE 9.13 Deepwater shark annual catches (CTS) and fishing season TACs, western zone, 1986 to 2015



Notes: TAC Total allowable catch. Data from 2011 to 2015 include catch disposal records from the CTS and the SHS. Source: Haddon 2013b; Australian Fisheries Management Authority catch disposal records (2011 to 2015 data)

Stock assessment

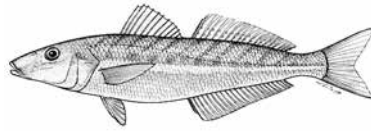
There is a lack of reliable data on historical catch and discards. This paucity of data, together with the multispecies nature of the stock and difficulties in species identification by fishers, means that the standardised CPUE series may not be a reliable index of abundance for the individual species or the multispecies stock (Haddon 2013b). 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 (SlopeRAG 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 for the purpose of targeting deepwater sharks. 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

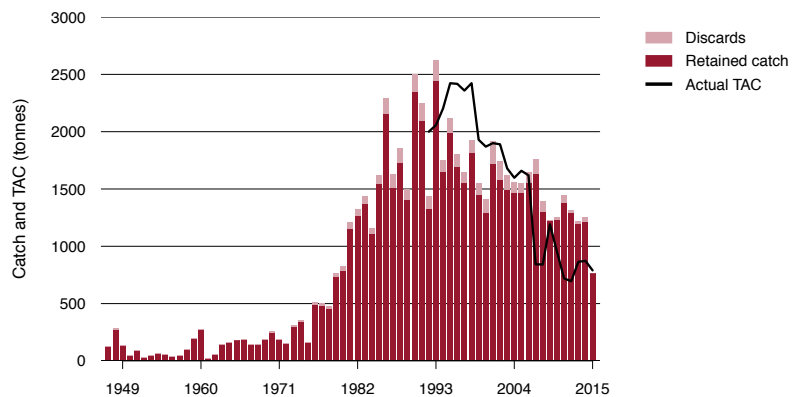
Stock structure

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 catch in 2015–16 was 733 t, taken entirely from the CTS (Figure 9.14).

FIGURE 9.14 Eastern school whiting annual catches (CTS, SHS and state combined) and fishing season TACs, 1947 to 2015



Notes: TAC Total allowable catch. Data up to 2014 include Commonwealth and state catches and discards; 2015 data do not include state catches and discards.

Source: Day 2012, 2011, 2010; Australian Fisheries Management Authority catch disposal records (2009 to 2015 catch data); CSIRO Integrated Scientific Monitoring Program (2009 to 2014 discard data)

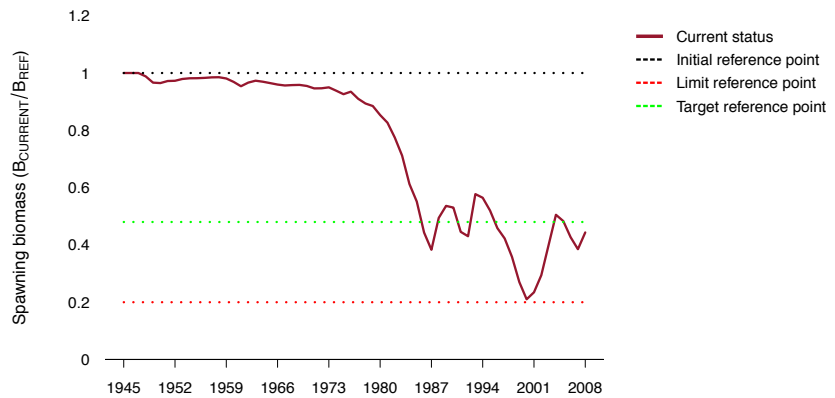
Stock assessment

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, close to the target biomass ($0.48SB_0$). The long-term RBC recommendation at that time was 1 660 t per year. The assessment was updated in 2010 and 2011, using catch, discard, age and length data (Day 2012, 2011). The estimated levels of depletion in the updated assessments were similar to those in the previous full assessment (Figure 9.15), although the estimates had wide confidence intervals, and the models provided a poor fit to the standardised CPUE series for the Danish-seine fleet. The assessments also did not reliably estimate recent recruitment, suggesting that there is conflict between the input datasets (Day 2011).

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 (ShelfRAG 2014a).

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 concerns that biological and fishery information for eastern school whiting has been collected from a relatively small area of the fishery (primarily from the Lakes Entrance Danish-seine fleet) and may not be representative of the species distribution that extends from Queensland to western Victoria. Given these concerns and the variability in model estimates of biomass for eastern school whiting, AFMA is currently seeking guidance from the Southern and Eastern Scalefish and Shark Fishery Resource Assessment Group (SESSFRAG) on what needs to be done to support a new assessment in the future.

The CTS landings in recent years have been below the TACs, with the exception of 2014–15 and 2015–16, when the TACs were almost fully caught (Figure 9.14). The low catches can be partly attributed to the reductions in fleet capacity following the Australian Government's Securing our Fishing Future structural adjustment package, as well as market fluctuations.

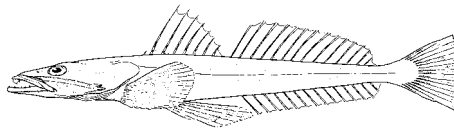
FIGURE 9.15 Spawning stock biomass for eastern school whiting, 1945 to 2008

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 similar levels of biomass depletion (Day 2012, 2011). Standardised CPUE to 2014 (Sporcic 2015), and size composition data from observers and port sampling (Thomson et al. 2015a) do not indicate any concerning trends for stock status. As a result, school whiting is classified as **not overfished**. Given that recent catches remain below the long-term RBC, eastern school whiting remains classified as **not subject to overfishing**.

Flathead (*Platycephalus richardsoni* and four other species)



Line drawing: Rosalind Poole

Stock structure

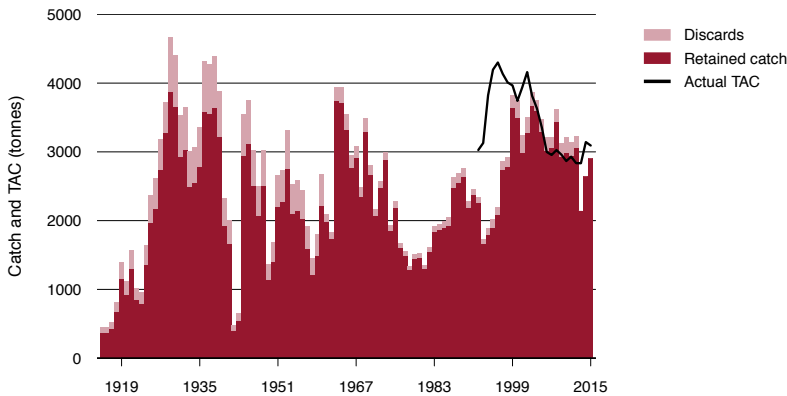
For SESSF management purposes, 'flathead' refers to a group of species. However, the catch is almost entirely tiger flathead (*Platycephalus richardsoni*). It includes sand flathead (*Platycephalus bassensis*) and, from 1996 onwards, southern or 'yank' flathead (*P. speculator*), bluespot flathead (*P. 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. Catch in recent decades has been relatively stable at approximately 3 000 t. Catch increased from 2 829 t in 2014–15 to 2 989 t in 2015–16 (Figure 9.16).

FIGURE 9.16 Flathead annual catches (CTS and state combined) and fishing season TACs, 1915 to 2015



Notes: TAC Total allowable catch. Data for 2013 to 2015 do not include discards and state catch.
 Source: Day & Klaer 2013; Australian Fisheries Management Authority catch disposal records (2013 to 2015 data)

Stock assessment

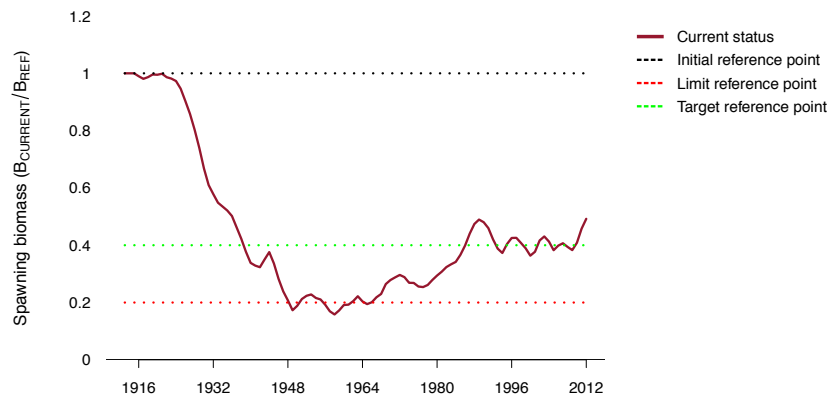
The flathead assessment is based on biological parameters relating to tiger flathead, which accounts for about 95 per cent of the flathead catch (Morison et al. 2013). However, the assessment and TAC include catches of all flathead species because the different species cannot be distinguished in historical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

The most recent assessment (2013) was an integrated, model-based (tier 1) stock assessment (Day & Klaer 2013). The base-case model forecasted the 2014 spawning biomass to be 50 per cent of unfished spawning biomass ($0.5B_0$), following an increasing trend in biomass since 2008 (Figure 9.17). The base case of the model estimated biomass at maximum sustainable yield (B_{MSY}) to be 32 per cent of the unfished spawning biomass ($0.32B_0$). Application of the HSP proxy of $1.2B_{MSY}$ for biomass at maximum economic yield (B_{MEY}) produces an estimate of $0.38B_0$. ShelfRAG recommended a more conservative approach, by setting the target reference point at $0.4B_0$ (Morison et al. 2013). Using $0.4B_0$ as the target reference point, the model estimated a one-year RBC of 3 428 t, a three-year RBC of 3 334 t or a five-year RBC of 3 252 t.

In 2014, ShelfRAG recommended that flathead be managed under a multiyear TAC based on the 2013 assessment. As the first year of a three-year multiyear TAC, the 2014–15 TAC was set at 2 878 t, with the option of maintaining this TAC for the following two seasons if appropriate breakout rules were applied. ShelfRAG recommended a breakout rule for review if the actual CPUE for the previous season was outside the 95 per cent confidence limits of the predicted CPUE (Morison et al. 2013). Analysis of the 2013–14 and 2014–15 fishery data indicated that, although CPUE for the trawl assessment was within the 95 per cent confidence limit, Danish-seine CPUE was below the 95 per cent confidence limit in both seasons, but increased between 2013–14 and 2014–15. As a result, ShelfRAG recommended that the multiyear TAC be continued (ShelfRAG 2014a) for the 2015–16 fishing season. SESSFRAG recommended that an updated tier 1 assessment be deferred until 2016 (SESSFRAG 2015).

The Commonwealth catch of flathead in the 2015–16 fishing season was 2 908 t, taken almost fully from the CTS (Table 9.2). In recent years, annual catches have been stable. State catches comprised around 7 per cent of the total catch in 2014 (Upston & Thomson 2015). Low rates of discarding (around 5–10 per cent) have been estimated for flathead since 2012 (Upston & Thomson 2015). Above-average estimated discard rates of around 15 per cent occurred in 2011, with one vessel in particular encountering and discarding large numbers of small flathead in two shots (Morison et al. 2013).

FIGURE 9.17 Estimated spawning stock biomass for flathead, 1913 to 2012

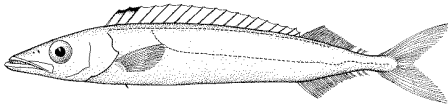


Source: Day & Klaer 2013

Stock status determination

The most recent assessment forecasts the spawning biomass of tiger flathead ($0.5B_0$ in 2014) to be above the target reference point ($0.4B_0$). As a result, the stock is classified as **not overfished**. The flathead stock has fluctuated near or above the target value since recovering to that level in the late 1980s (Day & Klaer 2013), and annual recruitments over the past 15 years have been above average (Morison et al. 2013). The 2 908 t Commonwealth catch in the 2015–16 fishing season was above the 2 860 t TAC but within the 10 per cent overcatch provision. Flathead is therefore classified as **not subject to overfishing**.

Gemfish, eastern zone (*Rexea solandri*)



Line drawing: Sharne Weidland

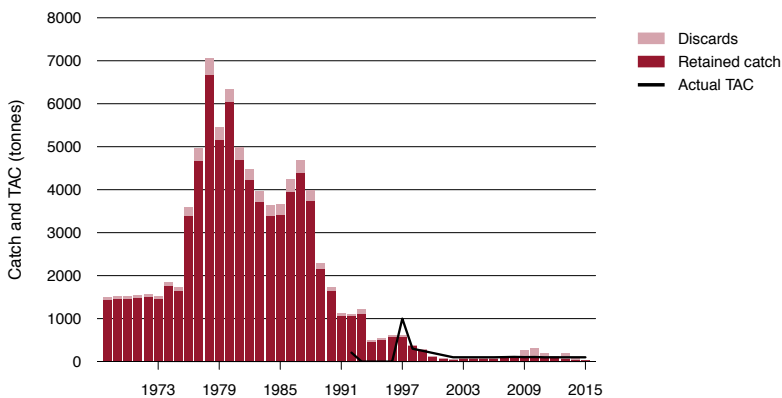
Stock structure

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. 2016). This assessment is for the eastern gemfish stock.

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 catch in 2015–16 was 30 t.

FIGURE 9.18 Gemfish annual catches (CTS, SHS and state combined) and fishing season TACs, eastern zone, 1968 to 2015



Notes: TAC Total allowable catch. Data for 2009 to 2015 do not include state catch. Data for 2015 does not include discards.

Source: Little & Rowling 2011; Australian Fisheries Management Authority catch disposal records (2009 to 2015 data); CSIRO Integrated Scientific Monitoring Program (2009 to 2014 discard data)

Stock assessment

The integrated stock assessment model for eastern gemfish was last updated in 2010 with data on catch and length frequency up to 2009 (Little & Rowling 2011). The 2010 estimate of spawning stock biomass was not substantially different from the 2008 or 2009 estimates. The base-case model estimated that the spawning stock biomass in 2009 was 15.6 per cent of the 1968 level (0.156SB₀; Figure 9.19).

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 the point estimate of biomass might reach $0.2SB_0$ 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 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).

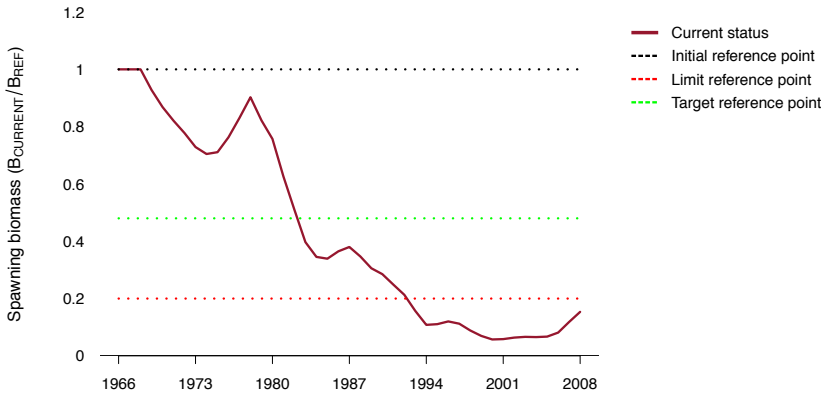
For the 2015–16 fishing season, trawl (27 t) and non-trawl (3 t) landings (30 t in total) were lower than the landings in the previous two seasons (52 t in 2013–14 and 37 t in 2014–15). Discards for 2013 were estimated at 131 t—around double the landed catch (Upston & Thomson 2015). These high discard rates in both the summer and winter trawl fishery might indicate that there is a level of stock rebuilding (Morison et al. 2013). Discards fell to 33 t in 2014 (44 per cent of total fishing mortality) (Upston & Thomson 2015); data on discards are not yet available for 2015.

The 2008 eastern gemfish rebuilding strategy adopted a time frame for rebuilding eastern gemfish to the limit reference point of approximately nine years. Given that recent recruitment levels have been below average, AFMA believed that this time frame was unlikely to be met (AFMA 2015a). The rebuilding strategy was updated in 2015 and has adopted the rebuilding time frame of one mean generation time plus 10 years (approximately 19 years from 2008), which is in line with the HSP. The rebuilding strategy aims to rebuild eastern gemfish to, or above, the limit reference point by 2027.

Industry continues to work to reduce catches of eastern gemfish. Targeting of eastern gemfish has declined since 2008, and total removals are at historically low levels. Analyses presented to ShelfRAG in 2012 suggested that the targeted catch of eastern gemfish by otter trawl declined to between 10 and 20 t (15–30 per cent of the catch) in 2011 (N Klaer, CSIRO, 2013, pers. comm.). The high estimates in the range are from strata with fewer than five shots, which might suggest that, although eastern gemfish was the most valuable species, catches were not intended.

Moore et al. (2016) 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, 1966 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**.

The SPR analyses (Little 2012) suggest high fishing mortality rates for eastern gemfish until the late 1990s, but much lower rates since 2002. Because fishing mortality rates have substantially decreased, assessment model projections indicate that, with average recruitment, the stock should reach B_{LIM} ($0.2SB_0$) in 2025, which is less than one generation time plus 10 years, as required under the HSP. The revised Eastern Gemfish Stock Rebuilding Strategy (AFMA 2015a) states that eastern gemfish should be rebuilt to, or above, the limit reference point by 2027. 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. Total removals were likely to have been about double the 100 t incidental catch allowance in 2013–14 but below the incidental catch allowance in 2014–15. Total removals are difficult to estimate because discard estimates are given for calendar years, whereas landings are considered by fishing season. Discard data are not yet available for 2015. 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. Because of the lack of a discard estimate for 2015, it is unclear whether total mortality for eastern gemfish remained below the incidental catch allowance prescribed in the rebuilding strategy. Therefore, eastern gemfish is classified as **uncertain if subject to overfishing**.

Gemfish, western zone (*Rexea solandri*)

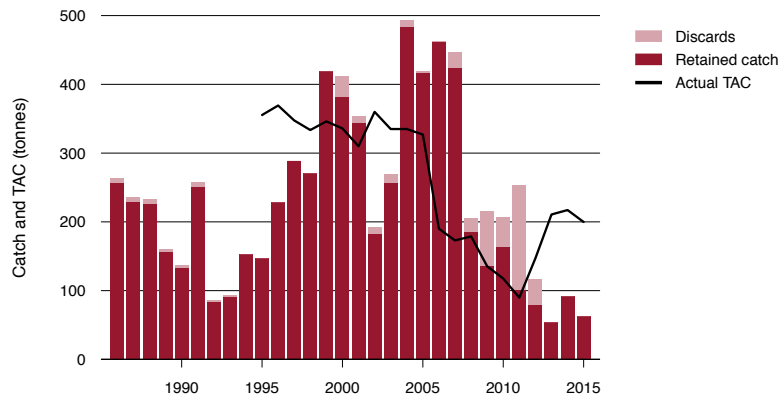
Stock structure

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. 2016). This assessment is based solely on the western gemfish stock.

Catch history

A total of 81 t of western gemfish was landed by the CTS (76 t) and the GHTS (5 t) in the 2015–16 fishing season (Figure 9.20). Historically, a substantial catch of western gemfish was taken within the GABTS. In 2008, catch in the GABTS decreased to approximately 50 t, partly due to low prices for gemfish and a key vessel leaving the fishery (GABRAG 2010). The GABTS catch in 2015–16 decreased to a historical low of 3 t.

FIGURE 9.20 Gemfish annual catches (CTS and SHS) and fishing season TACs, western zone, 1986 to 2015



Note: TAC Total allowable catch. Data for 2013 to 2015 exclude discards and state catch.

Source: Haddon 2013b; Australian Fisheries Management Authority catch disposal records (2013 to 2015 catch data)

Stock assessment

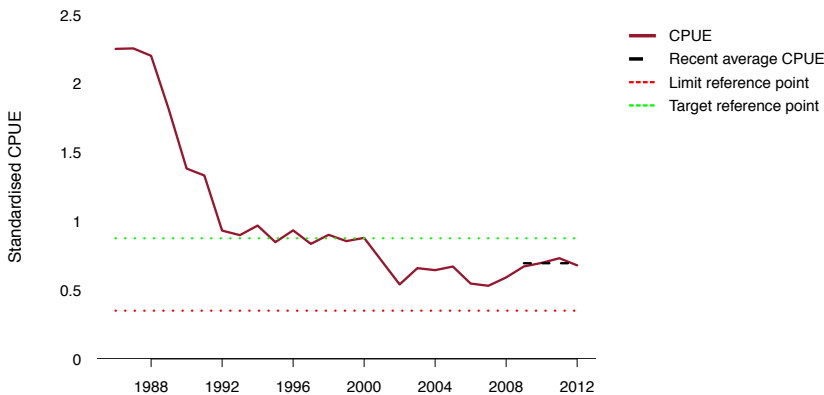
An updated integrated stock assessment model (tier 1) was developed for western gemfish in the CTS and the GABTS in 2011, and was repeated in 2012 and 2013 (Chambers et al. 2014). Updates included additional catch data, and revised age and length data. Western Tasmanian catches were excluded from the assessment because they were likely to be from the eastern gemfish stock. The most recent updated assessment gave a spawning biomass estimate of 74 per cent of unfished biomass in 2013 ($0.74SB_0$; Figure 9.21), compared with the 2010 estimate of $0.69SB_0$.

The Great Australian Bight Resource Assessment Group (GABRAG) had some concerns with the tier 1 assessments, particularly the increase in estimated biomass between assessments and uncertainties around stock structure. As a result, GABRAG also considered the tier 4 assessment results. The tier 4 analysis indicated that CPUE is above the limit reference point (Haddon 2013b). However, there were also concerns with the tier 4 assessment because it uses data only from the CTS and excludes catch in the Great Australian Bight, which may contain a large proportion of gemfish biomass. Additionally, CPUE, which the tier 4 assessment is based on, may not be a good indicator of abundance for a species that is often targeted when it forms winter spawning aggregations.

The RBC from the tier 4 assessment for the CTS for the 2015–16 fishing season was 247 t; this applies only to the CTS and not the entire western gemfish stock. The TAC set for the CTS by the AFMA Commission was 183 t for the 2015–16 fishing season. The GABTS has not moved to implement quota for 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 2014b).

Discarding has been high for this species, with an estimated 69 per cent of the catch discarded in 2013 (Upston & Thomson 2015). This may be linked to the availability of quota for the species in the CTS. Discards were estimated at 23 t (24 per cent of the catch) in 2014 (Upston & Thomson 2015). Discard estimates are not yet available for 2015.

FIGURE 9.21 Standardised CPUE for gemfish, western zone, 1986 to 2012

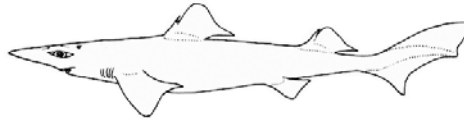


Source: Haddon 2013b

Stock status determination

The most recent assessments indicate that biomass and catch rates are above the limit reference points. Therefore, the western gemfish stock is classified as **not overfished**. Catches have been stable in recent years, and are low as a proportion of the RBC and below the Great Australian Bight catch trigger. Therefore, the western gemfish stock is 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. Harrison'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 Harrison'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 (2012) in 2013, Williams et al. (2013) investigated the relative carrying capacity and depletion of subpopulations of Harrison'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 Harrison's dogfish; and eastern, central and western populations for southern dogfish.

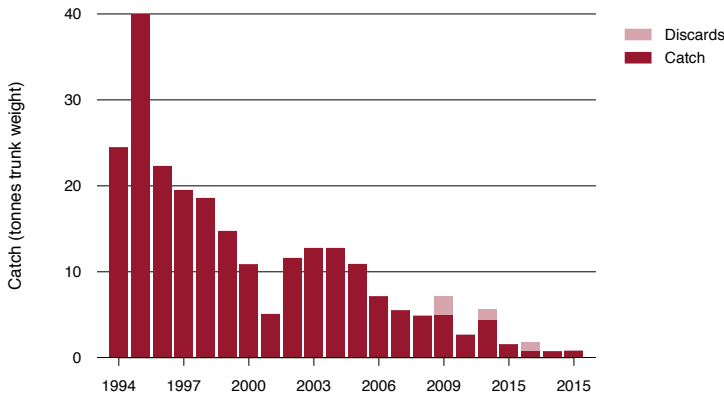


Trawl net and haul
Tamre Sarhan, AFMA

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 0.9 t in the 2015–16 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 2015



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 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 Harrison’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, Harrison's and southern dogfish on the New South Wales upper slope. Williams et al. (2013) derived depletion estimates for the identified subpopulations of Harrison's and southern dogfish, expressed as a percentage of the initial relative carrying capacity. For Harrison'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 Harrison'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 Harrison'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 Harrison'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 Harrison'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 2014b).

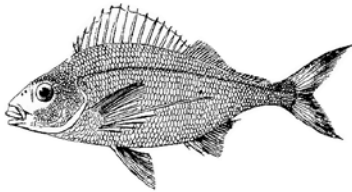
On 30 May 2013, the Minister for Sustainability, Environment, Water, Population and Communities listed Harrison's dogfish and southern dogfish under the EPBC Act as threatened species in the conservation dependent category. The minister noted that both species have experienced severe historical declines 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 Harrison's dogfish and/or southern dogfish; a zero retention limit for greeneye spurdog, and Harrison'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 Harrison'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 2014–15 and 2015–16 fishing seasons (0.7 t and 0.9 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** if subject to overfishing. 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

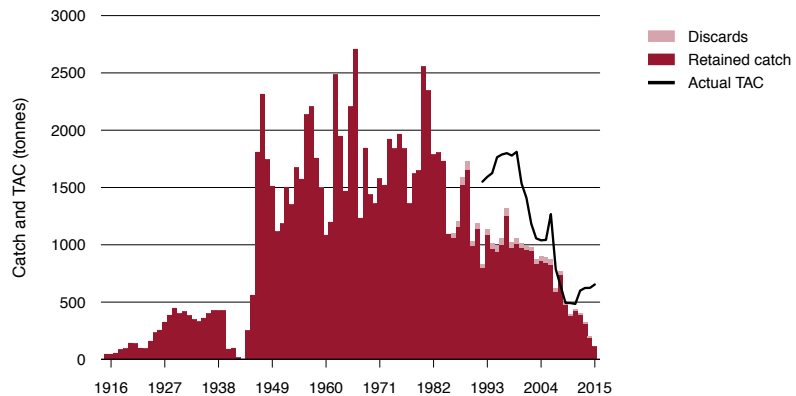
Stock structure

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. Significant 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). Catch in 2015–16 was 136 t. Discards were estimated at around 66 t in 2014 (Upston & Thomson 2015); estimates of discards are not yet available for 2015.

FIGURE 9.23 Jackass morwong annual catches (CTS, SHS and state combined) and fishing season TACs, east and west stocks combined, 1915 to 2015



Notes: TAC Total allowable catch. Data for 2015 do not include discards and state catches.

Source: Tuck et al. 2015; Australian Fisheries Management Authority catch disposal records (2015 catch data)

Stock assessment

Assessments of the eastern and western stocks were conducted 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) (ShelfRAG 2015a). While noting these concerns, ShelfRAG accepted the 2015 assessment (ShelfRAG 2015b) 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 (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 for 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).

Continuing the second year of a three-year TAC, the 2013 update of the 2011 assessment was used to calculate the RBCs for the 2015–16 season of 292 t for the west and 400 t for the east. After deduction of state catches and estimated discards, the TAC for the 2015–16 season was set at 598 t. Catch in 2015–16 was 136 t, around 23 per cent of the TAC. Discards were estimated to be around 16 per cent in 2013 and 26 per cent in 2014 (Upston & Thomson 2015); estimates of discards are not yet available for 2015.

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

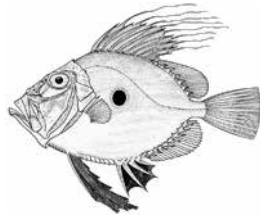
Stock status determination

The most recent assessment (Tuck et al. 2015) estimates that spawning biomass of western jackass morwong in 2016 would be above the target reference point of $0.48SB_0$. The lack of size and age data, and the wide spread of results from the sensitivity analyses contribute to uncertainty in the assessment. However, total removals have declined and have remained well below the RBCs produced by the 2011 and 2015 assessments, 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 $0.365B_0$ (36.5 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 (109 t in 2015–16) were well below the RBCs produced by the 2012 and 2015 assessments, and the stock is therefore classified as not overfished and not subject to overfishing.

On the basis of the above information, jackass morwong is classified as **not overfished** and **not subject to overfishing**.

John dory (*Zeus faber*)



Line drawing: Rosalind Poole

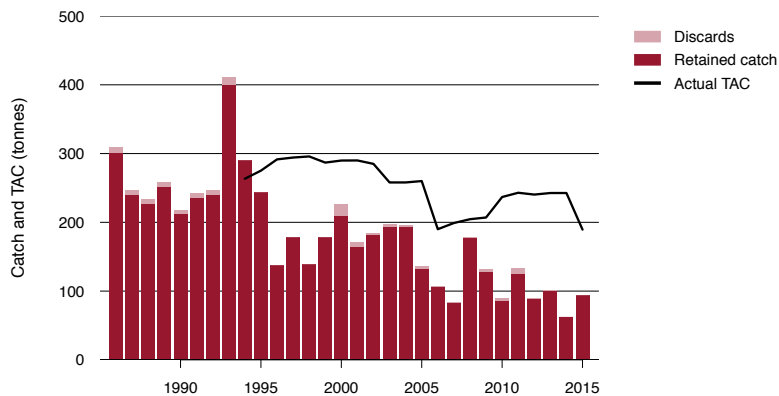
Stock structure

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).

FIGURE 9.25 John dory annual catches (CTS, SHS and state combined) and fishing season TACs, 1986 to 2015



Notes: TAC Total allowable catch. Data for 2014 and 2015 do not include discards and state catch.

Source: Haddon 2013b; Australian Fisheries Management Authority catch disposal records (2014 and 2015 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. In 2012, ShelfRAG recommended $0.4B_0$, the HSP default MSY proxy, as a target reference point for john dory instead of the SESSF harvest strategy's default MEY proxy of $0.48B_0$ (ShelfRAG 2012).

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 ($F_{\text{SPR40}} = 0.159$) 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 2015–16 fishing season. ShelfRAG recommended a three-year multiyear TAC of 169 t (ShelfRAG 2014b), which was adopted by the AFMA Commission.

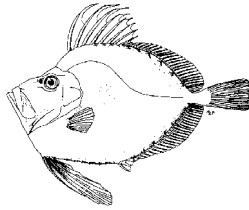
In 2014, ShelfRAG considered suitable breakout rules for the john dory multiyear TAC. It noted that a change in catch rate would not be appropriate because catch rate is not reflected in the tier 3 assessment. ShelfRAG therefore recommended adopting a breakout rule that it would review the available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

Recent catches have been well below the TAC, with 86 t landed in 2015–16 (Figure 9.25; Table 9.2).

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. As a result, john dory is classified as **not overfished** and **not subject to overfishing**.

Mirror dory (*Zenopsis nebulosa*)



Line drawing: FAO

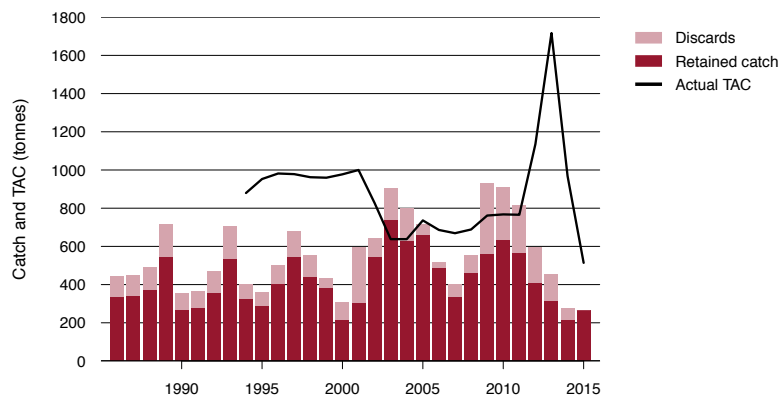
Stock structure

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). Catch in 2015–16 was 252 t, caught entirely by trawl in the CTS.

FIGURE 9.26 Mirror dory annual catches (CTS, SHS and state combined) and fishing season TACs, 1986 to 2015



Notes: TAC Total allowable catch. Data for 2015 do not include discards and state catch.

Source: Haddon 2015a; Australian Fisheries Management Authority catch disposal records (2015 catch data)

Stock assessment

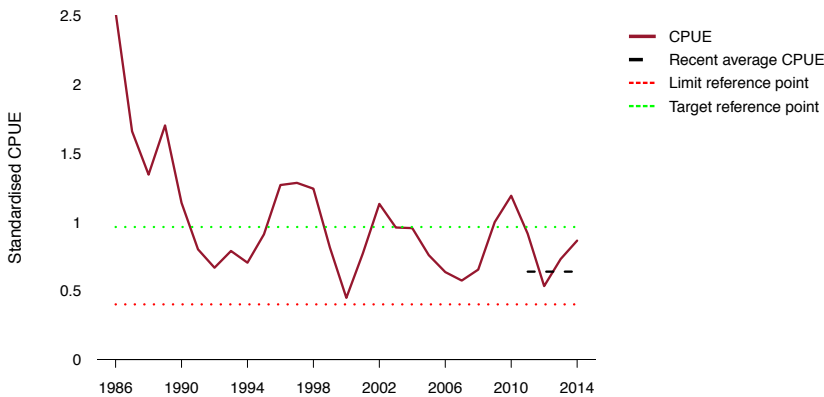
Most of the mirror dory catch is byproduct in the CTS and is mainly caught east of Bass Strait. A quantitative (tier 1) assessment was attempted in 2010, but ShelfRAG considered that it was not sufficiently robust because there was uncertainty around the natural mortality rate, and a time series of age-composition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

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 (ShelfRAG 2013a). 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 9.26.

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 and west 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 2015a). In the east, CPUE decreased towards the limit from 1993 to around 2000, and then increased back to above the target by 2005; recent average CPUE is between the limit and the target (Figure 9.28; Haddon 2015a).

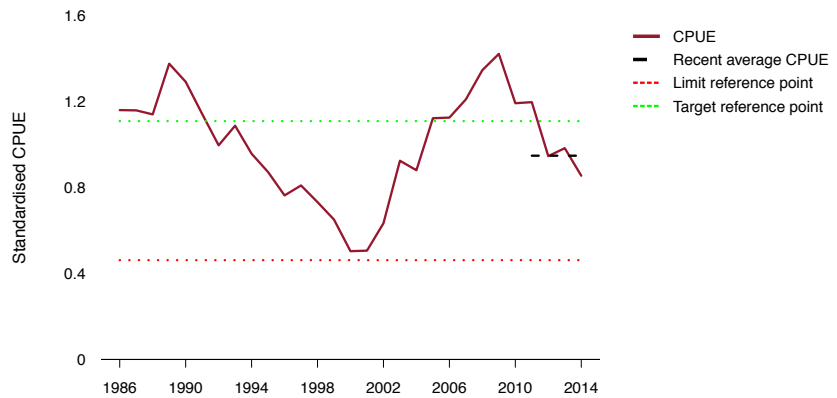
The 2014 tier 4 assessment produced an RBC for 2015–16 of 684 t (Haddon 2014). After deduction of the 15 per cent discount factor for tier 4 assessments, and deductions for state catches and discards, this resulted in a 2015–16 TAC of 437 t. Discards were estimated at around 30 per cent of total catch in 2013 and around 22 per cent of total catch in 2014 (Upston & Thomson 2015). Discard estimates are not yet available for 2015.

FIGURE 9.27 Standardised CPUE for western mirror dory, 1986 to 2014



Note: CPUE Catch-per-unit-effort.

Source: Haddon 2015a

FIGURE 9.28 Standardised CPUE for eastern mirror dory, 1986 to 2014

Note: CPUE Catch-per-unit-effort.

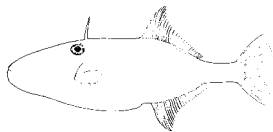
Source: Haddon 2015a

Stock status determination

Although discard estimates are not yet available for 2015, assuming no substantial change in discarding, it is likely that total mortality is below RBCs for the eastern and western components of the stock, and the stock is therefore classified as **not subject to overfishing**.

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**.

Ocean jacket (predominantly *Nelusetta ayraud*)



Line drawing: FAO

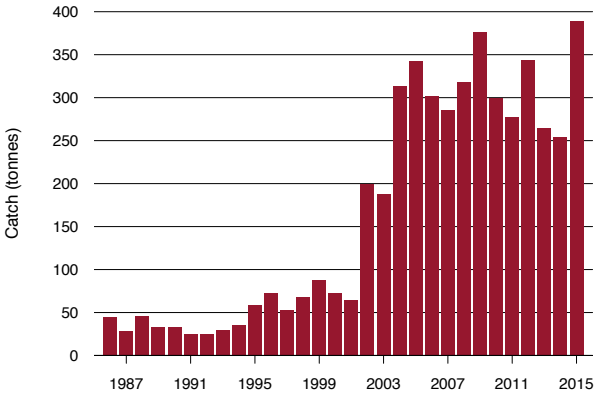
Stock structure

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. 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 2012 at 401 t. Catch in the 2015–16 fishing season was 312 t (Figure 9.29; excludes state catch).

FIGURE 9.29 Ocean jacket catch in the CTS and the SHS, 1986 to 2015



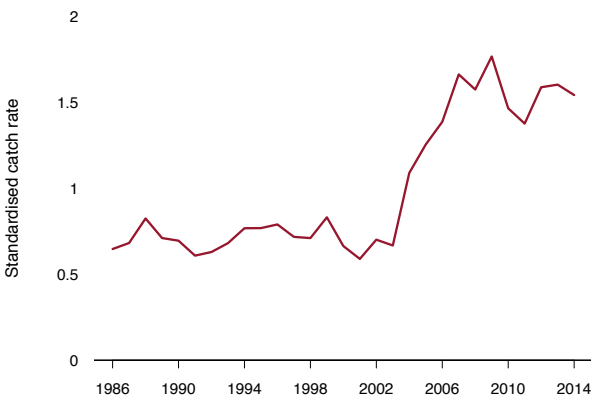
Notes: Catch includes chinaman leatherjacket and unspecified leatherjackets. Data for 2015 exclude state catches.

Source: Sporic 2015; Australian Fisheries Management Authority catch disposal records (2015 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; Sporic 2015). Catch rates for ocean jacket from zones 10 to 50 combined decreased in 2014, following increases in 2012 and 2013 (Sporic 2015). 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



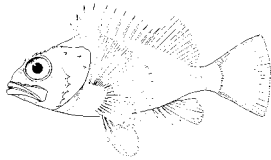
Note: CPUE Catch-per-unit-effort. There is no tier 4 assessment for ocean jacket, and so there is no target and limit reference point.

Source: Sporic 2015

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

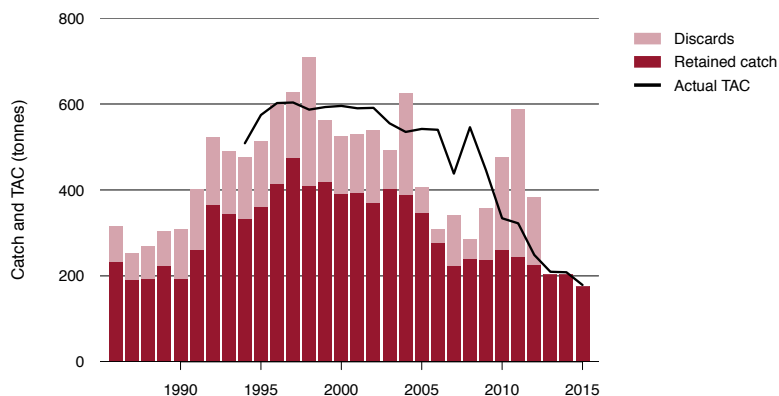
Stock structure

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. Landed catch for the 2015–16 season was 169 t (Figure 9.31). 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). Discard estimates are not yet available for 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 2015



Notes: TAC Total allowable catch. Data for 2013 to 2015 exclude discards and state catch.

Source: Haddon 2013b; Australian Fisheries Management Authority catch disposal records (2013 to 2015 catch data)

Stock assessment

Bigeye (offshore) and reef (inshore) ocean perch are managed as secondary stocks because they are not key economic drivers in the fishery (see Chapter 8 for further details). ShelfRAG therefore provides advice on the basis of B_{40} (B_{MSY} proxy) target reference points for both stocks (Morison et al. 2013).

Tier 4 standardised CPUE assessments were last updated in 2013 (Haddon 2013b). 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 2015–16 TAC was set at 166 t. Combined landings of both species in the 2015–16 fishing season were 169 t (Table 9.2). Annual landings by New South Wales state fishers have been around 15–30 t since 2000 (Upston & Thomson 2015).

The lower-value reef ocean perch is subject to high levels of discarding. The 2012 and 2013 CPUE assessments (Haddon 2013b, 2012) included discard estimates from the Integrated Scientific Monitoring Program. Although these assessments showed a similar trend to the series without discards, greater variability and a higher catch rate were observed in years with high discarding. The 2013 assessment 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.

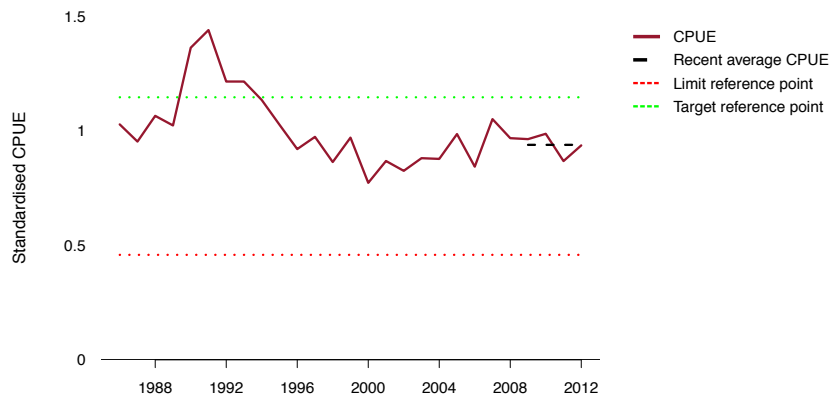
FIGURE 9.32 Standardised CPUE, including discards, for reef (inshore) ocean perch, 1986 to 2012



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

The CPUE to 2012 for bigeye ocean perch (Haddon 2013b) indicates stability in catch rates since 1996, with standardised CPUE remaining above the limit reference point (Figure 9.33; Haddon 2013b).

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 2013b

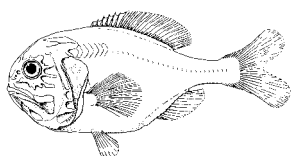
Stock status determination

Previous tier 4 assessments for reef (inshore) ocean perch, excluding discard estimates, estimated that the stock had declined to the limit reference point by 2003 and had started to rebuild back towards the target after 2008. The 2013 tier 4 assessment, including discards, found reef ocean perch to have rebuilt to the target by 2010, with recent four-year average standardised CPUE above the target. 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 (ShelfRAG 2013b). Given that reef ocean perch is assessed to be above the target, and to have rebuilt to above the target from being at the limit in 2008, reef ocean perch is assessed as **not overfished** and **not subject to overfishing**.

The 2013 tier 4 assessment for bigeye (offshore) ocean perch indicates that the stock biomass is above the limit reference point, and therefore the stock is assessed as **not overfished**. Because the 2015–16 catch was less than the RBC, bigeye ocean perch is assessed as **not subject to overfishing**.

Based on the above evidence, the combined stock of reef and bigeye ocean perch is classified as **not overfished** and **not subject to overfishing**.

Orange roughy (*Hoplostethus atlanticus*)

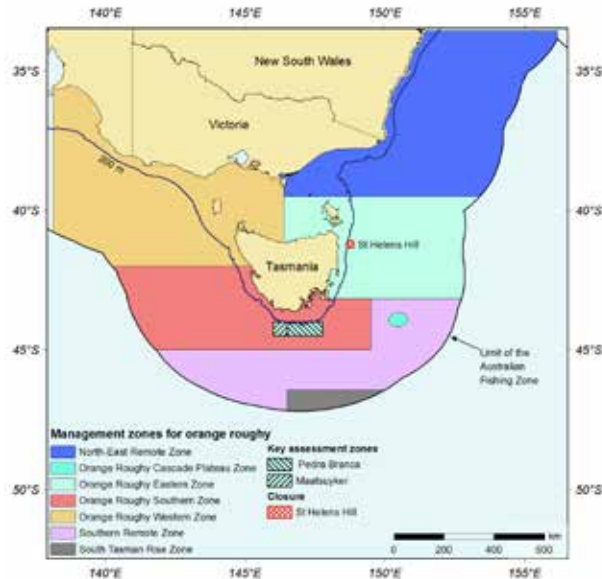


Line drawing: Rosalind Poole

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 2014c). 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.

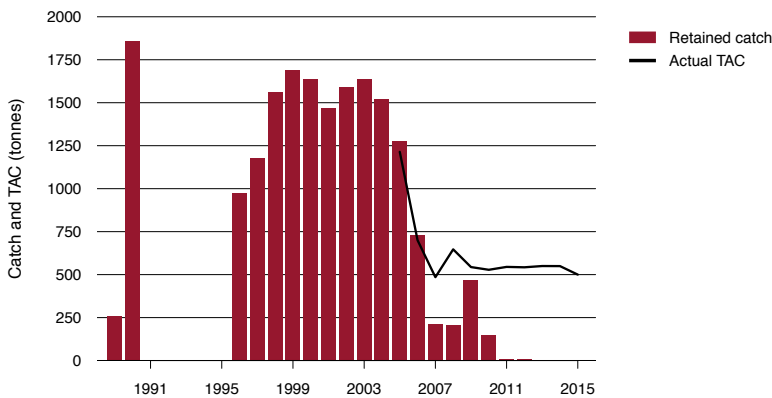
In October 2006, orange roughy was listed as conservation dependent under the EPBC Act and placed under the Orange Roughy Conservation Programme (ORCP). The ORCP was replaced by the Orange Roughy Rebuilding Strategy in 2015 (AFMA 2015b), the primary objective of which is to return all orange roughy stocks to levels at which the species can be harvested in an ecologically sustainable manner 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 of effort by limiting entry to existing fisheries, and ongoing research and monitoring to support stock assessments.

Orange roughy, Cascade Plateau

Catch history

Orange roughy on the Cascade Plateau is the only orange roughy fishery assessed in the CTS that is not estimated to have been depleted to below the limit reference point; this fishery shows a somewhat different catch trend from the depleted fisheries. Catch of orange roughy on the Cascade Plateau peaked at 1 858 t in 1990. No catch was taken between 1991 and 1995. Catches have been below 10 t in recent years, despite the TAC remaining at 500 t, reflecting negligible effort in the fishery. Reported catch from the Cascade Plateau in the 2015–16 season was 2 t (Figure 9.35).

FIGURE 9.35 Orange roughy catch (CTS), Cascade Plateau, 1989 to 2015



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 SSSF HSF (SlopeRAG 2014b). This revised target for the Cascade Plateau stock is reflected in the Orange Roughy Rebuilding Strategy (AFMA 2015b).

Spawning aggregations of Cascade Plateau orange roughy were assessed using acoustic survey abundance indices between 2003 and 2009. 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, no formal stock assessment has been undertaken 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 zero in 2013–14, 0.3 t in 2014–15 and 2 t in 2015–16, reflecting low effort in the fishery (Figure 9.35).

Stock status determination

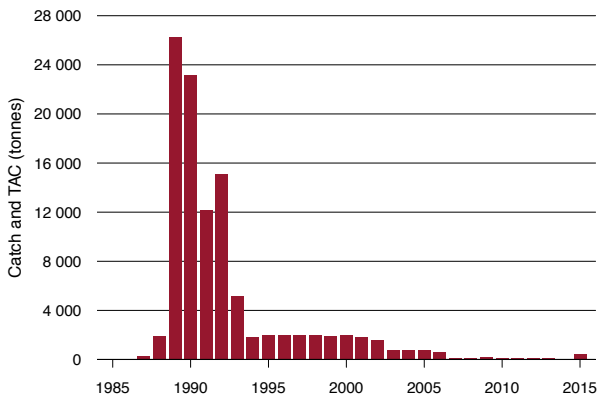
The most recent assessment (2009) predicted that the 2011 spawning stock biomass of Cascade Plateau orange roughy would be at 63–64 per cent of unfished levels (0.63 – $0.64SB_0$). Because catches in 2014–15 and 2015–16 were 0.3 t and 2 t, respectively, and the stock biomass was assessed to be above 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).

FIGURE 9.36 Orange roughy catch (CTS), eastern zone, 1985 to 2015

Note: The 2015–16 fishing season TAC of 465 t is not shown on this graph because of scaling of recent catches against historical catches.

Source: Upston et al. 2014; Australian Fisheries Management Authority catch disposal records (2014 and 2015 catch data)

Stock assessment

Eastern zone

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 9.36). The base-case estimate of spawning biomass from this assessment was less than 15 000 t. The 2006 model estimates of biomass were primarily driven by the substantial decline in abundance of larger and older orange roughy in the fishery.

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

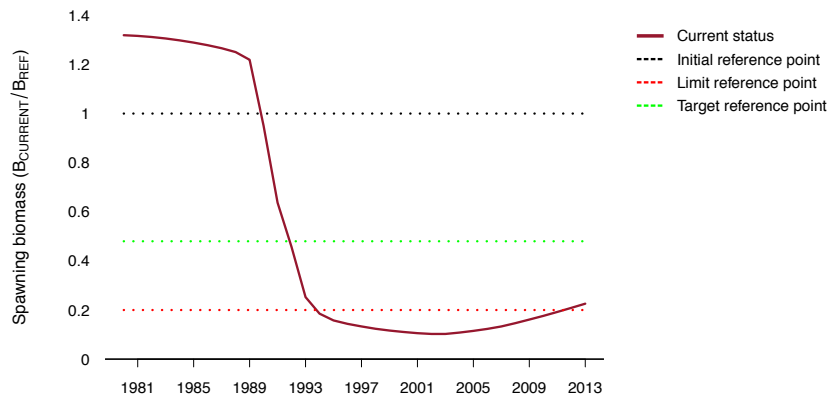
The proportion of the population that spawns each year is uncertain and variable. It was estimated to have increased from 54 per cent in the late 1980s to 71 per cent in the early 1990s (Morison et al. 2013), with the most recent estimates being 70 per cent in 2009 and 52 per cent in 2010 (Kloser et 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 (SlopeRAG 2013b).

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 TAC of 465 t for the 2015–16 fishing season, of which 436 t was landed.

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**.

Management controls to avoid overcatch are in place in the eastern zone, in which targeted fishing recommenced in 2015–16. Since catch of eastern zone orange roughy was constrained to within the TAC, the stock is classified as **not subject to overfishing**.

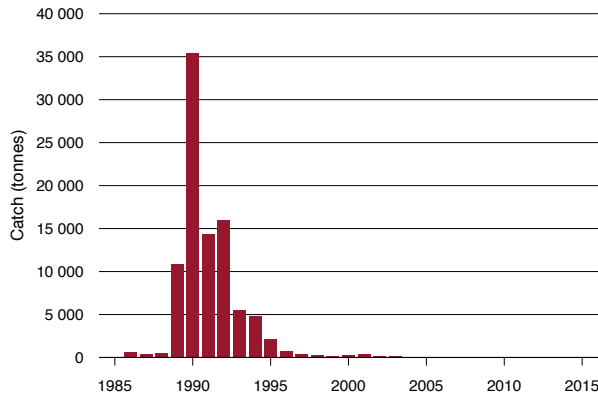
Orange roughy, southern and western zones

Catch history

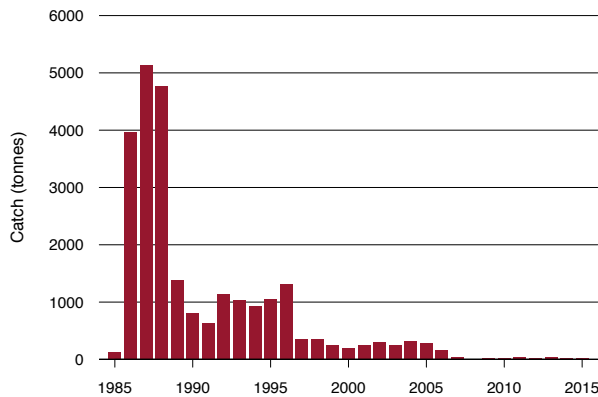
The southern and western orange roughy fisheries show similar catch trends to the eastern zone fishery, with a brief period of high catches when fishing first commenced (1989 to 1992 for the eastern and southern zones; 1986 to 1988 for the western zone) and low catches thereafter (Figures 9.36, 9.38 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 2015–16 fishing season, 57 t of orange roughy was landed from the southern zone (17 t in 2014–15) and 22 t from the western zone (29 t in 2014–15). For 2015–16, the incidental catch allowances were 35 t for the southern zone and 60 t for the western zone.

FIGURE 9.38 Orange roughy catch (CTS), southern zone, 1985 to 2015

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

FIGURE 9.39 Orange roughy catch (CTS), western zone, 1985 to 2015

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 (0.07SB₀). Because there has been no update to the stock assessment, SlopeRAG 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 total TAC for the southern zone was 66 t.

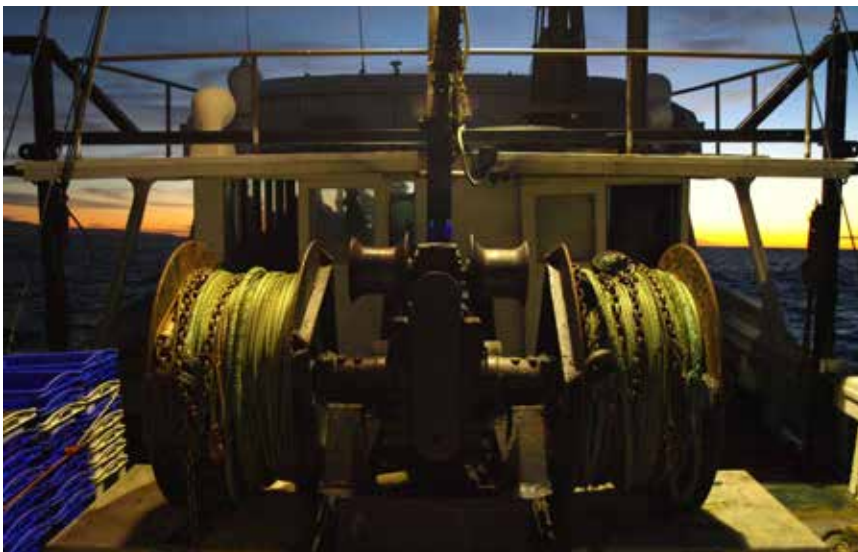
The western zone was most recently assessed in 2002. This assessment estimated that there was a greater than 90 per cent probability that the 2004 biomass was less than 30 per cent of the 1985 biomass. No evidence has been found of spawning aggregations in this region. A comparison of the age composition 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, SlopeRAG 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, SlopeRAG considered that the southern and western zones may be showing some level of recovery (SlopeRAG 2015b).

Stock status determination

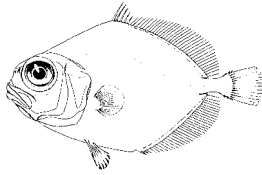
Previous assessments of orange roughy in the southern and western zones indicated that the stocks were substantially depleted, to below $0.2B_0$. Based on the age of the stock assessments for the southern and western zones, and the time since the areas have been closed to targeted orange roughy fishing, 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 the southern and western zone fisheries differed from those in the eastern zone, stocks in the southern and western zones 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**.



Trawl drums
Tristan New, AFMA

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



Line drawing: FAO

Stock structure

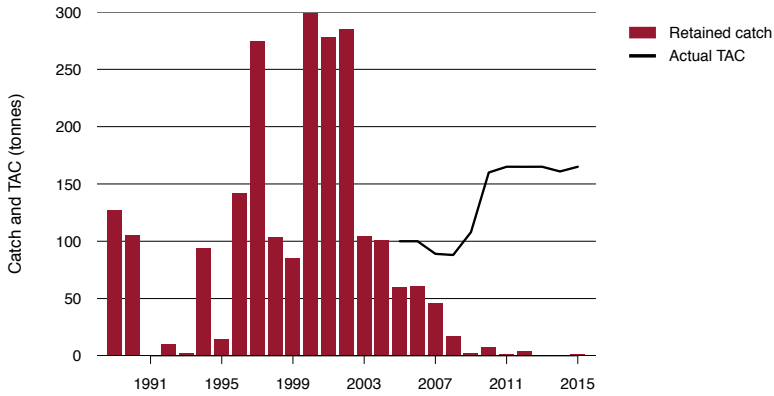
Little is known about the stock structure of smooth oreodory. For assessment and management purposes, smooth oreodory is treated as a single stock throughout the SESSF, excluding the Cascade Plateau and the South Tasman Rise, which are managed as separate stocks.

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.

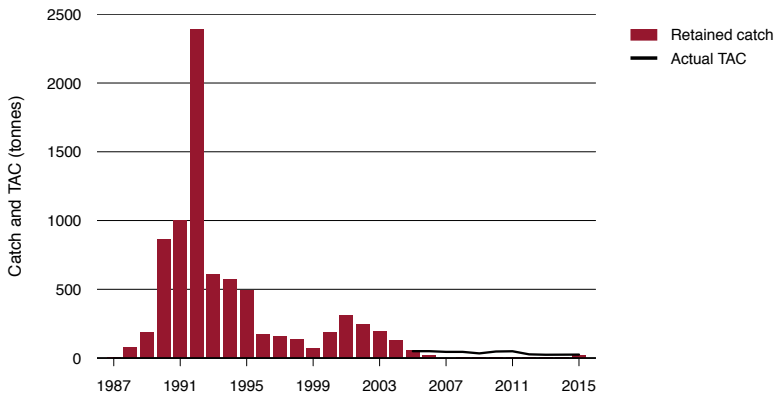
Catches of smooth oreodory on the Cascade Plateau reached maximum levels of 275–300 t in 1997, 2000, 2001 and 2002, but have otherwise remained below 100 t (Figure 9.40). From 2004 to 2009, Cascade Plateau smooth oreodory catches declined to low levels. No catches were reported in the 2014–15 season, and 1 t was landed in 2015–16. 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). Catches since then have been negligible, until the 2015–16 season, when 21 t was landed. Much of this increase in catch can be attributed to smooth oreodory taken in conjunction with orange roughy in the orange roughy southern zone.

FIGURE 9.40 Smooth oreodory annual catches (CTS) and fishing season TACs, Cascade Plateau, 1989 to 2015



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 2015



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

Stock assessment

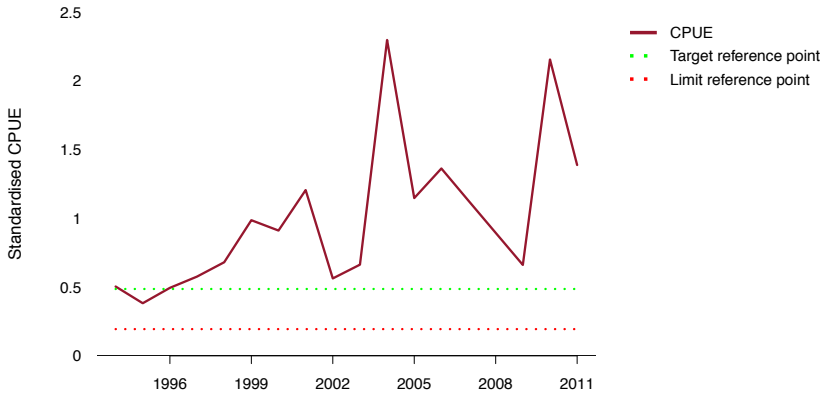
Smooth oreodory has been assessed using CPUE indices (tier 4) since 2008, using a target reference period of 1996 to 2005. Previous assessments concluded that standardised CPUE for smooth oreodory on the Cascade Plateau has remained above the target level since 1996 (Haddon 2012). The assessment for the Cascade Plateau was updated in 2011 and indicated that CPUE in 2011 was above the target reference point (Figure 9.42). However, this estimate was uncertain as a result of the low catch. 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 (SlopeRAG 2013a).

The CPUE for the non-Cascade Plateau stock remained above target until 2007 and then dropped below target (Haddon 2012). Standardised CPUE in 2011 apparently increased again to well above the target, but was uncertain (Figure 9.43). In the SSSF, most areas deeper than 700 m have been closed to trawling since July 2007 to promote rebuilding of orange roughy under the ORCP, which was replaced by the Orange Roughy Rebuilding Strategy in 2014. An estimated 54 per cent of the historical non-Cascade Plateau smooth oreodory catch came from these closed areas (Morison et al. 2013). In 2012, SlopeRAG concluded that, as a result of low catches, CPUE no longer reflected stock abundance and recommended a TAC of 20 t (SlopeRAG 2012). The large change-limiting rule prevented a decrease in the TAC to 20 t, and the TAC was set at 23 t for 2012–13. In the absence of adequate information to update the assessment in 2014, the TACs of 150 t (Cascade Plateau) and 23 t (non-Cascade Plateau) were retained for 2015–16.

In 2015, in response to work undertaken on alternative stock assessment options for data-poor fisheries (Haddon et al. 2015), SlopeRAG (2015a, b) 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 2015a). 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 a target depletion of $0.48B_0$, the analysis produced a yield estimate of 90 t, which would keep the stock above $0.35B_0$ at least 90 per cent of the time. Noting that the TAC of 23 t was somewhat arbitrary and that there are no sustainability issues, SlopeRAG recommended an RBC of 90 t for the 2016–17 fishing season and that the large change-limiting rule not be applied when calculating the TAC.

In 2015, SEMAC noted that catches of smooth oreodory might increase with the commencement of fishing for orange roughy in the eastern zone of the fishery (SEMAC 2015). The 90 t RBC for the 2016–17 fishing season is likely to be adequate to cover the anticipated increase in smooth oreodory catches taken in association with orange roughy fishing.

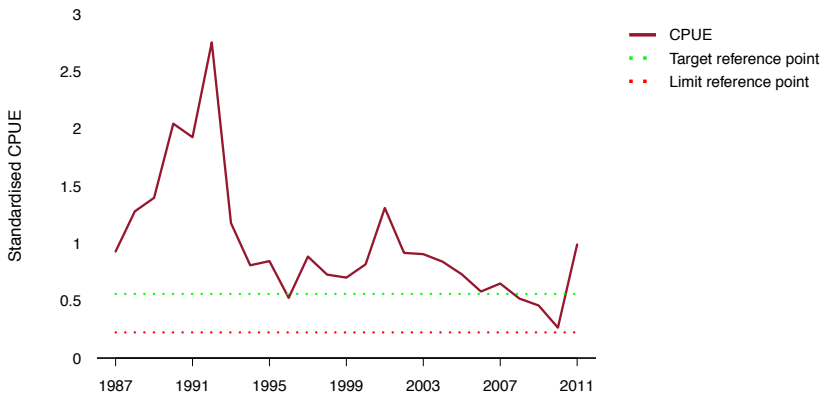
FIGURE 9.42 Standardised CPUE for smooth oreodory, Cascade Plateau, 1994 to 2011



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.

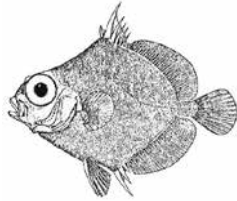
Source: Haddon 2012

Stock status determination

The CPUE throughout the history of the smooth oreodory fisheries has remained above the limit reference point and generally above the target reference point. CPUE has always remained above the target for the Cascade Plateau and only dropped below the target (but remained above the limit) for non-Cascade Plateau areas from 2008 to 2010. 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. Therefore, the smooth oreodory (Cascade Plateau and non-Cascade Plateau) stocks are both classified as **not overfished**.

Catches of Cascade Plateau and non-Cascade Plateau smooth oreodory were substantially higher during the decade up to 2006 than after 2006. Although catch in non-Cascade Plateau areas approached the TAC in 2015–16 in response to the recommencement of fishing for orange roughy in the eastern zone, the 2016–17 RBC of 90 t produced by the DBSRA is likely to be a more reliable indicator of the sustainable catch level than the current TAC (23 t). Given the limited effort on the Cascade Plateau and the current deepwater closures in other areas, the smooth oreodory (Cascade Plateau and non-Cascade Plateau) stocks are classified as **not subject to overfishing**.

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



Line drawing: FAO

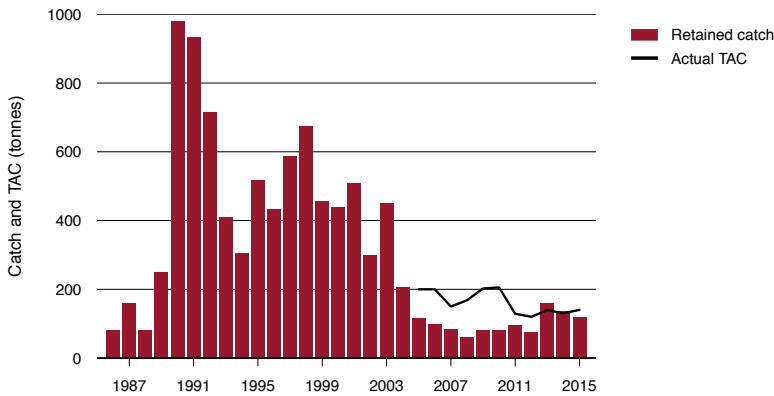
Stock structure

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

In the past five years, 80–97 per cent of the catch of other oreodories has been reported as spikey oreodory, and the remainder as other oreodory (Haddon 2013a). Catch peaked in 1990 at 980 t, but has since declined to around 100 t in recent years and was 141 t in 2015–16 (Figure 9.44).

FIGURE 9.44 Other oreodories annual catches (CTS) and fishing season TACs, 1986 to 2015



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 increased from 2012 to 2014, which is the most recent year of data (Sporcic 2015).

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) (SEMAG 2014). After consideration of discards, the RBC (and resulting TAC) for the 2015–16 season was reduced to 128 t (SlopeRAG 2015a).

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 2015) 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**. Despite the 2015–16 fishing season catch exceeding the TAC (and RBC) by slightly more than the 10 per cent overcatch provision allowed for under the SESSF harvest strategy, most of the historical fishing grounds are closed, which affords the stock protection. Therefore, the other oreodories 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.

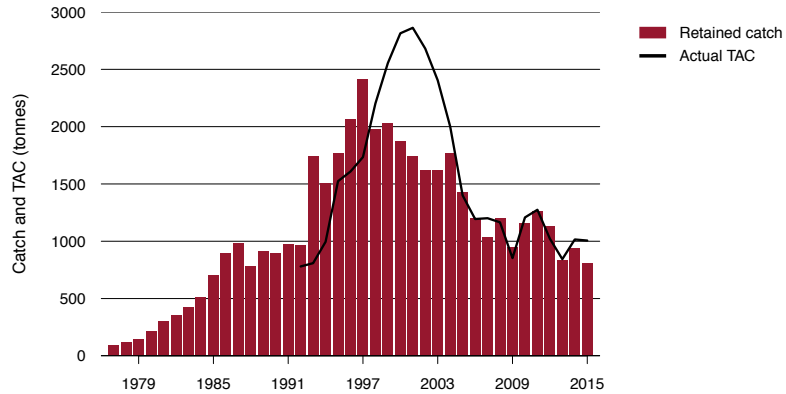
Catches of pink ling are managed under a single TAC. However, AFMA has management arrangements in place to constrain catches of the eastern stock to the eastern catch limit.

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. 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. The TAC was 834 t in 2013–14 (Figure 9.46), increased to 996 t in 2014–15 and was 980 t in 2015–16. Landed catches of pink ling in 2014–15 and 2015–16 were 967 t and 825 t, respectively. There was significant under-reporting of pink ling catches in logbooks for the 2014–15 and 2015–16 fishing seasons, with 873 t and 699 t, respectively, reported.

Estimated discards of pink ling were 3 per cent in 2013 and 6 per cent in 2014 (Upston & Thomson 2015). Estimates of discards are not yet available for 2015.

FIGURE 9.46 Pink ling annual catches (CTS, SHS and state combined) and fishing season TACs, 1977 to 2015



Notes: TAC Total allowable catch. Data for 2014 and 2015 do not include state data.

Source: Cordue 2013; Australian Fisheries Management Authority catch disposal records (2014 and 2015 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 was undertaken to provide 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 (SlopeRAG 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).

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, 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 2015–16 season, but with a TAC of 980 t and a tighter restriction on the daily catch allowance (175 kg per day).

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 .

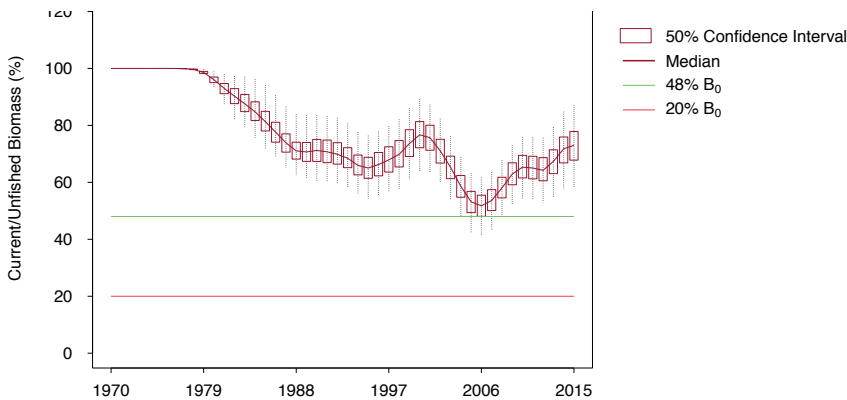
Source: Cordue 2013

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 SSSF 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).

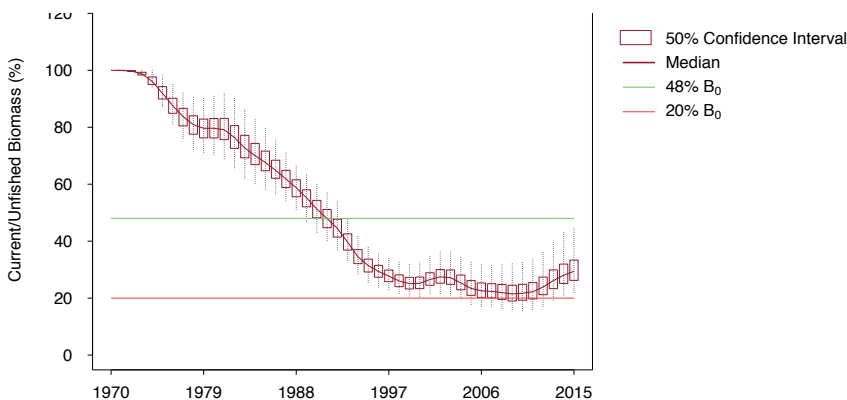
The Cordue (2013) assessment was updated in 2015 (Cordue 2015). The updated assessment estimated the eastern stock biomass in 2015 to be $0.30B_0$ and the western stock biomass in 2015 to be $0.72B_0$ (Figures 9.47 and 9.48). This produced RBCs for the 2016–17 fishing season of 250 t for the east and 990 t for the west. Constant-catch scenarios were run for the eastern stock and indicated that catches in excess of 550 t lead 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 ($0.48B_0$) (SlopeRAG 2015c). 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
250	0.35	0.48	0.01	0	2023
300	0.33	0.43	0.02	0.01	2026
350	0.31	0.38	0.04	0.04	2036
400	0.30	0.35	0.07	0.08	>2050
450	0.29	0.32	0.09	0.13	>2050
500	0.27	0.17	0.15	0.28	>2050

Notes: B_{2017}/B_0 Predicted biomass ratio in 2017. B_{2022}/B_0 Predicted biomass ratio in 2022. $B_{2017} < 0.2B_0$ Biomass below 20 per cent B_0 in 2017. $B_{2022} < 0.2B_0$ 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**. Nonetheless, eastern pink ling needs rebuilding towards the $0.48B_0$ target reference point.

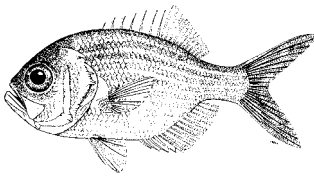
Assessments confirm that the western pink ling stock is above the target, with catches well below western RBC levels. As a separate stock, the western stock would be classified as not subject to overfishing.

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 2015–16 fishing season was 230 t, which was below the 337 t TAC that was derived from the constant-catch scenarios run as part of the 2013 stock assessment. 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_{R0}) 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**.

There is a significant level of under-reporting in logbooks for pink ling—according to AFMA catch disposal records, 825 t was landed in 2015–16, while only 699 t was reported in logbooks. This makes it difficult to assess the total level of fishing mortality because the 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.

Redfish (*Centroberyx affinis*)



Line drawing: FAO

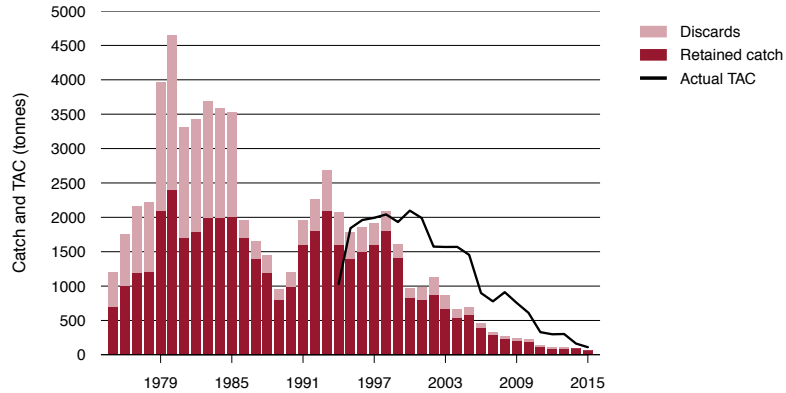
Stock structure

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 2015–16 catch was 49 t (Figure 9.49).

FIGURE 9.49 Redfish annual catches (CTS, SHS and state combined) and fishing season TACs, 1975 to 2015



Note: TAC Total allowable catch. Data for 2014 and 2015 do not include discards and state catch.

Source: Tuck & Day 2014; Australian Fisheries Management Authority catch disposal records (2014 and 2015 catch data)

Stock assessment

The redfish TAC has been progressively reduced since 2000. The TAC was 551 t in 2010–11, 276 t for the 2011–12 to 2013–14 seasons, and 138 t in 2014–15. Annual catches remained well below annual TACs from 2000 to around 2013 (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 and 67 t in 2014 (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 2015.

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 (ShelfRAG 2013a). Industry representatives confirmed that redfish were 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 2013b). 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 2013b). Updated standardised CPUE shows a small increase from 2012 to 2014 (Sporcic 2015).

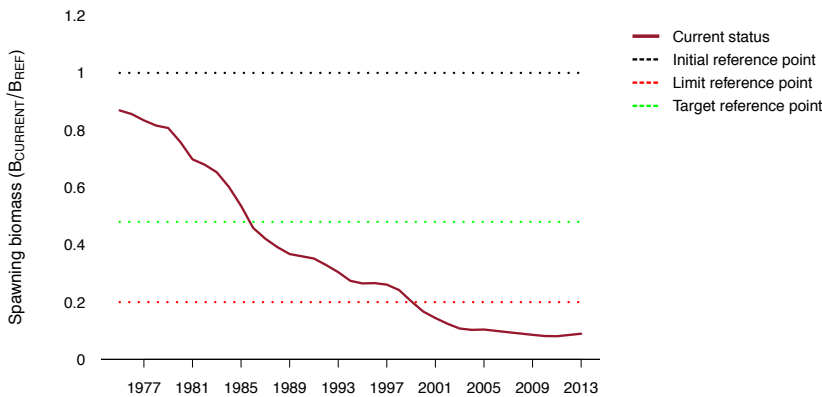
Based on the tier 4 assessment that excluded discards (Haddon 2013b), ShelfRAG recommended a zero RBC for the 2014–15 fishing season (ShelfRAG 2013a). After applying the large change-limiting rule, AFMA set the TAC for the 2014–15 season at 138 t.

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 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 2015–16 fishing season.

The 2015–16 catch was 49 t. The level of discarding of redfish has been variable in recent years, and increased to 67 t in 2014 (Upston & Thomson 2015). Estimates of discards are not yet available for 2015.

The stock is now managed under the Redfish Stock Rebuilding Strategy 2016–2021 (AFMA 2016), 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 stock spawning biomass for redfish, 1975 to 2013



Source: Tuck & Day 2014

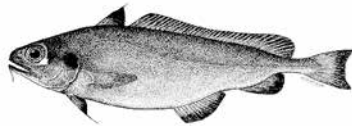
Stock status determination

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.

There are indications that total redfish fishing mortality in the 2014–15 fishing season may not have been constrained to within the 100 t incidental catch allowance recommended by ShelfRAG, or the 150 t limit run as part of the stock assessment. In the 2015–16 fishing season, the reduced catch means that total fishing mortality is likely to have been constrained to the 100 t or 150 t limits. However, because the total level of fishing mortality for the 2015–16 season is unknown, and recruitment is variable and uncertain, redfish remains classified as **uncertain if subject to overfishing**.

Ribaldo (*Mora moro*)



Line drawing: FAO

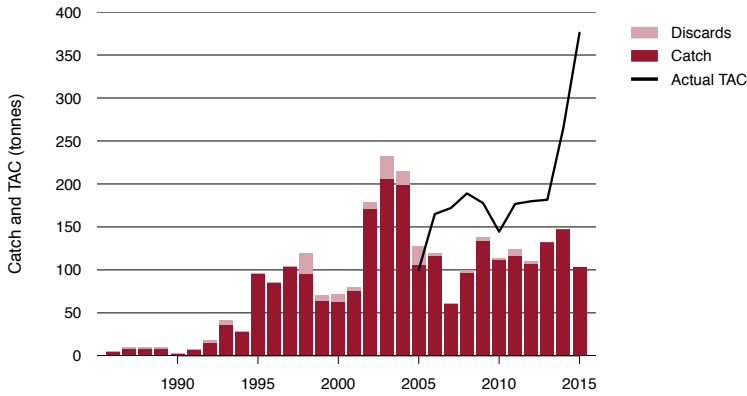
Stock structure

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. Discards for 2014 were estimated to be around 7 per cent of the catch (Upston & Thomson 2015). Estimates of discards are not yet available for 2015.

FIGURE 9.51 Ribaldo annual catches (CTS and SHS) and fishing season TACs, 1986 to 2015



Notes: TAC Total allowable catch. Data for 2013 to 2015 do not include discards.
 Source: Haddon 2013b; Australian Fisheries Management Authority catch disposal records (2013 to 2015 catch data)

Stock assessment

Ribaldo is assessed as a tier 4 stock using trawl CPUE (Morison et al. 2013). Ribaldo fits the criteria agreed by SESSFRAG 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 2013b). 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 (Figure 9.52). Throughout this period, catches have remained below the established TACs and below RBCs. The 2013 analysis produced an RBC of 355 t using the B_{40} target (Haddon 2013b). 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 (SlopeRAG 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. Catch in 2015–16 was 90 t.

FIGURE 9.52 Standardised CPUE for ribaldo, 1986 to 2012

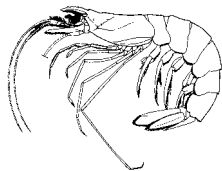
Notes: CPUE Catch-per-unit-effort. Standardised CPUE after 2012 is not shown because there has been no new tier 4 assessment.

Source: Haddon 2013b

Stock status determination

Standardised CPUE has remained stable or increased, and is above the target level. Catches have remained below established TACs and associated RBCs. Ribaldo is therefore classified as **not overfished** and **not subject to overfishing**.

Royal red prawn (*Haliporoides sibogae*)



Line drawing: FAO

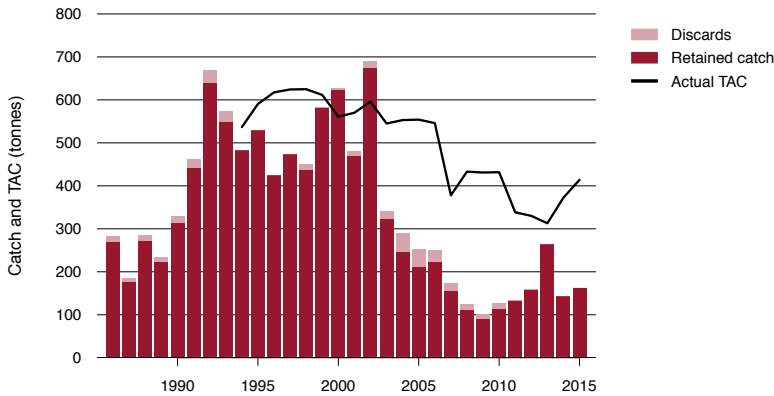
Stock structure

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

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 2015–16 fishing season was 183 t, which is just under half of the TAC of 386 t.

FIGURE 9.53 Royal red prawn annual catches (CTS and state combined) and fishing season TACs, 1986 to 2015

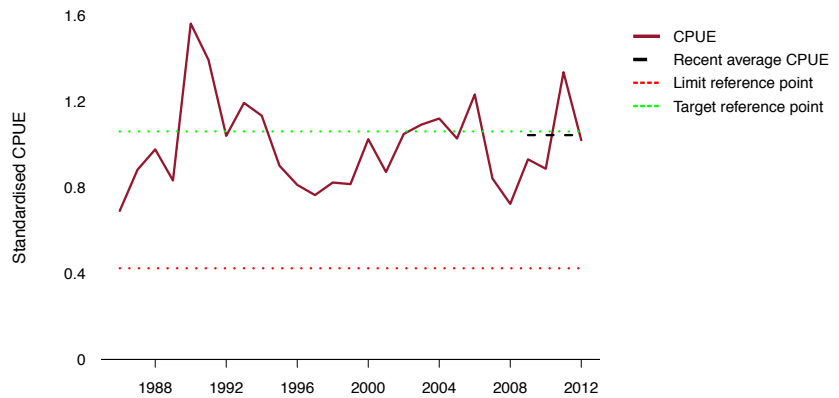


Note: TAC Total allowable catch. Data for 2013 to 2015 do not include discards and state catch. Source: Haddon 2013b; Australian Fisheries Management Authority catch disposal records (2013 to 2015 catch data)

Stock assessment

The RBC for royal red prawn is based on the most recent tier 4 assessment (Haddon 2013b) 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 2015–16 to 2016–17 fishing seasons. After deduction of discard estimates and state catch, the TAC was set at 386 t for the 2015–16 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

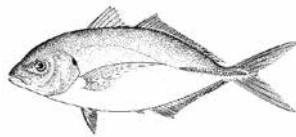
Notes: CPUE Catch-per-unit-effort. Standardised CPUE after 2012 is not shown because there has been no new tier 4 assessment.

Source: Haddon 2013b

Stock status determination

The recent average CPUE is close to 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** and **not subject to overfishing**.

Silver trevally (*Pseudocaranx georgianus*)



Line drawing: FAO

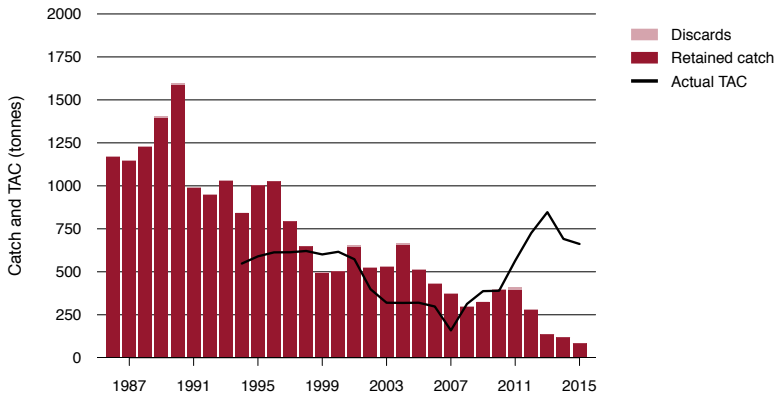
Stock structure

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 the 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 2013b). 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. Silver trevally is also a popular target for recreational fishers off south-eastern Australia; the recreational catch in New South Wales was estimated to be around 27 t in 2013–14 (West et al. 2015).

FIGURE 9.55 Silver trevally annual catches (CTS, SHS and state combined) and fishing season TACs, 1986 to 2015



Notes: TAC Total allowable catch. Data for 2013 to 2015 exclude discards and state data.
 Source: Haddon 2013b; Australian Fisheries Management Authority catch disposal records (2013 to 2015 catch data)

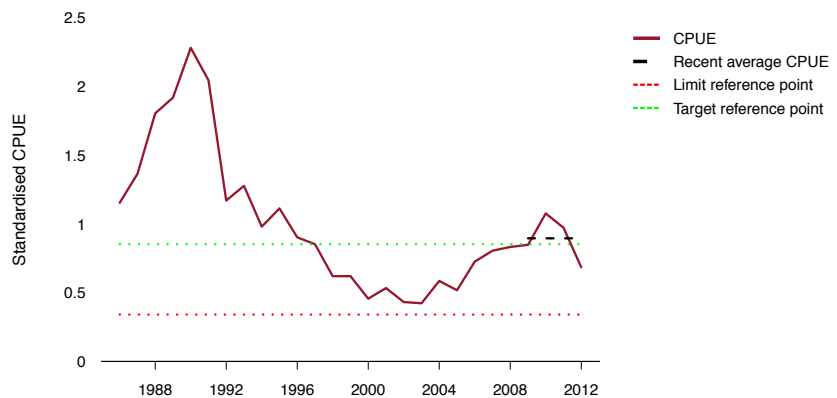
Stock assessment

The 2013 tier 4 assessment (Haddon 2013b) used the reference period 1992 to 2001, since high catch rates before 1992 (Figure 9.56) were not considered to be sustainable (Haddon 2013c). 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 2013b; Figure 9.56). The most recent tier 4 assessment (Haddon 2013b) 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 (ShelfRAG 2013a). AFMA subsequently set a three-year multiyear TAC of 615 t for the 2013–14 to 2015–16 seasons. After deduction for 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 2013b) 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 (ShelfRAG 2013a). However, adult silver trevally are highly mobile, and the inclusion of past marine park catches in RBC calculations assumes that silver trevally in these areas are fully available to fisheries outside the park.

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

FIGURE 9.56 Standardised CPUE for silver trevally, 1986 to 2012

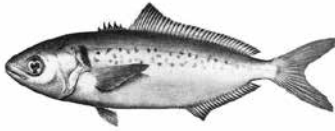


Notes: CPUE Catch-per-unit-effort. Standardised CPUE after 2012 is not shown because there has been no new tier 4 assessment.
Source: Haddon 2013b

Stock status determination

The four-year average standardised CPUE used for the most recent tier 4 assessment is near the target reference level, and catches in the past seven seasons have been well below the RBC. As a result, silver trevally is classified as **not overfished** and **not subject to overfishing**.

Silver warehou (*Seriolella punctata*)



Line drawing: FAO

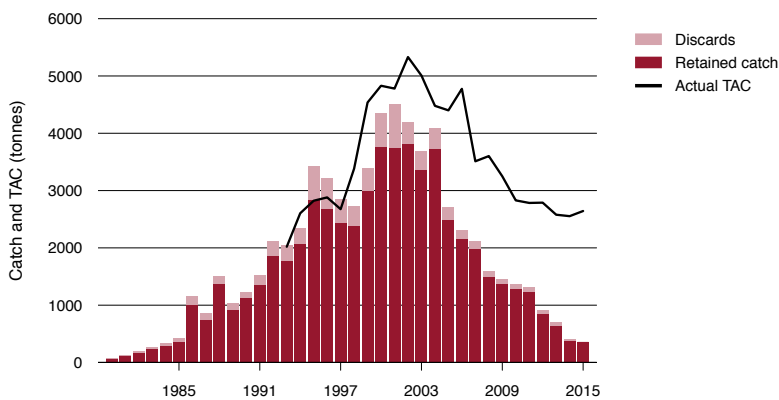
Stock structure

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.

FIGURE 9.57 Silver warehou annual catches (CTS, SHS and state combined) and fishing season TACs, 1980 to 2015



Notes: TAC Total allowable catch. Data for 2015 do not include discards and state catch.
 Source: Thomson et al. 2015b; Australian Fisheries Management Authority catch disposal records (2015 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 (SlopeRAG 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 did not fit 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 (SlopeRAG 2013a). However, the base-case assessment projected that the 2013 spawning stock biomass would be $0.47B_0$ (Figure 9.58), indicating that there was little immediate concern over stock status. Following SlopeRAG's recommendations, a three-year TAC of 2 329 t was established based on this assessment, starting in 2013–14.

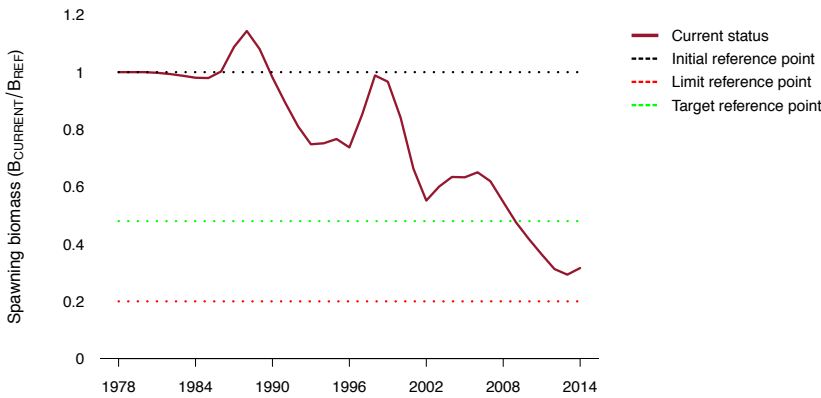
The CPUE breakout rule was again triggered in 2013 and 2014, as expected. SlopeRAG advised against repeating a full stock assessment, because there appeared to be a retrospective problem with the assessment, causing it to repeatedly overestimate biomass in recent years. SlopeRAG recommended that the 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 (SlopeRAG 2013a). The TAC was therefore retained at 2 329 t for 2014–15 and 2015–16. After deduction for state catches and discards, the 2015–16 TAC was set at 2 417 t.

A tier 1 assessment was undertaken in 2015 (Thomson et al. 2015b), which 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 (SlopeRAG 2015a). 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 (2015a) 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 (2015a) 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 2015c). Consequently, the TAC for the 2016–17 fishing season was set at 1 209 t.

FIGURE 9.58 Estimated spawning stock biomass for silver warehou, 1978 to 2014



Source: Thomson et al. 2015a

Stock status determination

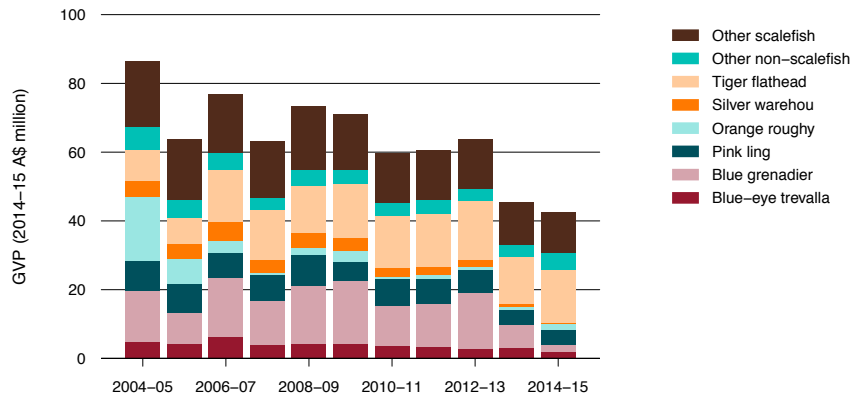
The 2015 stock assessment predicted spawning biomass in 2016 to be $0.4B_0$. The target reference point is $0.48B_0$. Catches have remained below TACs since 2006 and were 276 t in 2015–16. This catch was also below the low-recruitment constant-catch scenario that produced an updated 2016–17 RBC of 604 t. Silver warehou therefore remains classified as **not overfished** and **not subject to overfishing**.

9.3 Economic status

Key economic trends

The CTS and the SHS contributed approximately 56 per cent of total SESSF GVP (\$8 million) in 2014–15. Since 2005–06, the GVP for the two sectors has been lower than in previous years. In 2003–04, the real GVP from both sectors combined was \$82.3 million (2013–14 dollars; Figure 9.59). By 2005–06, it had fallen to \$62.7 million. A key driver of this reduction in scalefish GVP was a decline in the value of catch for orange roughy and blue grenadier. In 2003–04, orange roughy catches were valued at \$10.4 million (13 per cent of total GVP), and blue grenadier value was \$14.5 million (18 per cent of total GVP). By 2005–06, orange roughy GVP had declined to \$7.2 million, while blue grenadier value had declined to \$8.9 million. For orange roughy, this declining trend was due to TAC reductions to recover stocks. Between 2005–06 and 2012–13, scalefish GVP across both sectors fluctuated around an average of \$63 million, but has since fallen to \$41.9 million in 2013–14 and further to \$37.7 million in 2014–15. The main driver for this fall was an 88 per cent fall in the value of the blue grenadier catch due to declining prices (–64 per cent) and volume (–66 per cent) because a large vessel that had previously accounted for most of the catch did not participate in the fishery—this accounted for roughly two-thirds of the decline in GVP. The mix of species caught (in terms of value) was dominated by tiger flathead (\$15.4 million; 36 per cent of the total GVP) and pink ling (\$4.5 million; 11 per cent).

FIGURE 9.59 Real GVP, by key species, for the CTS and the SHS, 2004–05 to 2014–15



Note: GVP Gross value of production.

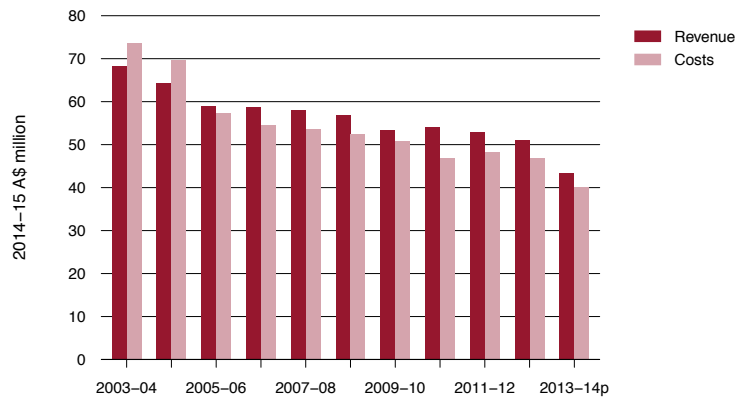
Estimates of the net economic returns (NER) associated with scalefish catches for the CTS and SHS combined are not available, because ABARES undertakes economic surveys of the CTS separately from the SHS (which is surveyed as part of the GHTS). However, the CTS accounts for the majority of scalefish catch in value terms. Estimates of NER for the CTS have been positive for the past seven financial years, increasing from \$1.8 million in 2005–06 to \$7.3 million in 2010–11, then falling to \$1.4 million in 2013–14 (2014–15 dollars; Figure 9.60). The reduction in NER since 2010–11 has been due to increasing costs, and a fall in fish prices between 2012–13 and 2013–14 (Skirtun & Green 2015). Although GDP has decreased, 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, by financial year, 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, by financial year, 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 another species' MEY. 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, elephantfish, john dory and sawshark.

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 $0.4B_0$). Tiger flathead, blue grenadier, pink ling and blue-eye trevalla accounted for 61 per cent of total GVP in both sectors in 2013–14. The biomass of these species, relative to their 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 50 per cent of unfished spawning biomass ($0.50SB_0$), the estimated biomass of tiger flathead in 2014 was above the MEY target. 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 these two stocks are currently not constraining NER, and NER could be increased 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 blue grenadier stock. In 2015, an updated stock assessment estimated that the western pink ling stock was significantly above the target reference point ($0.73B_0$), but below the target reference point in the east ($0.30B_0$). The combined east and west stocks of blue-eye trevalla are 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.

Two other species considered here are silver warehou and orange roughy. Silver warehou accounted for only 51 per cent of scalefish GVP in 2014–15, 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 2015, which is below the target of $0.48B_0$; however, latency is very high, with only 16 per cent of the 2014–15 TAC caught by fishers. This implies that NER are not constrained by stock size, and have instead fallen because of other factors, including consumer preferences. Although orange roughy accounted for only 4 per cent of the value of the scalefish catch in 2014–15, 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 fifth 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 2002–03, 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 2002–03. Although preliminary estimates for 2013–14 show some deterioration in economic performance, lower fuel prices 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 their 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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Blue-eye trevalla
Tamre Sarhan, AFMA

Chapter 10

East Coast Deepwater Trawl Sector

L Georgeson and J Savage

FIGURE 10.1 Management area of the East Coast Deepwater Trawl Sector, 2015–16 fishing season

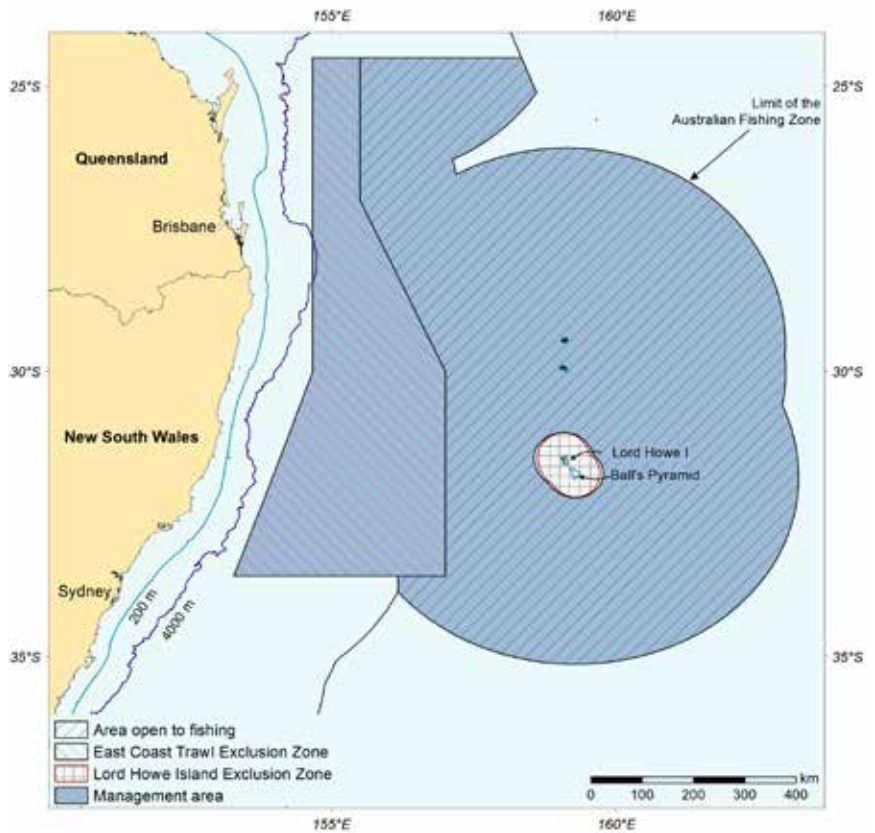


TABLE 10.1 Status of the East Coast Deepwater Trawl Sector

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Biological status					
Alfonsino (<i>Beryx splendens</i>)					No fishing mortality because catch and effort in 2015–16 were zero.
Economic status	A high level of latency indicates low net economic returns.				
Fishing mortality	■ Not subject to overfishing	■ Subject to overfishing	■ Uncertain		
Biomass	■ Not overfished	■ Overfished	■ Uncertain		

10.1 Description of the fishery

Area fished

The East Coast Deepwater Trawl Sector (ECDTS) began as an exploratory fishery in the early 1990s, primarily taking orange roughy (*Hoplostethus atlanticus*) in the Lord Howe Rise area (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 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 was no effort in the fishery in 2015–16.

TABLE 10.2 Main features and statistics for the ECDTS

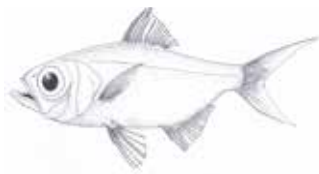
Fishery statistics a	2014–15 fishing season			2015–16 fishing season	
	TAC (t)	Catch (t)	Real value (2014–15)	TAC (t)	Catch (t)
Alfonsino	1 017	0	0	1 016	0
Total fishery	1 267 b	0	0	1 266 b	0
Fishery-level statistics					
Effort	0			0	
Fishing permits	10			10	
Active vessels	0			0	
Observer coverage	0			0	
Fishing methods	Demersal and midwater trawl				
Primary landing ports	Brisbane (Queensland), Sydney (New South Wales)				
Management methods	Input controls: limited entry, boat SFRs 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 2015–16 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

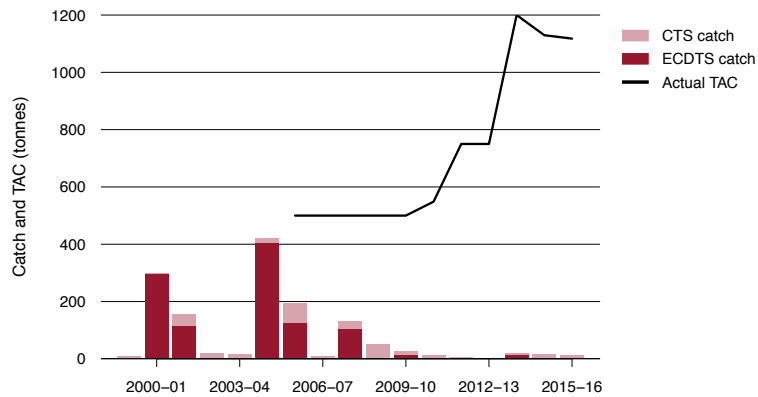
Alfonsino is a widely occurring pelagic species that aggregates around seamounts and features on the upper continental slope. Alfonsino in Australia's EEZ is currently managed as a single management unit across the CTS and the ECDTS, with a single total allowable catch (TAC) that applies only within 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 and 2005–06 (Figure 10.2).

The landed alfonsino catch from the ECDTS decreased from 15 t in 2013–14 to zero in 2014–15 and 2015–16, reflecting zero fishing effort. The 2015–16 alfonsino TAC was 1 016 t.

FIGURE 10.2 Catch and TAC for alfonsino in the ECDTS and the CTS, 1999–2000 to 2015–16

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

Stock assessment

The limited, patchy and highly variable nature of catch-and-effort data for alfonsino in the ECDTS resulted in the Slope Resource Assessment Group rejecting early attempts at a tier 4 assessment in 2007 and recommending that alfonsino be assessed under tier 3.

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 $F_{\text{CURR}} = 0.022$, well below the estimated $F_{\text{RBC}} = 0.149$ (Klaer 2013). Fishing mortality has been negligible because catches have remained well below the TAC each year; they were zero in 2015–16.

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 in the past two fishing seasons. 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 are not available for the ECDTS, and estimates of the sector's gross value of production have been confidential. There was no fishing activity in 2014–15 or 2015–16.

Management arrangements

The alfonsino TAC was reduced for the 2014–15 season to 1 017 t and was 1 016 t in 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.

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 unlikely to be high enough to justify a significant increase in fishing effort, implying that low prevail in the sector.

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 2014 (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 2015. 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.

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Chapter 11

Great Australian Bight Trawl Sector

A Moore, L Georgeson and J Savage

FIGURE 11.1 Relative fishing intensity in the Great Australian Bight Trawl Sector, 2015–16 fishing season

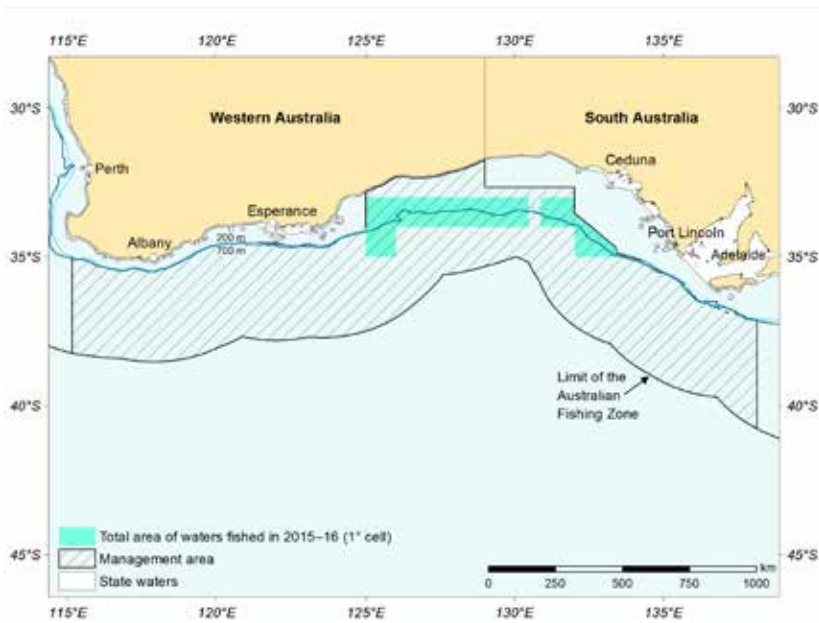


TABLE 11.1 Status of the Great Australian Bight Trawl Sector

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Bight redfish (<i>Centroberyx gerrardi</i>)					Catch is below RBC. Estimate of current biomass is above the target.
Deepwater flathead (<i>Platycephalus conatus</i>)					Catch is below RBC. Estimate of current biomass is near the target.
Ocean jacket (<i>Nelusetta ayraud</i>)					Catch has been stable in recent years. No formal assessment. Fishery-independent survey data indicate stock is not overfished.
Orange roughy (<i>Hoplostethus atlanticus</i>)					No commercial catch. No formal assessment of biomass, and impact of historical catches is uncertain.
Economic status	Net economic returns are likely to have increased slightly in 2014–15, because the positive impacts of lower effort and lower fuel price are likely to have offset the negative impact of falling gross value of production.				

Notes: RBC Recommended biological catch.

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



Trawl catch
Mike Gerner, AFMA

11.1 Description of the fishery

Area fished

The former Great Australian Bight Trawl Fishery was amalgamated with the Southern and Eastern Scalefish and Shark Fishery (SESSF) in 2003 to become the Great Australian Bight Trawl Sector (GABTS; Figure 11.1) of the SESSF.

The GABTS can be divided into a continental-shelf fishery (at depths of less than 200 m), an upper continental-slope fishery (at depths of about 200–700 m) and a deepwater fishery (on the mid- 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 trialed 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 215 t landed in 2015–16. Other byproduct species include angel shark (*Squatina* spp.), yellow-spotted boarfish (*Paristioporus 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 2015–16 fishing season.

Fishing effort

Total trawl fishing effort across all depths in 2015–16 was 13 509 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 11 317 trawl hours in 2015–16 (Figure 11.2), compared with 945 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. Three trawl vessels and one Danish-seine vessel operated in the fishery in 2015–16.

Catch

Reduced effort in the fishery has led to reduced catches of key target species over time. Deepwater flathead continues to dominate catches, with 604 t landed in the 2015–16 fishing season, which was 53 per cent of the TAC. Bight redfish landings in 2015–16 were 188 t, which was 8 per cent of the TAC.

FIGURE 11.2 Catch and effort on the GABTS shelf, 1988–89 to 2015–16

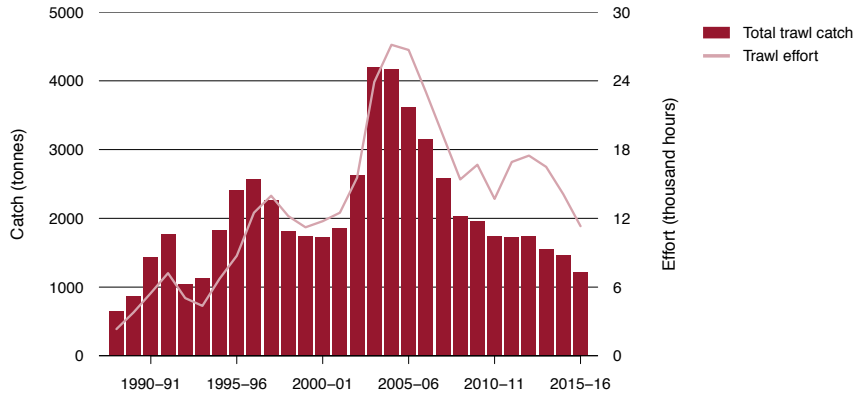


FIGURE 11.3 Catch and effort on the GABTS slope, 1988–89 to 2015–16

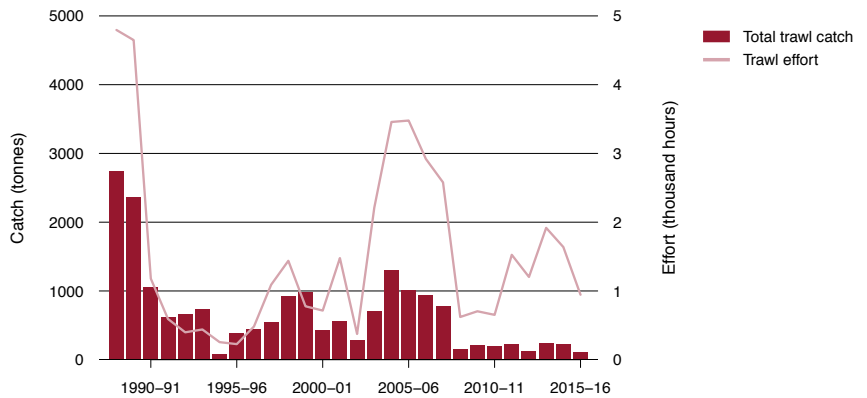


TABLE 11.2 Main features and statistics for the GABTS

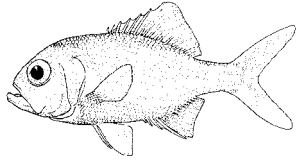
Fishery statistics ^a	2014–15 fishing season			2015–16 fishing season		
	TAC (t)	Catch (t)	Real value (2014–15)	TAC (t)	Catch (t)	Real value (2015–16)
Bight redfish	2 358	260	\$1.3 million	2 358	188	na
Deepwater flathead	1 150	681	\$4.2 million	1 150	604	na
Ocean jacket	–	184	\$0.4 million	–	215	na
Orange roughy ^b	0 (200, 50)	0 (0, 0)	0	0 (200, 50)	0 (0, 0)	na
Total	3 508 (250) ^c	1 125	\$8.5 million	3 508 (250) ^c	1 007	na
Fishery-level statistics						
Effort	15 820 trawl hours; 553 shots			13 509 trawl hours; 414 shots		
Fishing permits (SFRs)	10			10		
Active vessels	5 trawl; 1 seine			3 trawl; 1 seine		
Observer coverage ^d	635 trawl hours (3.68%)			182 trawl hours (1.35%)		
Fishing methods	Trawl, Danish-seine					
Primary landing ports	Port Lincoln, Thevenard, Adelaide (South Adelaide)					
Management methods	Input controls: limited entry, area closures, gear restrictions Output controls: ITQs, TACs, trigger limits					
Primary markets	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 2015–16 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. TAC Total allowable catch. – Not applicable.

11.2 Biological status

Bight redfish (*Centroberyx gerrardi*)



Line drawing: FAO

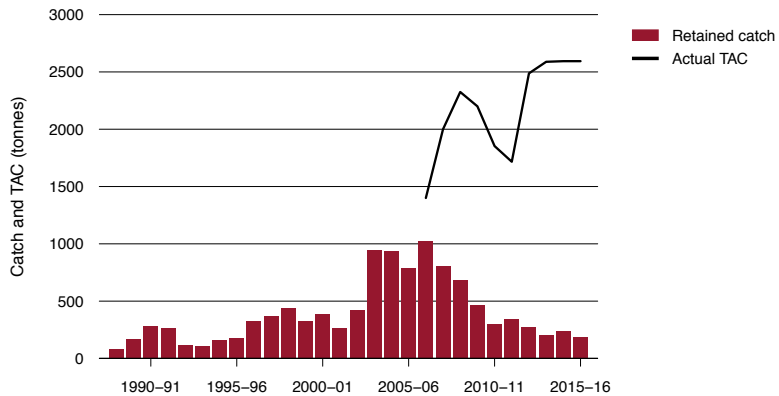
Stock structure

The biological stock structure of bight redfish 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 2015–16 fishing season was 188 t (Figure 11.4).

FIGURE 11.4 Catch and TAC of bight redfish in the GABTS, 1988–89 to 2015–16



Note: TAC Total allowable catch.

Stock assessment

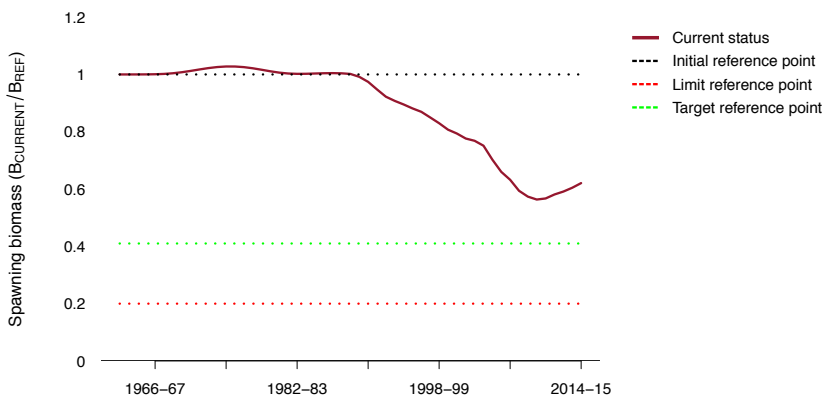
The target reference point for bight redfish of 41 per cent of the unfished spawning stock biomass ($0.41SB_0$; Kompas et al. 2012) was accepted by the Great Australian Bight Resource Assessment Group in 2011 (AFMA 2011). The 2011 tier 1 stock assessment for bight redfish (Klaer 2011) was updated in 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, well above the target reference point of $0.41B_0$. 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. 2011, 2009, 2008). 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 suggest a reduction in the abundance of older redfish in recent years.

Using the Klaer (2011) stock assessment, the long-term RBC was estimated at 2 358 t. No discount factors were applied, and so the multiyear TAC of 2 358 t was retained for the 2015–16 fishing season. 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 would prevent a reduction in the 2016–17 fishing season TAC to these levels.

FIGURE 11.5 Estimated spawning biomass of bight redfish in the GABTS, 1962–63 to 2014–15

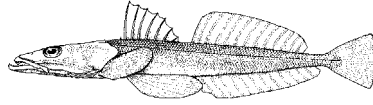


Source: Haddon 2015

Stock status determination

The decrease in estimated female spawning biomass, combined with decreases in relative abundance measures from the fishery-independent survey and a reduction in older year classes is concerning and likely to reflect earlier fishing pressure. However, 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

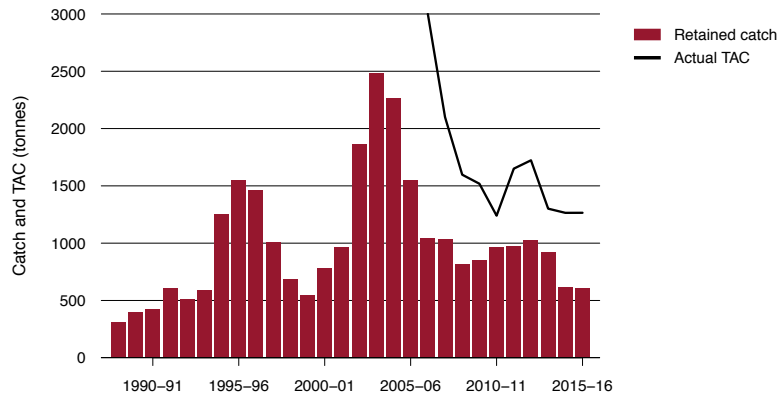
Stock structure

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 2015–16 fishing season was 604 t (Figure 11.6).

FIGURE 11.6 Catch and TAC of deepwater flathead in the GABTS, 1988–89 to 2015–16



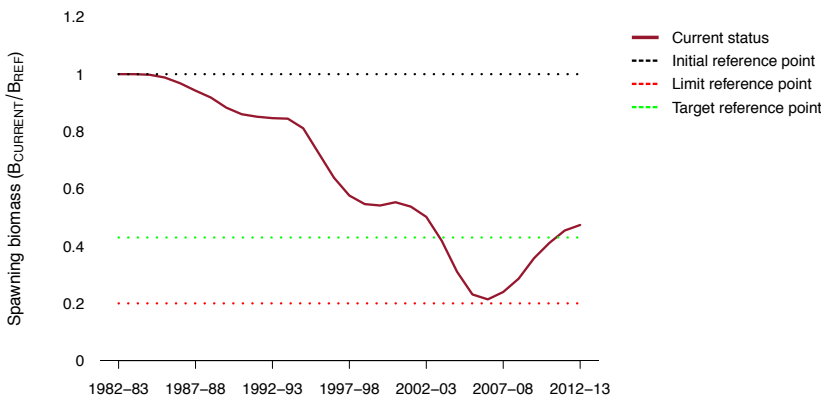
Note: TAC Total allowable catch.

Stock assessment

The most recent tier 1 integrated stock assessment for deepwater flathead in the GABTS (Figure 11.7; Klaer 2013) predicted spawning biomass in 2014–15 to be 45 per cent of the unfished spawning stock biomass ($0.45SB_0$), close to the target reference point of $0.43SB_0$. 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 2015–16 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. 2015, 2011, 2009). Without an updated assessment, it is unclear whether this decrease is due to changes in the biomass of the stock or the availability of deepwater flathead on the fishing grounds. The data from the fishery-independent survey will be incorporated into the next tier 1 assessment, to be undertaken in 2016. 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 (Knuckey et al. 2015).

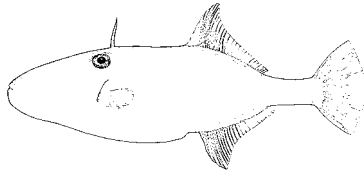
FIGURE 11.7 Estimated spawning biomass of deepwater flathead in the GABTS, 1982–83 to 2012–13



Stock status determination

The 2015 fishery-independent survey suggests a decrease in relative biomass compared with previous surveys. However, the most recent stock assessment (2013) predicted spawning biomass in 2014–15 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

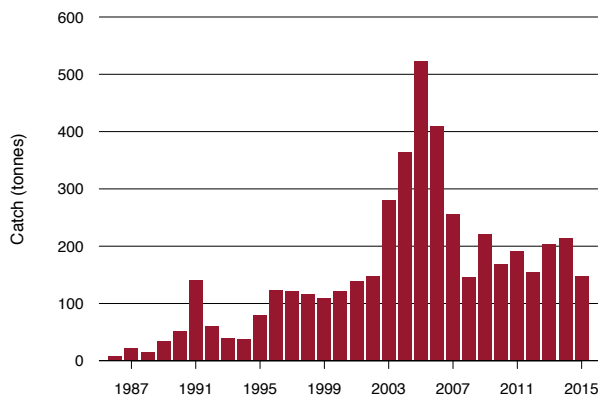
Stock structure

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 2015–16 fishing season was 215 t.

FIGURE 11.8 Ocean jacket catch in the GABTS, 1986 to 2015



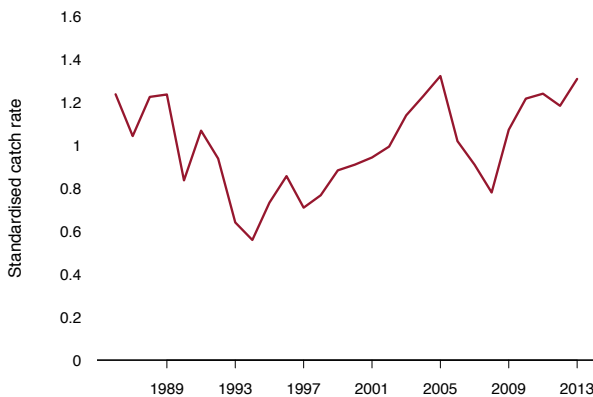
Stock assessment

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. 2011, 2009, 2008). 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), raising concerns about 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

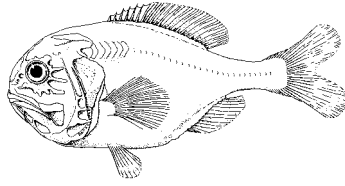


Source: Sporic & Haddon 2015

Stock status determination

No formal stock assessment for ocean jacket in the GABTS has been done. However, life history characteristics suggest that it is unlikely that the stock is overfished. The level of catch in 2015–16 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

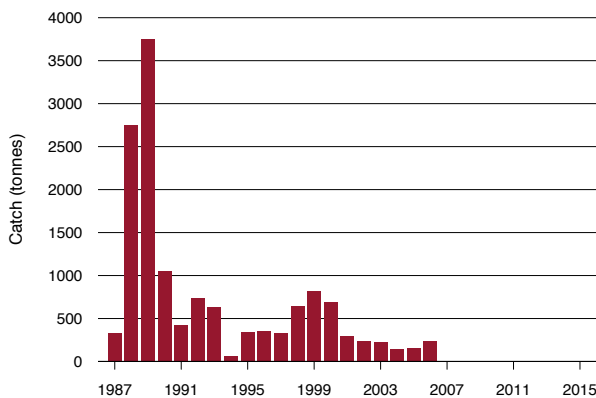
The stock structure of orange roughy in the Australian Fishing Zone (AFZ) is unresolved. Based on the existing data and fishery dynamics, multiple regional stocks of orange roughy are assumed, and the fishery is managed and assessed as a number of discrete regional management units, shown in Figure 9.34 (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 survey 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 2015–16 fishing season.

FIGURE 11.10 Orange roughy catch in the GABTS, 1987 to 2015



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 programme 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**.

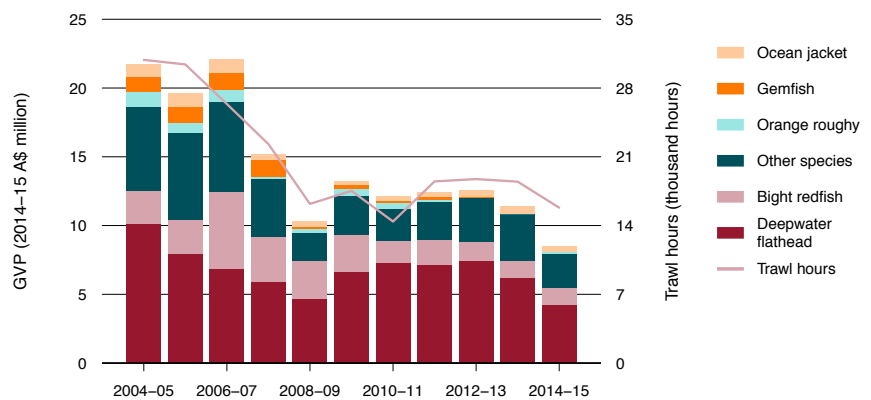
11.3 Economic status

Key economic trends

Estimates of net economic returns (NER) for the GABTS are not available. The sector’s real gross value of production (GVP) increased from \$21.8 million in 2004–05 to a peak of \$22.1 million in 2006–07 (2014–15 dollars; Figure 11.11). With declines in the sector’s catch, GVP declined substantially in the two years after 2006–07, falling to \$10.4 million in 2008–09, and then increased in 2009–10 to \$13.2 million. GVP for the fishery remained steady at \$12 million for the four years to 2013–14, but declined by 26 per cent in 2014–15 to \$8.5 million. In 2014–15, deepwater flathead contributed \$4.2 million (50 per cent of total GVP), and bight redfish contributed \$1.3 million (15 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 past decade (Figure 11.11). Hours trawled decreased from 30 866 hours in 2004–05 to 18 468 hours in 2013–14. Hours trawled declined by a further 14 per cent in 2014–15 to 15 820 hours. The decline in effort in 2014–15 coincided with a 20 per cent fall in the fuel price. Although GVP declined by 26 per cent in 2014–15, the decline in effort and unit fuel price suggests that cost in the fishery fell faster than revenue in 2014–15, suggesting an increase in profitability.

FIGURE 11.11 Real GVP for the GABTS by key species and trawl hours, 2004–05 to 2014–15



Notes: GVP Gross value of production. Trawl hours do not include Danish-seine effort. One Danish-seine vessel was active in 2012–13 and 2013–14.

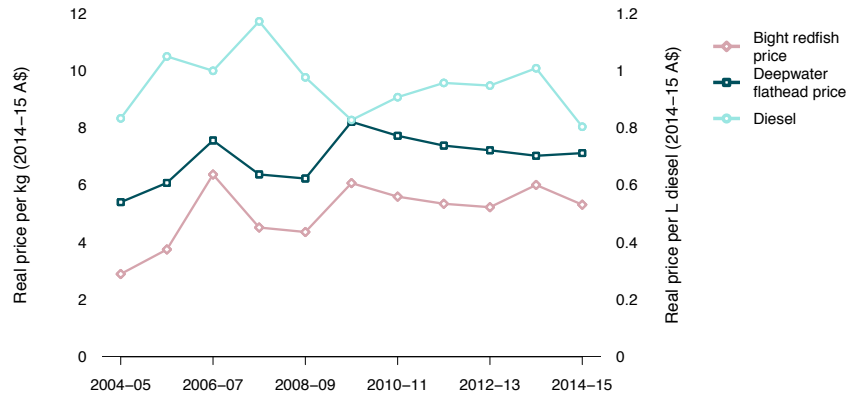
Although lower catches have driven the decrease in GVP in recent years, this has been partially offset by increasing prices received for key species caught in the sector (Figure 11.12). Higher prices in 2009–10, which are considered to partially reflect improvements in product quality (GABMAC 2010, 2009), drove the increase in GVP between 2008–09 and 2010–11. Average prices in 2014–15 were \$7.11 per kilogram for deepwater flathead and \$5.31 per kilogram for bight redfish, up from \$5.40 per kilogram for deepwater flathead and \$2.90 per kilogram for bight redfish (2014–15 dollars) in 2004–05.

Trawling—the main method used in the sector—is typically fuel-intensive. Fluctuations in fuel prices are therefore likely to be a key driver of sector profitability. The Australian average off-road diesel price followed an increasing trend over the decade (Figure 11.12). It peaked in 2007–08 at \$1.17 per litre, before declining to \$1.00 per litre in 2013–14, and then fell sharply in 2014–15 to \$0.80 per litre (all expressed in 2014–15 dollars). High fuel prices can negatively affect profitability, but increases in fish prices since 2003–04 and the significant fall in fuel prices in 2014–15 have reduced this impact. A Danish-seine vessel also operates in the fishery.



Deck of trawler
Mike Gerner, AFMA

FIGURE 11.12 Annual average prices for deepwater flathead and bight redfish, and annual average off-road diesel price, 2004–05 to 2014–15



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. For the 2015–16 fishing season, 604 t (53 per cent) of the 1 150 t TAC for deepwater flathead was caught; for bight redfish, only 188 t (8 per cent) of the 2 358 t TAC was caught. Market prices for bight redfish are sensitive to supply (Kompas et al. 2012), so this 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, industry has voluntary trip limits in place for bight redfish.

The GABTS began a trial of fishery co-management in July 2009 (AFMA 2012). 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 GABTS operators (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 2013–14 to be above the target (Klaer 2012, 2011), 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 (Klaer 2013). 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 2012 and 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. South East Trawl Fishing Industry (SETFIA) has also introduced a code of conduct and training programme to improve seabird avoidance measures, and undertook a trial of 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 has 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. Four interactions with species protected under the EPBC Act were reported in the GABTS in 2015. Two interactions were reported with shy albatross (*Thalassarche cauta*), both of which were reported to be dead. One interaction was reported with an unidentified shearwater, which was reported to be dead. One interaction was reported with a New Zealand fur seal (*Arctocephalus forsteri*), which was reported to be alive.

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Chapter 12

Shark Gillnet and Shark Hook sectors

N Marton and R Green

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, 2015–16 fishing season

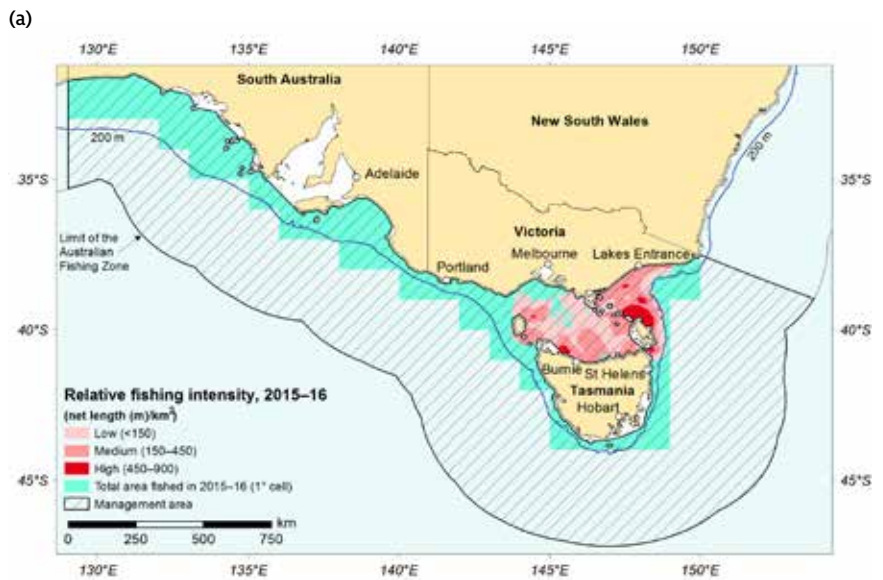
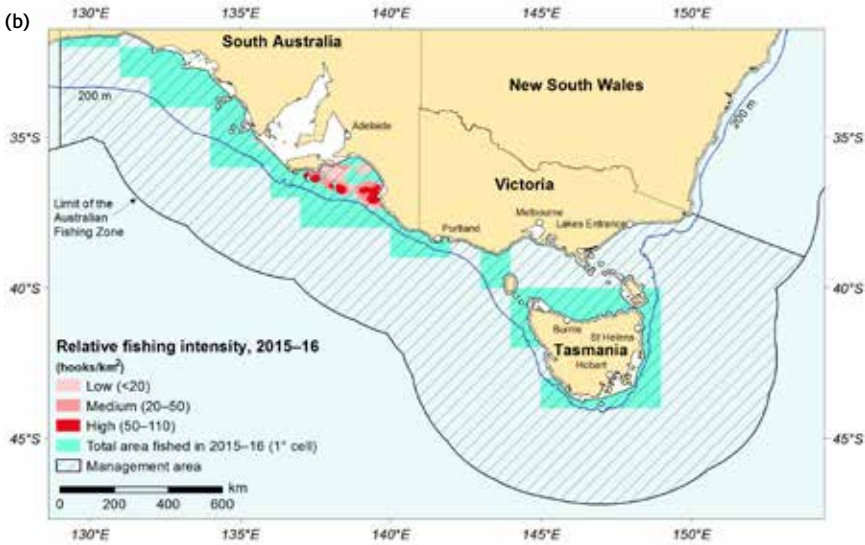


FIGURE 12.1 Relative fishing intensity in (a) the Shark Gillnet Sector and (b) the Shark Hook Sector of the Southern and Eastern Scalefish and Shark Fishery, 2015–16 fishing season continued ...



Gummy shark
AFMA

TABLE 12.1 Status of the Shark Gillnet and Shark Hook sectors

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Elephantfish (<i>Callorhinchus milii</i>)					CPUE is above target; catch is below RBC.
Gummy shark (<i>Mustelus antarcticus</i>)					Catch is below RBC. Estimates of pup production are close to or above the target.
Sawshark (<i>Pristiophorus cirratus</i> , <i>P. nudipinnis</i>)					CPUE is above target; catch is below RBC.
School shark (<i>Galeorhinus galeus</i>)					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 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.				

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 a variety of line methods to target gummy shark (*Mustelus antarcticus*). Elephantfish (*Callorhinchus milii*) and sawsharks (*Pristiophorus cirratus* and *P. nudipinnis*) are byproducts from the gummy shark fishery. School shark (*Galeorhinus galeus*) 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*), spotted swellshark (*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, 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% of all hauls are reviewed to verify the accuracy of logbooks. In addition, gillnet boats operating off South Australia are subject to 100% review of video footage for interactions with protected species. Logbooks must be completed for 100 per cent of shots.

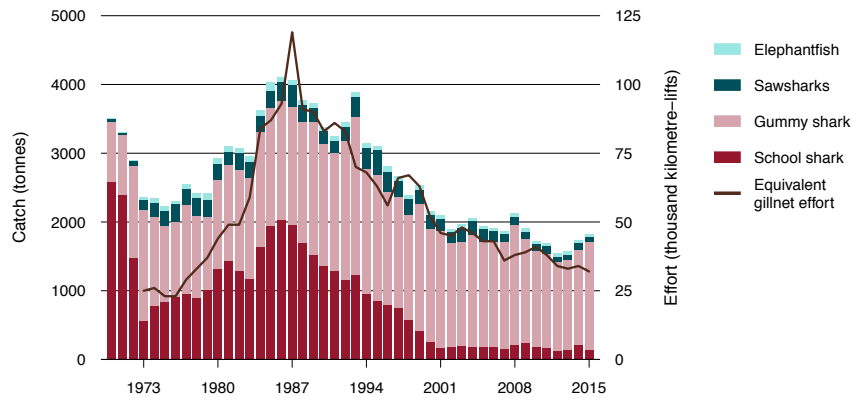
Fishing effort

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. The majority 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 2015



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 2015

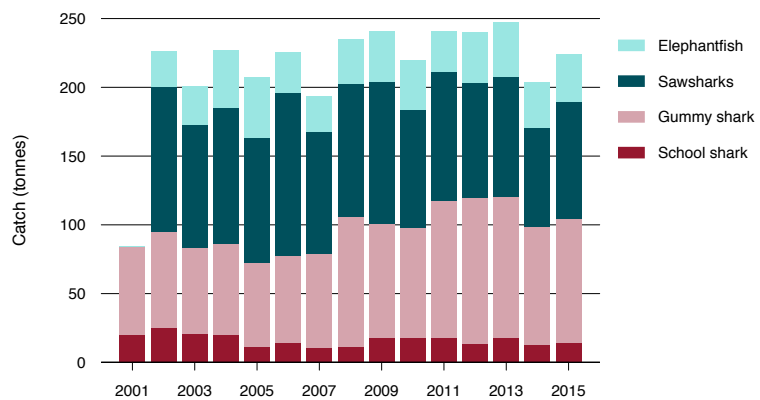


TABLE 12.2 Main features and statistics for the SGSHS

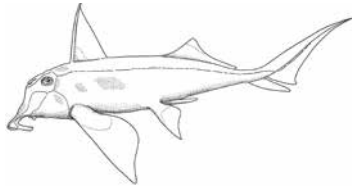
Fishery statistics a		2014–15 fishing season		2015–16 fishing season	
Stock	TAC (t)	Catch (t) (GHTS, CTS)	Real value (2014–15) (GHTS, CTS)	TAC (t)	Catch (t) (GHTS, CTS)
Elephantfish	109	73 (36, 37)	\$0.1 million (<\$0.1 million, <\$0.1 million)	163	67 (35,32)
Gummy shark	1 836	1 530 (1 395, 135)	\$14.6 million (\$13.7 million, \$0.9 million)	1 836	1 798 (1 667, 131)
Sawsharks	459	202 (93, 109)	\$0.5 million (\$0.3 million, \$0.2 million)	482	187 (93, 94)
School shark	215 b	200 (186, 14)	\$1.7 million (\$1.6 million, \$0.1 million)	215 b	181 (165, 16)
Total fishery	2 619	2 005 (1 710, 295)	\$16.9 million (\$15.6 million, \$1.3 million)	2 696	2 233 (1 960, 273)
Fishery-level statistics					
Effort	Gillnet: 33 694 km of net hauled Hook: 2 256 098 hooks set			Gillnet: 30 645 km of net hauled Hook: 1 975 090 hooks set	
Fishing permits (SFRs) c	Gillnet: 61 Hook: 13			Gillnet: 61 Hook: 13	
Active vessels	Gillnet: 40 Hook: 29			Gillnet: 37 Hook: 24	
Observer coverage d	Gillnet: 1 003 km (3.0%) Hook: na			Gillnet: 10% Hook: 10%	
Fishing methods	Demersal gillnet, demersal longline, dropline, mechanised handline, auto-longline				
Primary landing ports	Adelaide, Port Lincoln, Robe (South Australia); Lakes Entrance, San Remo, Port Welshpool (Victoria); Devonport, Hobart (Tasmania)				
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 2015–16 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 hauls are reviewed to verify the accuracy of logbooks. In addition, gillnet boats operating off South Australia 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. na Not available. TAC Total allowable catch (for the entire Southern and Eastern Scalefish and Shark Fishery fishery).

12.2 Biological status

Elephantfish (*Callorhinchus milii*)



Line drawing: Karina Hansen

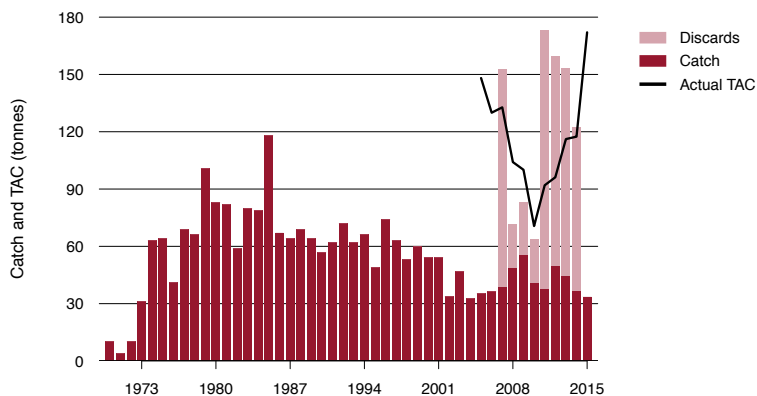
Stock structure

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 2015–16 in the Gillnet, Hook and Trap Sector (GHTS) and the Commonwealth Trawl Sector (CTS) decreased to 67 t (Table 12.2). In the 2014 calendar year, 86 t was reported as discards (Upston & Thomson 2015). Discard rates for the stock have not been well documented or estimated in the past, but this has improved in recent years. There are reports that 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 them to have increased from 29 t in 2002 to 45 t in 2008 and then been a constant 45 t per year for the period 2008–2014 (Sporcic & Thomson 2015).

FIGURE 12.4 Annual elephantfish catch and fishing season TAC in the SGSHS, 1970 to 2015



Notes: TAC Total allowable catch. Actual TAC includes carryover from previous season (undercatch/overcatch). Discard data 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).

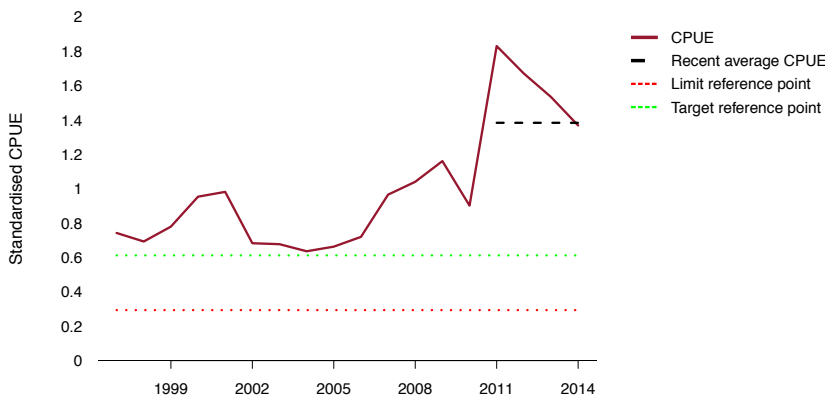
In 2014, SharkRAG recommended a decrease in the virgin biomass target (B_{TARG}) from 48 per cent to 40 per cent (AFMA 2014a). In recommending the decrease in B_{TARG} , SharkRAG noted that elephantfish is currently a byproduct species in the gillnet sector and that commercial catch largely depends on effort targeted at gummy shark (AFMA 2014a). SharkRAG further noted that they were not concerned about the sustainability of elephantfish. SharkRAG recommended the lower B_{TARG} in 2015 (AFMA 2015a).

Four alternative tier 4 assessments of elephantfish were conducted in 2015 using data up to 2014: 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 for the period 2008–2014 (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 dataset 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).

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) as this was thought to be more conservative than other scenarios (AFMA 2015b). This resulted in an RBC of 306 t. In converting this to a total allowable catch (TAC), it was constrained by the large change rule (which limits increases in TAC to 1.5 times the previous year’s TAC).

The TAC for the 2015–16 season was set at 163 t. In comparison, the landed catch of elephantfish in the 2015–16 season was 67 t. Discarding rates have been reasonably consistent in the past four years, at 57–67 per cent of total catches (Upston & Thomson 2015).

FIGURE 12.5 Standardised gillnet CPUE index (including discards) for elephantfish in the SGSHS, 1997 to 2014

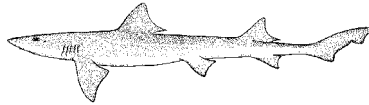


Notes: CPUE Catch-per-unit-effort. Discard data only available by calendar year and for the period 2007 to 2014. Source: Sporcic & Thomson 2015

Stock status determination

The average recent CPUE for elephantfish was estimated to be above the target and well above the limit. On this basis, the stock is assessed as **not overfished**. Catch in the 2015–16 season, including consideration of the potential level of discards, was below the TAC and below the 2015–16 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

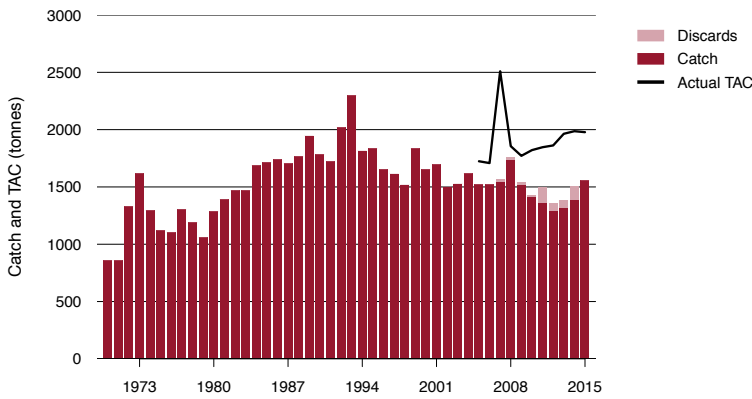
Stock structure

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 (Thomson & Sporcic 2013) 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. It dropped to a low of 1 288 t in 2012 before increasing since then to 1 667 t in 2015 (Figure 12.6). Total Commonwealth catch (including from the CTS) in 2014–15 was 1 798 t. Estimates of discards have been stable in recent years, at 3–6 per cent of total catch. Discards were reported as 114 t in the 2014 calendar year (Upston & Thomson 2015).

FIGURE 12.6 Annual gummy shark catch and fishing season TAC in the SGSHS, 1970 to 2015



Notes: TAC Total allowable catch. Actual TAC includes carryover from previous season (undercatch/overcatch). Discard data only available by calendar year and for the period 2007 to 2014.

Stock assessment

The most recent update of the integrated stock assessment model for gummy shark was in 2013, using data to the end of 2012 (Thomson & Sporcic 2013). Updated inputs to the assessment included landings data from 2010–12, adjustments to landings data from 2006 to 2009 for trawl and line methods, length-frequency data, and CPUE data. 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 the number of pups, and the number and length of females.

The gillnet closures off South Australia have influenced catch and CPUE of gummy shark in this area. The closures may also have influenced catch and CPUE off Victoria, as a result of less experienced operators moving from South Australia to Victoria. Given these changes, there was concern that the South Australian CPUE data were less reliable as an index of abundance in recent years (Thomson & Sporcic 2013). Consequently, South Australian CPUE data after 2009 are not included in the model.

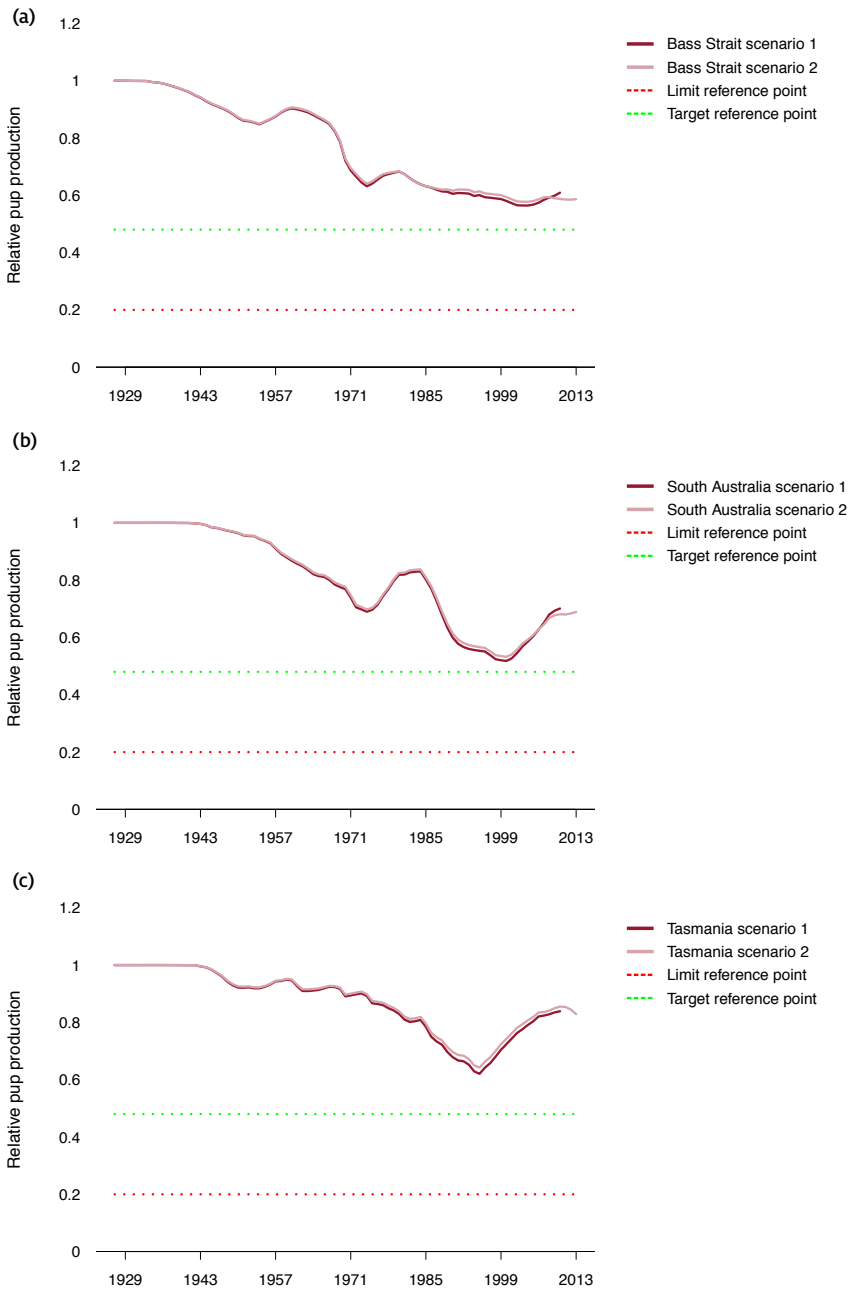
The base-case assessment estimated 2012 pup production as a proportion of the unfished level of pup production (1927) to be above $0.48P_0$ (48 per cent of virgin pup production) for all three gummy shark populations: $0.59P_0$ for Bass Strait (Figure 12.7a), $0.69P_0$ for South Australia (Figure 12.7b) and $0.83P_0$ for Tasmania (Figure 12.7c). The sensitivities of the model to density dependence was examined through seven alternative models. Four of the seven alternative models estimated pup production to be below $0.48P_0$ in Bass Strait (range $0.31P_0$ to $0.64P_0$), while the alternative models were all above $0.48P_0$ for South Australia (range $0.54P_0$ to $0.89P_0$) and Tasmania (range $0.69P_0$ to $0.83P_0$).

Different gear types are known to have different selectivities, which result in differences in the average size of sharks caught. Consequently, a range of RBCs were initially calculated, based on different catch proportions taken by line and gillnet (Thomson & Sporicic 2013). The estimated RBC decreased when the proportion of catch taken by line was higher (AFMA 2013a). An RBC of 2 010 t for 2014–15 was calculated based on the 2013 catch proportions for gear (100 per cent of catch taken from Tasmania and Bass Strait attributed to gillnet, and 75 per cent of catch in South Australia attributed to line). This RBC was above the historical average catch for the fishery. As a result, SharkRAG recommended retaining the (lower) 2013–14 TAC of 1 836 t for the 2014–15 to 2016–17 seasons as a three-year (multiyear) TAC (AFMA 2013a). 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 2015–16 was 1 798 t, below the 2015–16 TAC.



Gillnet vessel
AFMA

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, 1929 to 2013

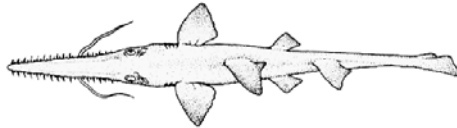


Note: Scenario 1 refers to the base-case scenario from the 2010 assessment (Punt & Thomson 2010), while scenario 2 refers to the base-case from the 2013 assessment (Thomson & Sporcic 2013).
 Source: Thomson & Sporcic 2013.

Stock status determination

The results of the 2013 stock assessment estimate that 2012 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. Catches since the assessment are unlikely to have reduced the biomass to below the limit reference point. As a result, gummy shark is classified as **not overfished**. Since catch was less than the RBC and the TAC, the stock is classified as **not subject to overfishing**.

Sawshark (*Pristiophorus cirratus*, *P. nudipinnis*)



Line drawing: FAO

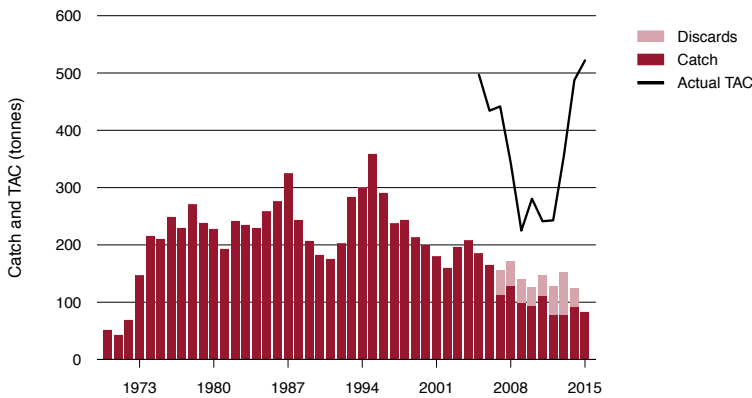
Stock structure

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 and 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 (SharkRAG 2011). 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 2015–16 was 187 t (Table 12.2). Estimates of discards have varied in recent years, with 13–28 per cent of total catch estimated as discarded. In the 2014 calendar year, 33 t was reported as discards (Upston & Thomson 2015).

FIGURE 12.8 Sawshark catch and TAC in the SGSHS, 1970 to 2015



Notes: TAC Total allowable catch. Actual TAC includes carryover from previous season (undercatch/overcatch). Discard data only available by calendar year and for the period 2007 to 2014.

Stock assessment

Sawshark has been assessed as a tier 4 stock under the SESSF harvest strategy framework since 2009. Four tier 4 assessments were conducted in 2015: 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 2015b, 2014b). 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 2015b).

In 2014, SharkRAG recommended a decrease in the virgin biomass target (B_{TARG}) from 48 per cent to 40 per cent. 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). 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).

The TAC for the 2015–16 season was set at 482 t. In comparison, the landed catch of sawshark in the 2015–16 season was 187 t. Discarding rates have fluctuated between 13 and 28 per cent of total catches in the past four years (Upston & Thomson 2015).

FIGURE 12.9 Standardised CPUE index for sawshark in the CTS, 1997 to 2014 (trawl)

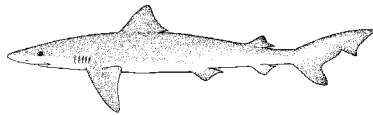
Note: CPUE Catch-per-unit-effort.

Source: Haddon 2014

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 2015–16 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**.

School shark (*Galeorhinus galeus*)



Line drawing: Karina Hansen

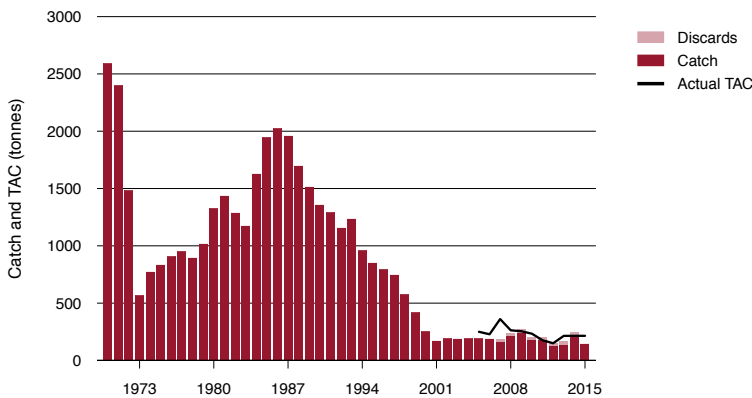
Stock structure

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). The species was listed as conservation dependent in 2009 and has been subject to other measures to reduce catch, including the implementation of a catch ratio of 20 percent 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 2015–16 was 181 t. Estimates of discards have continued to increase in recent years, from 9 per cent in 2011 to 15 per cent in 2014 (Upston & Thomson 2015). This increase is likely in part due to the recent requirement to release all live school shark. The Integrated Scientific Monitoring Program (ISMP) reported discards as 43 t in the 2014 calendar year (Upston & Thomson 2015).

FIGURE 12.10 Annual school shark catch and fishing season TAC in the SGSHS, 1970 to 2015



Notes: TAC Total allowable catch. Actual TAC includes carryover from previous season (undercatch/overcatch). Discard data only available by calendar year and for the period 2007 to 2014.

Stock assessment

School shark has been considered to be below the 0.2B₀ limit since about 1990. The base case of the most recent full stock assessment in 2009, using data to 2008, estimated the biomass at 0.12B₀ (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 0.2B₀ within 23 years. At a constant catch of 250 t, the stock was projected to rebuild to 0.2B₀ 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 0.2B₀ 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 (Thomson et al. 2015). Data from the 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 (likely in 2017) (AFMA 2013c). A new stock assessment will be run once results from the close-kin genetics project are finalised (likely in 2018) (AFMA 2015a).

The reported landed catch in the SGSHS in 2015–16 was 181 t, a decrease from the 2014–15 catch of 200 t and below the incidental catch allowance of 215 t. Although the reported landings of school shark in the SGSHS in 2015–16 were less than the incidental catch allowance, discards have consistently increased. Based on the 2014 discard estimate (15 per cent), discards for the 2015–16 season could have been around 27 t. Total state catches of school shark in 2015–16 are unknown. South Australia reported a 12 t catch of school shark in 2013 (15 t in 2012 and 16 t in 2011) (Upston & Thomson 2015). New South Wales and Tasmania reported a combined catch of 8.3 t in 2014 (Upston & Thomson 2015).

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 129–230 t in each year since these analyses were run. The stock therefore remains classified as **overfished**.

If state catches in 2015–16 were similar to those in recent years, total catch (retained and discarded) from the Commonwealth and states in 2015–16 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.

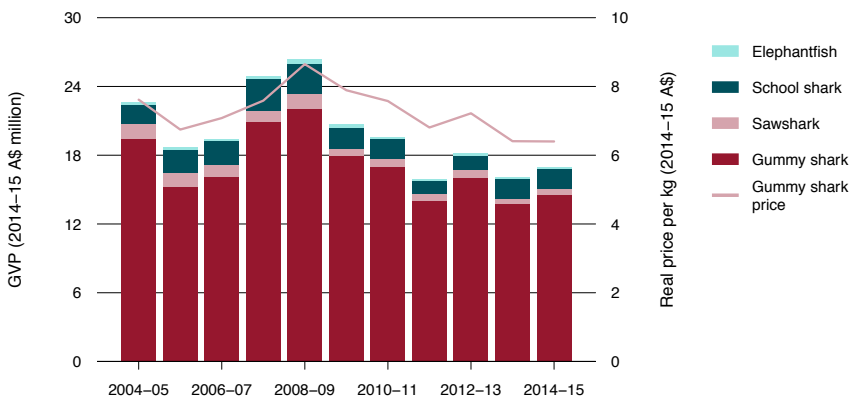
Although there is some evidence that indicates the stock may be rebuilding under current catches (for example, trawl CPUE, IMAS surveys, ISMP data and anecdotal reports from industry), there is uncertainty around discarding estimates for the 2015–16 season, because discarding has consistently increased in recent years and the latest available data relate to the 2014 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 recent peak of \$26.4 million in 2008–09 to \$16.9 million in 2014–15 (both figures in 2014–15 dollars; Figure 12.11). This long-term fall is the result of a 12 per cent fall in the volume of catch and a 26 per cent fall in the price of gummy shark, which accounts for the majority of GVP in the SGSHS (86 per cent in 2014–15).

FIGURE 12.11 Real GVP for the SGSHS, by key species, and real price for gummy shark, 2004–05 to 2014–15

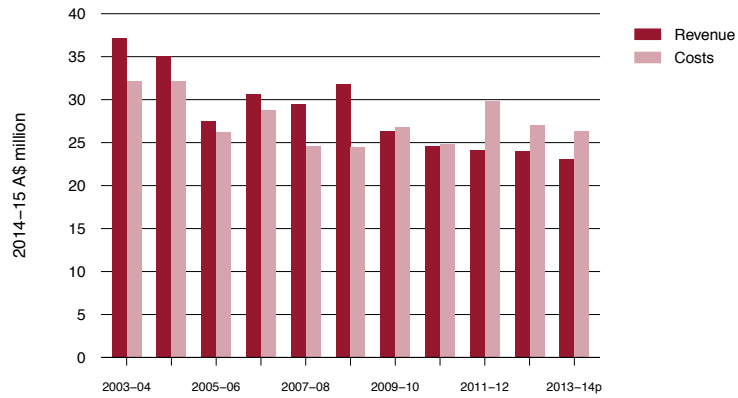


Note: GVP Gross value of production.

The four shark species that make up the SGSHS—gummy shark, school shark, sawshark and elephantfish—account for around 75 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 2002–03 and 2008–09, peaking in 2008–09 at \$7.2 million (2013–14 dollars; Figure 12.13). NER declined in 2011–12 to –\$5.6 million. Preliminary estimates for 2013–14 indicate that NER were likely to have remained negative. Because fuel is a less important input in gillnet and hook fisheries than in trawl fisheries, lower fuel prices are unlikely to have significantly improved NER.

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 decreases in fish prices in 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 been important.

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 fishers to relocate their 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 were temporarily allowed to use non-automated hook methods in areas where gillnetting is prohibited (or restricted), so that fishers could continue to operate. However, anecdotal reports from industry suggest that vessel-level economic efficiency is lower using this hook method (AFMA 2011). Anecdotal information also indicates that allowing gillnet permit holders to use hooks has had a negative impact on the value of hook permits in the sector, because rights provided by hook permits have become less exclusive. The viability of auto-longlining is also being trialled in areas closed to gillnetting. One adaptive management zone (zone C) was closed in 2015 for 18 months while three closed adaptive management zones (zones A, B and D) were reopened following 18 months of closure.

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. Because school shark fetches relatively high beach prices, changes in its catch allowance can have a relatively large influence on the sector's revenue. Additionally, school shark is often caught with gummy shark, the sector's main target species. Operators who do not hold quota for school shark and actively avoid it when targeting gummy shark are likely to experience some detrimental impact on profitability. 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; in January 2016, SharkRAG considered the preliminary results inconclusive (AFMA 2016). 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 2011). The Australian Fisheries Management Authority (AFMA) Commission has since approved the removal of net length restrictions, subject to the rollout of dolphin management arrangements across the fishery.

Performance against economic objective

A comparison of the biomass levels of key species with harvest strategy targets provides further information on economic status. Since gummy shark accounted for 88 per cent of the SGSHS GVP in 2013–14, this species is the driver of the sector's overall economic performance. The target reference point for gummy shark is the B_{MEY} (biomass at maximum economic yield) 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 greater NER to be earned 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 10 per cent of SGSHS GVP in 2014–15. 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 GHTS NER and may be related to increased gummy shark quota latency since 2009. Lower prices have likely also contributed to lower catch.

12.4 Environmental status

The SESSF was accredited against parts 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999* in February 2013. Conditions associated with the accreditation relate to the impact of fishing on bycatch species, particularly Australian sea lions (*Neophoca cinerea*), dolphins, seals, seabirds and gulper sharks (*Centrophorus* and *Squalus* spp.). Further recommendations associated with the accreditation relate to requirements for ecological risk assessment, monitoring of bycatch and discarding, and collaborative or complementary management arrangements for shared stocks.

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 brachyurus*), white shark (*Carcharodon carcharias*), whiskery shark (*Furgaleus macki*), smooth hammerhead shark (*Sphyrna 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 2012). The results of the ecological risk assessments have been consolidated to form a priority list in an ecological risk assessment strategy for the SESSF (AFMA 2015d).

AFMA publishes quarterly reports of logbook-reported interactions with protected species on its website. Reports for the GHTS in the 2015 calendar year indicate 257 interactions: 59 with mammals, 45 with seabirds and the remainder with sharks. The mammal interactions comprised 29 interactions with dolphins (all dead), 13 with Australian fur seals (2 released alive), 2 with Australian sea lions (both dead), 1 with a New Zealand fur seal (dead) and 14 with seals (unclassified; 9 dead). Forty-five seabirds (14 of which were released alive), including albatrosses, cormorants, petrels, prions and shearwaters, were caught in 2015.

Logbooks reported that 78 shortfin mako sharks (*Isurus oxyrinchus*; all dead), 57 longfin mako sharks (*I. paucus*; all dead), 3 porbeagle sharks (*Lamna nasus*; all dead) and 15 great white sharks (10 released alive) were caught during 2015. The two Australian sea lion mortalities resulted in the closure of adaptive management zone C. 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

S Hansen and A Bath

FIGURE 13.1 (a) Commonwealth Trawl Sector squid catch and (b) relative fishing intensity in the Southern Squid Jig Fishery, 2015

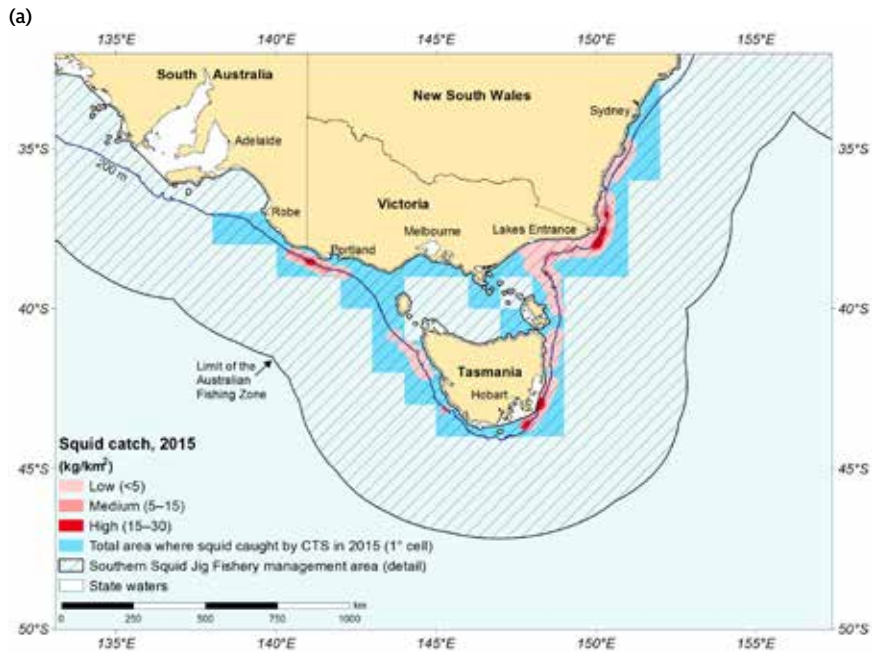
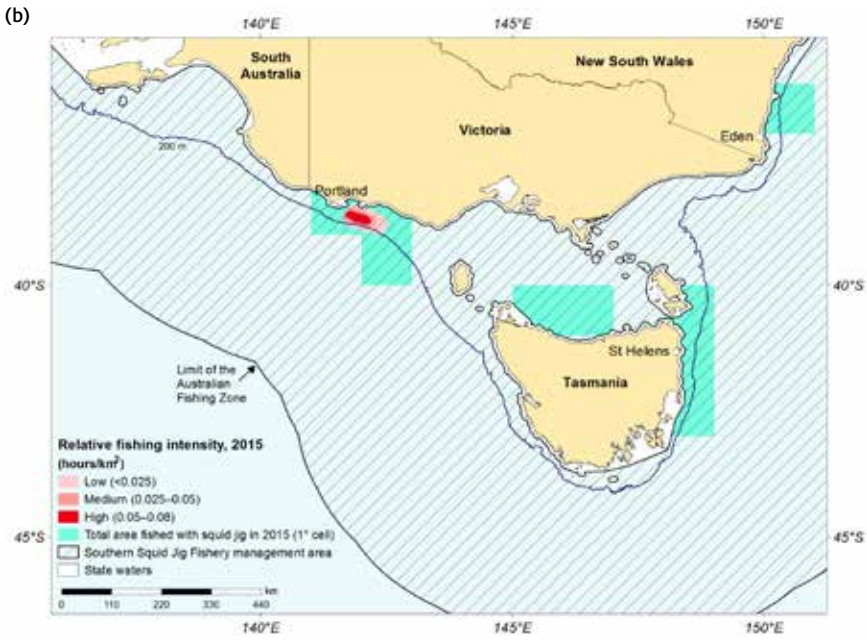


FIGURE 13.1 (a) Commonwealth Trawl Sector squid catch and (b) relative fishing intensity in the Southern Squid Jig Fishery, 2015 continued ...



Squid vessel
Rupert Summerson, ABARES

TABLE 13.1 Status of the Southern Squid Jig Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Biological status Gould's squid (<i>Nototodarus gouldi</i>)					Jig fishing effort in recent seasons has been much lower than the long-term average. Catch rates in the CTS are stable.
Economic status	Latent effort in the fishery remains high, but has decreased in the 2015 fishing season. The increased effort and higher catch levels in the 2015 fishing season suggest that NER 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 by these sectors than by 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.

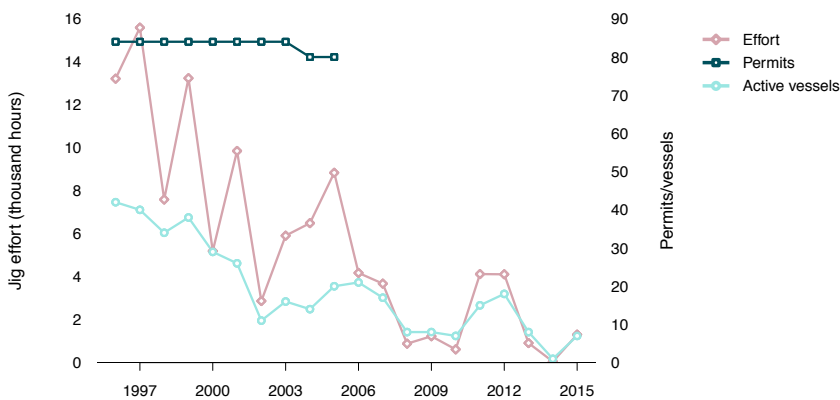
The species’ short life span, fast growth and sensitivity to environmental conditions result in highly variable recruitment and strongly fluctuating stock sizes, making it difficult to estimate biomass before a fishing season. Therefore, the SSJF harvest strategy (AFMA 2007) relies on within-season monitoring against catch triggers for the jig and trawl sectors. Breaching 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 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 the 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 in the CTS and the GABTS are listed as a ‘permitted species’ in the state-managed fisheries of Tasmania, South Australia, New South Wales and Queensland, whereas no regulations apply to squid in Victorian fisheries (AFMA 2014).

Fishing effort

In 2015, there were 5 500 gear statutory fishing rights (SFRs) and seven active vessels, and fishing effort was 1 304 jig hours (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 nature of the stock, are the main reasons for the reduction in effort since 2008. Effort increased in 2015 as a result of increased market prices and improved access to domestic markets (Australian Fisheries Management Authority [AFMA], 2016, pers. comm.). Trawling effort in the CTS and the GABTS is discussed in Chapters 9 and 11.

FIGURE 13.2 Effort, number of permits and number of active vessels in the SSJF, 1996 to 2015



Note: Permits were replaced by gear statutory rights in 2005.

TABLE 13.2 Main features and statistics for the SSJF

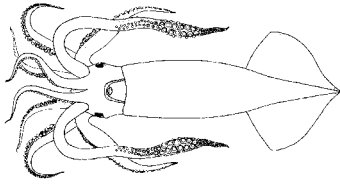
Fishery statistics ^a		2014		2015		
Fishery	TAE	Catch (t)	Real value (2013–14)	TAE	Catch (t)	Real value (2014–15)
SSJF	550 standard jigging machines ^b	2	\$0.25 million	550 standard jigging machines ^b	330	\$0.89 million
CTS	–	260	\$0.74 million	–	450	\$1.25 million
GABTS	–	57	\$0.13 million	–	44	\$0.16 million
Total	–	319	\$1.12 million	–	824	\$2.30 million
Fishery-level statistics						
Effort	50 jig hours			1 304 jig hours		
Gear SFRs ^c	5 500			5 500		
Active vessels	1			7		
Observer coverage	0			0		
Fishing methods	Squid jig					
Primary landing ports	Portland, 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. Real-value statistics are by financial year and are in 2014–15 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 require 10 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. SSJF Southern Squid Jig Fishery. TAE Total allowable effort. – Not applicable.

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).

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.

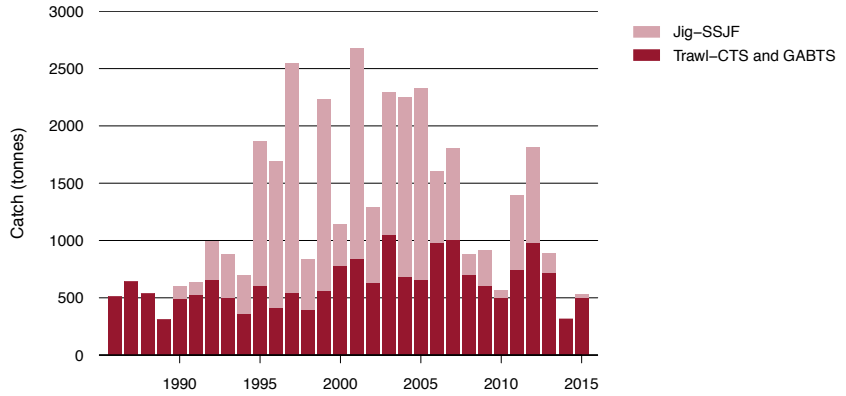
In 2015, a total of 824 t of squid was reported across the three squid fishery sectors—SSJF (330 t), CTS (450 t) and GABTS (44 t)—an increase from a total of 319 t in 2014 (Table 13.2). Total annual reported catch of Gould's squid by all methods was less than 1 000 t between 2008 and 2010, before the brief period of high 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 catches have fluctuated between 1 569 t in 2005 and 2 t in 2014. In the CTS, the annual catch of squid has ranged between 260 and 947 t during the past 10 years, increasing to 450 t in 2015 from 260 t in 2014. In the GABTS, the annual catch peaked in 2006 at 261 t, but has been much lower in recent years.

In 2015, the nominal annual average catch rate from the jig fishery (253 kg/hour) was the highest since recording of effort began in 1996, an increase from an average of 182 kg/hour in 2013 and 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 was 14.4 t. This was an increase from 5.1 t in 2014, 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, CTS and GABTS, 1986 to 2015



Notes: CTS Commonwealth Trawl Sector. GABTS Great Australian Bight Trawl Sector.

FIGURE 13.4 Nominal catch rate of Gould’s squid in the SSJF, CTS and GABTS, 1996 to 2015



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 can fluctuate substantially between years.

In 2008, the Squid Resource Assessment Group analysed catch, catch rates and effort since 2000 for four regions in the SSJF. Only one region—the central region from Cape Otway in Victoria to Robe in South Australia—had levels of fishing that could cause substantial 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 declines in stock 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 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 high average catch rates (with the exception of the 2014 season, when effort declined) indicate that the stock has not yet been overfished in any season. As a result, the Gould's squid stock is classified as **not overfished**. Low SSJF catch levels during the past five years are attributed to a low availability of squid in traditional fishing grounds, combined with unfavourable prices that have discouraged fishing. Effort increased in 2015 as a result of higher market prices and improved access to domestic markets; however, total effort remains low, and trawl catches have been relatively stable. The stock is classified as **not subject to overfishing**.

13.3 Economic status

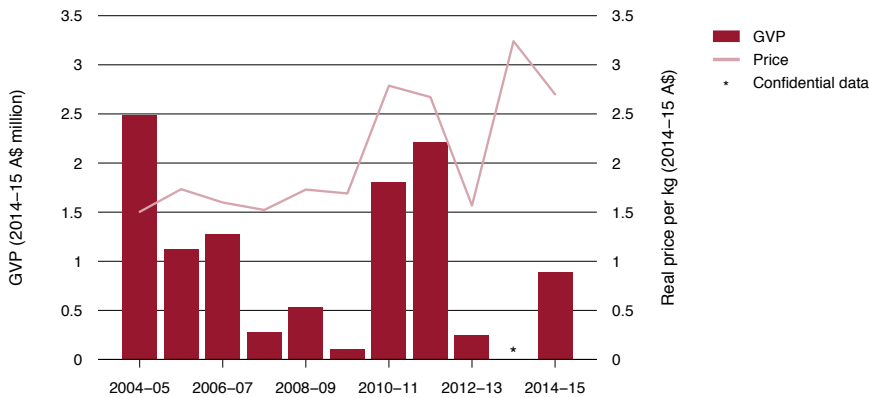
Key economic trends

The long-term decline in the fishery's catch since 2004–05 is likely to have been driven by unfavourable prices and the high cost of fishing, in terms of both fuel prices and having to search for less available squid. Low availability of squid and low fishing effort resulted in the lowest SSJF catch on record in 2013–14 (2 t). In 2014–15, the catch increased significantly to 330 t, with a total value of \$0.89 million. Notably, squid also contributed \$1.25 million in the CTS and \$0.16 million in the GABTs in 2014–15.

Effort levels in the fishery increased for the 2015 fishing season, with seven active vessels, an increase from one active vessel during the 2014 fishing season. Despite a decrease in the price of squid from 2013–14 to 2014–15 (from an average of \$3.24 to \$2.70 in 2014–15 real dollars), prices were still high when compared with historical levels (Figure 13.5). The squid price and easing fuel prices during 2014–15 are likely to have contributed to the increased effort in the fishery.

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 fishery are still low relative to other Commonwealth fisheries, and also historically for the fishery. It could be expected that net economic returns (NER) are also likely to be comparatively low. However, the increase in effort compared with the previous year (from 50 jig hours to 1 304 jigs hours) suggests that it has become more profitable to operate in the fishery, and NER in the fishery are expected to have improved in 2014–15.

FIGURE 13.5 Real GVP and average unit prices in the SSJF, 2004–05 to 2014–15



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) levels in the fishery have been set by the Squid Resource Assessment Group and the South East Management Advisory Committee at levels matching the number of SFRs held by fishers. There has been no economic basis for setting the fishery’s TAE (AFMA 2007).

The number of active vessels has increased from one vessel in the 2014 fishing season to seven in 2015. Despite this improvement, a high degree of latent effort still exists in the fishery. Boats use up to 10 jigging machines, with each machine requiring 10 gear SFRs. In both 2014 and 2015, 5 500 gear SFRs were present in the fishery, potentially enabling 55 vessels (with 10 jigging machines per vessel) to operate in the fishery each year. Although the level of gear SFR latency (unused gear) has been variable in the SSJF, it has persisted at high levels since 1996; management arrangements have never 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 from 2013–14 to 2014–15, 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 will 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 14 October 2016. 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. However, the main effect of these interactions is damage to, or loss of, fishing gear, and 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.

AFMA publishes quarterly reports of logbook interactions with protected species under the EPBC Act. No interactions were reported for the SSJF in 2015. The occurrence of fur seals (*Arctocephalus* spp.) in the vicinity of 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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Squid
Andrew Sampaklis, ABARES

Chapter 14

Western Deepwater Trawl Fishery

J Woodhams and A Bath

FIGURE 14.1 Area fished in the Western Deepwater Trawl Fishery, 2014–15

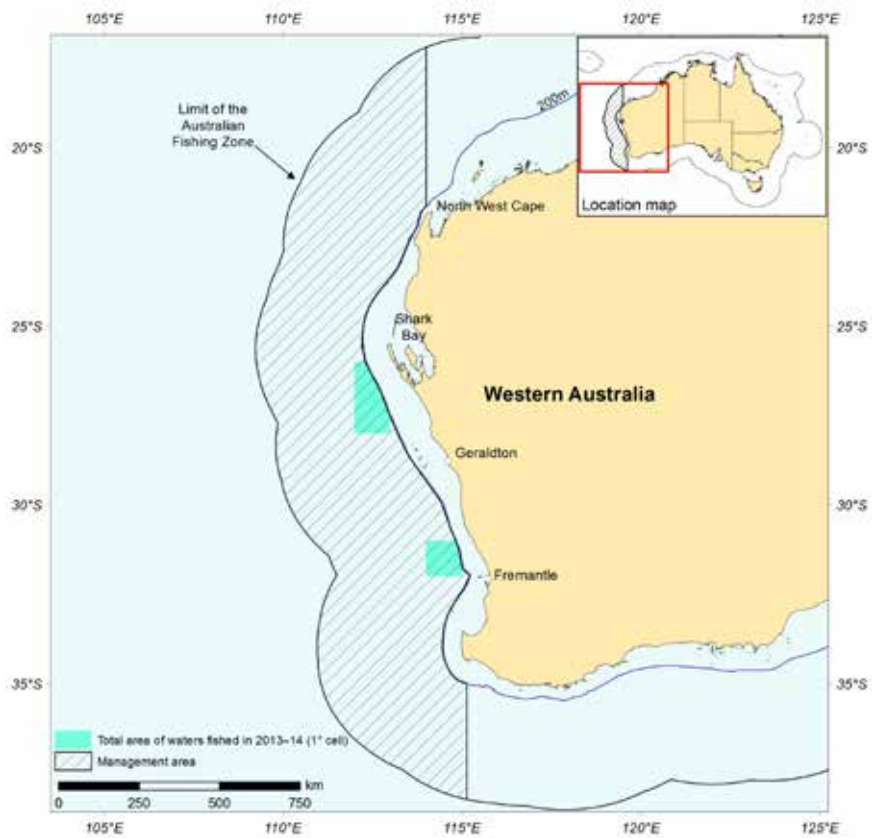


TABLE 14.1 Status of the Western Deepwater Trawl Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Biological status					
Deepwater bugs (<i>Ibacus</i> spp.)					No fishing effort in 2014–15. No reliable estimate of biomass.
Ruby snapper (<i>Etelis carbunculus</i> , <i>E. marshi</i>)					No fishing effort in 2014–15. No reliable estimate of biomass.
Economic status	No fishing activity occurred in the fishery during the 2015 fishing season. Estimates of NER for previous years are not available, but 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

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

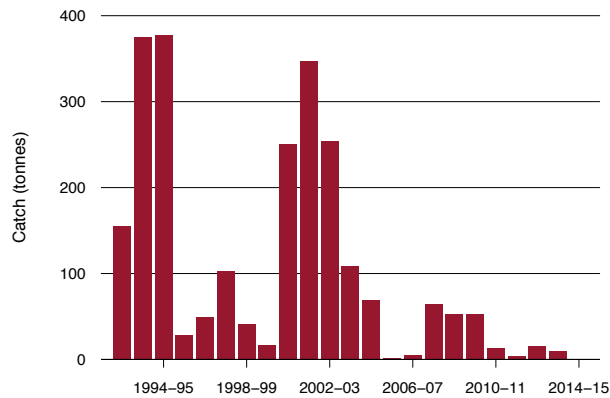
The number of vessels active in the fishery and total hours trawled has fluctuated from year to year. Notably, total hours trawled were relatively high for a brief period during the early 2000s when fishers targeted ruby snapper (*Etelis carbunculus* and *E. marshi*) and then deepwater bugs. Total fishing effort has been comparatively low since 2005–06, although still variable, and mostly targeted at deepwater bugs. No vessels were active in the 2014–15 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 2014–15 (Figure 14.2; Table 14.2).

FIGURE 14.2 Total catch in the WDTF, 1992–93 to 2014–15



Source: Australian Fisheries Management Authority

TABLE 14.2 Main features and statistics for the WDTF

Fishery statistics a	2013–14 fishing season			2014–15 fishing season		
	TAC (t)	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t)	Real value (2014–15)
Deepwater bugs	–	5.2	Confidential	–	0	0
Ruby snapper	–	<1	Confidential	–	0	0
Total fishery	–	9.8	Confidential	–	0	0
Fishery-level statistics						
Effort	13 days; 156 trawl hours			0		
Fishing permits	11			11		
Active vessels	3			0		
Observer coverage	0 days (0%)			0 days (0%)		
Fishing methods	Demersal trawl					
Primary landing ports	Fremantle, Carnarvon (Western Australia)					
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.

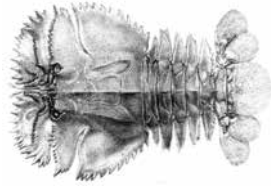
Notes: TAC Total allowable catch. – Not applicable.



Trawl catch
Gavin Kewan, AFMA

14.2 Biological status

Deepwater bugs (*Ibacus* spp.)



Line drawing: FAO

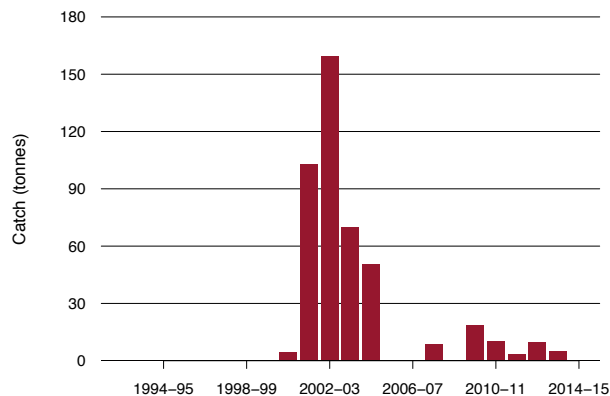
Stock structure

The WDTF targets several species of deepwater bugs. Stock structure of these species is not known, and they are grouped into a multispecies stock for status assessment.

Catch history

The catch history of deepwater bugs in the WDTF is characterised by 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. Small quantities of deepwater bugs have been harvested in each of the past five years (between 18.7 t in 2009–10 and 3.7 t in 2011–12). There was no catch in 2014–15.

FIGURE 14.3 Deepwater bug catch in the WDTF, 1992–93 to 2014–15



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 2014–15 (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 *E. marshi*)



Line drawing: FAO

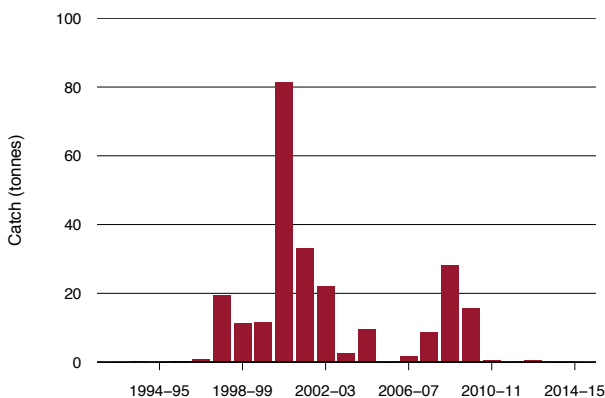
Stock structure

Stock structure of ruby snapper caught in the WDTF is not known, so the stock is assessed here based on the management unit.

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 2014–15 (Figure 14.4).

FIGURE 14.4 Ruby snapper catch in the WDTF, 1992–93 to 2014–15



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 it 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 two distinct species (*E. carbunculus* and *E. marshi*) 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 2014–15. 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 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 2013–14 and 2014–15 seasons, with only three vessels active during 2013–14. 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 2014–15, 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, low-cost management arrangements are appropriate.

14.4 Environmental status

The WDTF was reaccredited under parts 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) until 25 November 2016.

Recommendations associated with the approval included requirements for the validation of catch-and-effort data recorded by observers and in fisher logbooks, and continued cooperation with relevant jurisdictions to achieve complementary management for harvested species.

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 2015.

14.5 References

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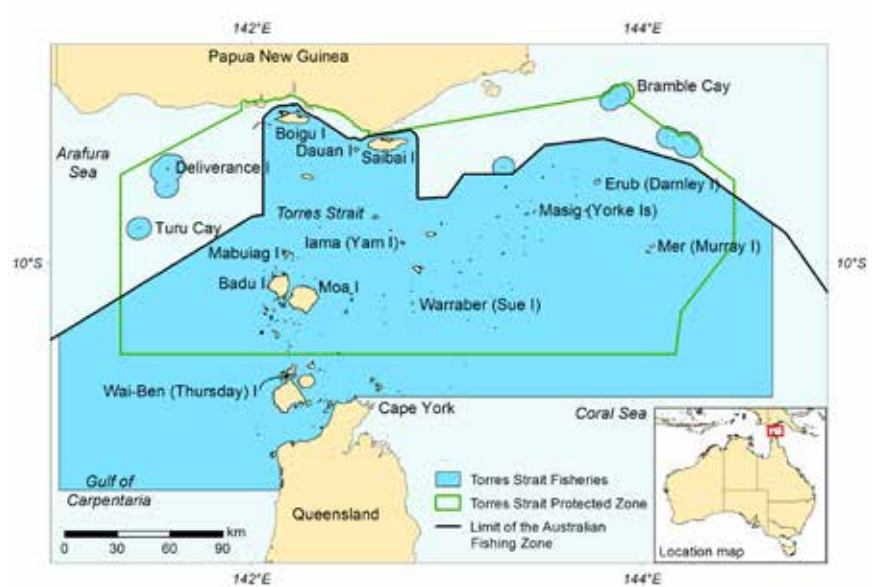
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Chapter 15

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 the Northern Peninsula Area in the Australian area. 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 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 of 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 programmes 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 are able to 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 to fishers who satisfy the Traditional Inhabitant requirements. TVH licences are issued to other commercial fishers. Catch-and-effort reporting through logbook systems 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 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 \$10.8 million (270 t) in the 2014–15 financial year. This is followed by the Torres Strait Prawn Fishery (600 t, worth \$9.1 million in 2014–15).

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 specific harvest strategy for the Torres Strait Prawn Fishery was developed in 2010 (AFMA 2011). The development of harvest strategies for the Torres Strait Finfish and Bêche-de-Mer fisheries will commence in 2016–17.

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

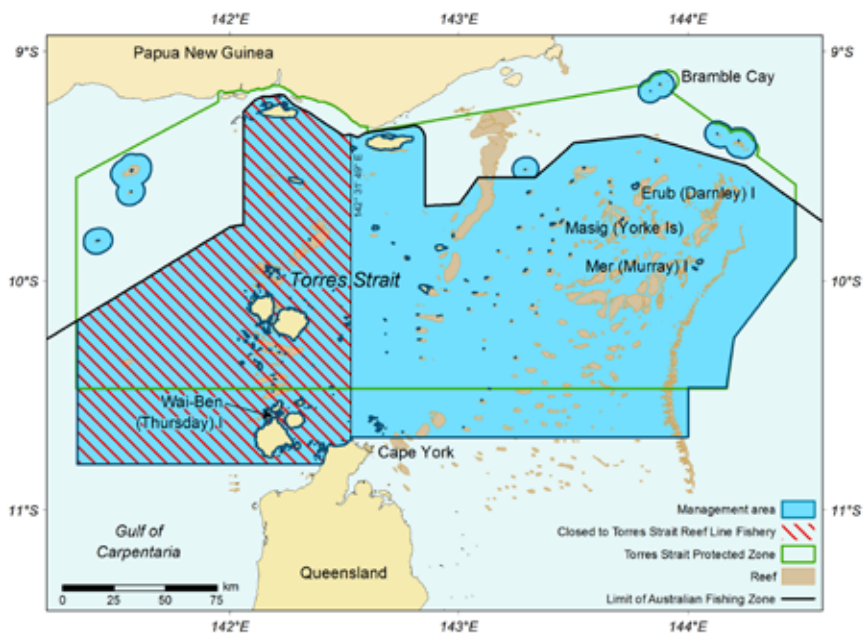


TABLE 16.1 Status of the Torres Strait Finfish Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Coral trout (<i>Plectropomus</i> spp., <i>Variola</i> 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 (<i>Scomberomorus commerson</i>)					Recent catches have been below maximum sustainable yield. Stock assessment scenarios do not show biomass declining below $0.2B_0$.
Economic status	Estimates of net economic returns are not available. Economic performance in 2014–15 remains uncertain because the effect on revenue of lower prices received and lower catch may have been offset by lower fishing costs.				

Notes: B_0 Unfished biomass.

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 $142^{\circ}32'E$ is closed to commercial fishing.

Fishing methods and key species

The TSFF has two components: the Torres Strait Spanish Mackerel Fishery (TSSMF) and the Torres Strait Finfish (Reef Line) Fishery (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 more than 65 per cent of the retained commercial catch (by weight) for both the TIB and non-TIB sectors, while mackerel and snapper contribute a further 23 per cent of the retained catch for both sectors (Williams et al. 2008). Both sectors discard 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, many for subsistence (Busilacchi et al. 2013, 2012).

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, prohibited species) and output controls (size limits, 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 coral trout and Spanish mackerel each year through the Torres Strait Regional Authority (TSRA).

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, such as the fisheries in Torres Strait. Although the Torres Strait Protected Zone Joint Authority has asked its management forums to provide advice on the application of the HSP to the Torres Strait fisheries, no formal harvest strategies are currently in effect in the TSFF.

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 (DAFF 2013). The removal of the ban on live exports in Torres Strait has done little to increase activity in the TSFRLF. To date, the option to export live coral trout has not been taken up, primarily because of difficulties and costs associated with transporting live fish from remote areas (Australian Fisheries Management Authority [AFMA], 2015, pers. comm.).

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

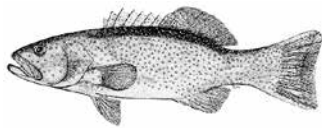
Fishery statistics a	2013–14 fishing season		2014–15 fishing season	
	Catch (t) b	Real value (2013–14)	Catch (t) b	Real value (2014–15)
Coral trout	30.9	Confidential	18.0	Confidential
Spanish mackerel	105.5	Confidential	83.7	Confidential
Other	2.1	Confidential	1.3	Confidential
Total fishery	138.5	\$1.47 million	103.0	\$1.06 million
Fishery-level statistics				
<i>Effort (days)</i>				
TSSMF	Spanish mackerel: TIB—not available Sunset permits c —523 operation-days, 1 326 tender-days		Spanish mackerel: TIB—not available Sunset permits—394 operation-days, 721 tender-days	
TSRLF	Coral trout: TIB—not available Sunset permits—112 coral trout, 157 all effort		Coral trout: TIB—not available Sunset permits—112 coral trout, 157 all effort	
Fishing permits	TIB: 136 mackerel endorsements, 132 line endorsements Sunset permits: 5 mackerel and/or line licences		TIB: 210 mackerel endorsements, 194 line endorsements Sunset permits: 6 mackerel and/or line licences	
<i>Active vessels</i>				
TSSMF	Spanish mackerel: TIB—not available Sunset permits—5		Spanish mackerel: TIB—not available Sunset permits—5	
TSRLF	Coral trout: TIB—not available Sunset permits—1		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 Mer (Murray), Erub (Darnley) and Masig (Yorke) 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 2014–15 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 quota in Torres Strait is 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. A total of six sunset permits are available for primary boats that carry a small number of tenders.

Notes: TIB Traditional Inhabitant Boat. TSRLF Torres Strait Reef Line Fishery. TSSMF Torres Strait Spanish Mackerel Fishery.

16.2 Biological status

Coral trout (*Plectropomus* spp., *Variola* spp.)



Line drawing: FAO

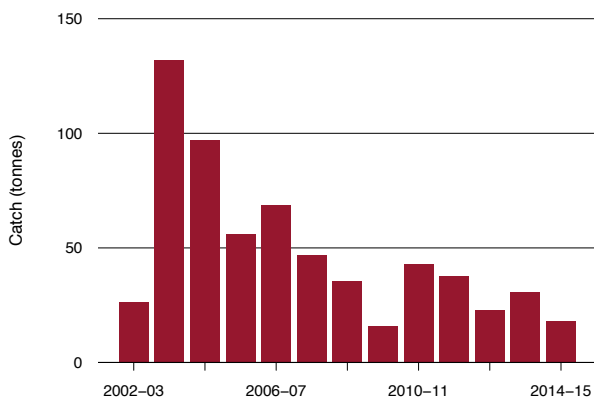
Stock structure

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

Catch in the TSFRLF peaked in 2003–04 at 132 t before dropping to below 50 t in 2007–08 (Figure 16.2). Commercial catch has remained below this level since then.

FIGURE 16.2 Catch history for coral trout in the TSFRLF, 2002–03 to 2014–15



Source: Australian Fisheries Management Authority

Stock assessment

No formal stock assessment of coral trout in the TSFRLF has been done. However, a management strategy evaluation (MSE) has been undertaken for the stock (Williams et al. 2011, 2007). 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 tested the effects of seasonal closures, minimum size limits and effort reductions.

Stock status determination

Results of the MSE, combined with a comparison of the 2014–15 catch with the historical catch record (Figure 16.2), form the basis of the classification of this stock. 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. 2011, 2007). As a result, the stock is classified as **not overfished** and **not subject to overfishing**.

Spanish mackerel (*Scomberomorus commerson*)



Line drawing: FAO

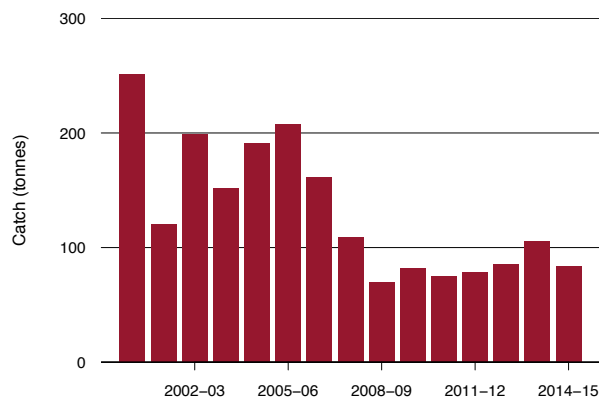
Stock structure

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

Catch in the TSSMF declined from a peak in 2000–01 of 251 t to around 100 t in 2008–09 and subsequent seasons (Figure 16.3). The 2014–15 catch of Spanish mackerel was 84 t.

FIGURE 16.3 Catch history for Spanish mackerel in the TSSMF, 2000–01 to 2014–15



Source: Australian Fisheries Management Authority

Stock assessment

The only formal stock assessment of Spanish mackerel in Torres Strait was published in 2006, informed by data to 2003 (Begg et al. 2006). An MSE that formed part of this assessment examined the effects of various catch levels on the stock over a 20-year projection period to 2023. The base-case estimate of maximum sustainable yield (MSY) for Spanish mackerel in Torres Strait was 169 t. The stock assessment concluded that the stock was probably harvested at levels near or exceeding this level up to 2003. Results of the MSE indicated that annual catches of around 150 t per year or less would achieve a fishing mortality target of half natural mortality (noting that no formal target or limit reference points have been set for this fishery) and result in decreased risk to the stock (Begg et al. 2006). Although there is significant uncertainty in the 2006 assessment outputs, none of the constant-catch scenarios examined in the MSE resulted in the estimated biomass falling below 20 per cent of the unfished biomass ($0.2B_0$). The base-case simulation estimated biomass at $0.37B_0$ (range: 0.26 to $0.67B_0$).

The potential for ‘hyperstability’, where catch rates are maintained although biomass is declining, was raised as a concern for the TSSMF by Begg et al. (2006). Hyperstability might be expected to result from fishing operations focusing on spawning aggregations around Bramble Cay. Begg et al. (2006) standardised the catch rates, based on several variables, and included dory (fishing boat) day as the unit of effort. They noted that standardisation at a finer temporal scale might provide a more robust index of abundance. However, data were not available for such analyses.

Stock status determination

Although there is no formal target or limit reference point for the fishery, $0.2B_0$ is the proxy specified in the HSP and is used for status determination in the absence of an agreed limit reference point. None of the model sensitivities in the stock assessment resulted in biomass declining below $0.2B_0$. In addition, catches since 2007–08 (Figure 16.3) have been below both the base-case estimate (169 t) and the lower-risk estimate (150 t) of MSY in the 2006 stock assessment that estimated stock biomass to be at $0.26B_0$ to $0.67B_0$. As a result, the stock is classified as **not overfished**. Catches in 2014–15 were below the base-case and the lower-risk estimates of MSY in the 2006 stock assessment. On this basis, the stock is classified as **not subject to overfishing**.

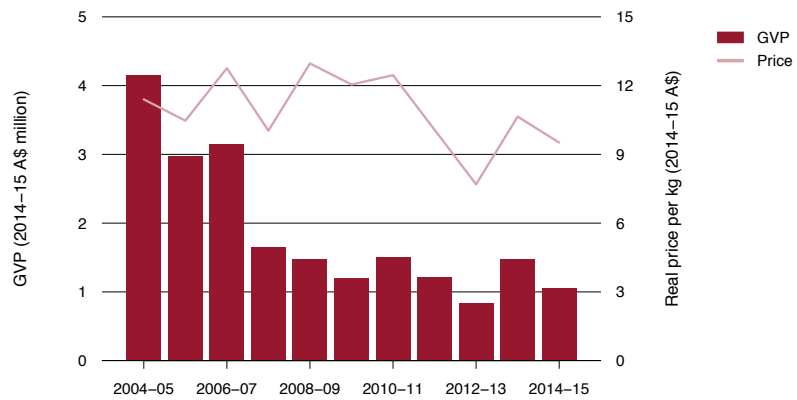
16.3 Economic status

Key economic trends

From 2003–04 to 2006–07, the gross value of production (GVP) for the TSFF averaged \$3.60 million (2014–15 dollars; Figure 16.4). In 2007–08, real GVP fell by \$1.50 million (48 per cent) compared with 2006–07, as a result of declines in catch of the two key species, Spanish mackerel and coral trout. Between 2007–08 and 2012–13, real GVP remained at an average of \$1.31 million. In 2013–14, prices for the two key species improved, resulting in a GVP of \$1.47 million, which is \$0.63 million higher than in 2012–13 (Figure 16.4). In 2014–15, prices and quantities of catch declined for both Spanish mackerel and coral trout. This was reflected in lower GVP, which fell by 28 per cent to \$1.06 million.

Quota leasing arrangements were introduced in 2008. The amount of quota leased for each fishing season is determined by the TSRA, 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, 2004–05 to 2014–15



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.

In September 2011, the ban on catching coral trout for live export (in place since December 2002) was removed (TSFMAC 2012). This could improve profitability in the fishery if price premiums on live fish can be achieved, and if these exceed the additional costs associated with handling live fish. To date, however, the option to export live coral trout has not been taken up, primarily because of difficulties and costs associated with transporting live fish from remote areas (AFMA, 2015, pers. comm.).

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 2013–14, \$119 000 of grant payments were disbursed, leaving the Finfish Quota Trust account with a closing balance of \$886 000 at the end of the 2013–14 financial year (TSRA 2015). In 2014–15, \$4 000 of grant payments were disbursed, leaving the Finfish Quota Trust account with a closing balance of \$1.1 million (higher than in 2013–14) at the end of the 2014–15 financial year (TSRA 2015). 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 was reaccredited under part 13 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 9 July 2013 and under part 13A on 17 July 2013. The accreditation under part 13A expires on 25 November 2016.

No ecological risk assessments have been conducted for the TSFF. The strategic assessment report 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 2015.

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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

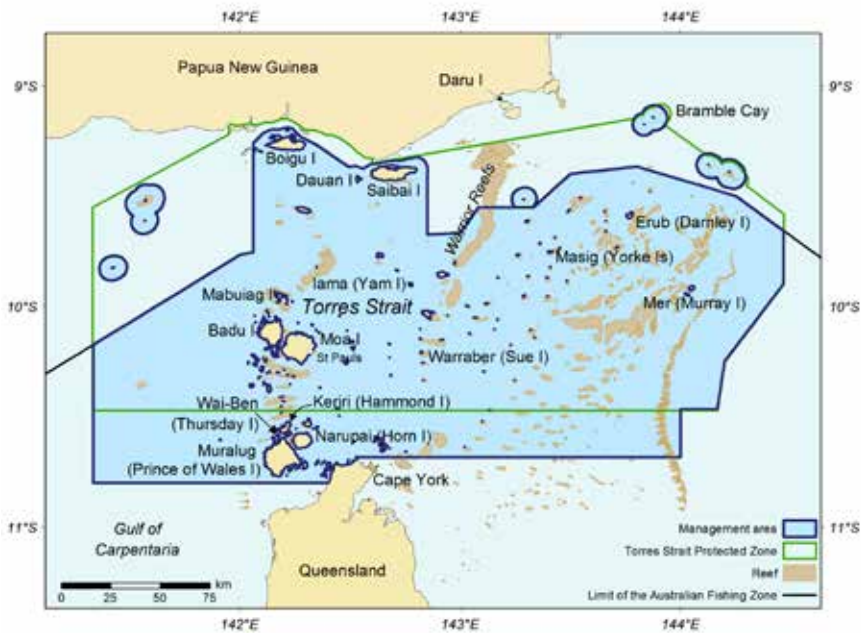


TABLE 17.1 Status of the Torres Strait Tropical Rock Lobster Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Tropical rock lobster (<i>Panulirus ornatus</i>)					Current catches are unlikely to result in substantial biomass declines. Spawning stock biomass is above the target.
Economic status	NER are likely to have declined in 2014–15 because effort applied to the fishery increased but GVP declined for the Australian Torres Strait Tropical Rock Lobster Fishery (not including PNG). The fishery is meeting its objective to provide commercial opportunities for Traditional Inhabitants, but it is uncertain whether its objective to optimise value is being met.				

Notes: GVP Gross value of production. NER Net economic returns. PNG Papua New Guinea.

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). The majority of 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*). The fishery is predominantly a dive-based, hand-collection fishery using surface-supplied air (hookah) or free-diving. Divers work from 4–6 metre tenders (one diver per tender). Some lobsters are also collected at night by fishing with a light and handheld spear or scoop-net on shallow reef flats.

The TVH Sector uses motherships (large catch-storage vessels) in conjunction with smaller fishing tenders, generally using hookah gear, with a small fleet of TVH vessels (~12) undertaking trips to fishing grounds that last from a few days to several weeks. In contrast, the majority of TIB Sector trips 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 2005, the Protected Zone Joint Authority (PZJA) decided to move to a quota management system (output controls). As a result, the Tropical Rock Lobster Resource Assessment Group (TRLRAG) developed methods to determine a sustainable total allowable catch (TAC) and prioritised research to obtain the necessary data to estimate the TAC (Plagányi et al. 2014). The transition from input- to output-controlled management has not yet occurred.

As part of the transition planning, a revised harvest strategy is being developed 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 unfished spawning biomass [SB_0]— $0.32SB_0$) a trigger reference point for biomass ($0.48SB_0$), a target reference point for biomass ($0.65SB_0$), and a target reference point for fishing mortality rate (F_{TARG}). 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 declines linearly to zero as the spawning biomass declines from the trigger to the limit reference point. The interim harvest strategy is used to determine a nominal (non-binding) 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. Currently, shares for the three commercial fishing sectors are 29.57 per cent for the TVH Sector, 37.94 per cent for the TIB Sector and 32.50 per cent for PNG.

The input controls that are currently applied 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.



Tropical rock lobsters
Jim Prescott, AFMA

Fishing effort

Between 2008 and 2015, fishing effort, measured in tender-days, has varied from 1 281 to 4 623 for the TVH Sector, 1 457 to 4 564 for the TIB Sector, and 524 to 2 207 for PNG. For the 2014–15 fishing season, effort in Australian waters was 4 623 tender-days for the TVH Sector, 1 935 tender-days for the TIB Sector and zero for PNG.

TABLE 17.2 Main features and statistics for the TSTRLF

Fishery statistics a	2013–14 fishing season			2014–15 fishing season		
Stock	TAC (t)	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t) b	Real value (2014–15)
Australia (TVH, TIB)	416 (181, 235)	401 (272, 129)	\$20.9 million	604 (265, 339)	303 (152, 151)	\$12.2 million
PNG	200	255	na	290	192	na
Total fishery	616	656	na	894	495	na
Fishery-level statistics						
Effort c	TVH: 3 795 tender-days, 1 845 operation-days TIB: 2 013 tender-days PNG: 0 tender-days (in Australian waters)			TVH: 4 623 tender-days, 1 168 operation-days TIB: 1 935 tender-days PNG: 0 tender-days (in Australian waters)		
Fishing permits	TVH: 12 licences, 33 tenders TIB: 291 PNG: 0 PNG cross-endorsed; hundreds of PNG dinghies and canoes fish from coastal villages in PNG waters			TVH: 12 licences, 33 tenders TIB: 291 PNG: 0 PNG cross-endorsed; hundreds of PNG dinghies and canoes fish from coastal villages in PNG waters		
Active vessels	TVH: 12 TIB: 291 PNG: 0 (cross-endorsed)			TVH: 12 TIB: 291 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), traditional land and recreational bag limits					
Primary markets	Domestic: live lobsters and frozen tails International: United States (frozen tails), Hong Kong/China (live lobsters)					
Management plan	None					

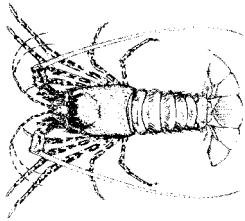
a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 December to 30 September. Real-value statistics are by financial year. b Estimate at time of publishing; this figure is preliminary and likely to be updated in future editions of this publication.

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

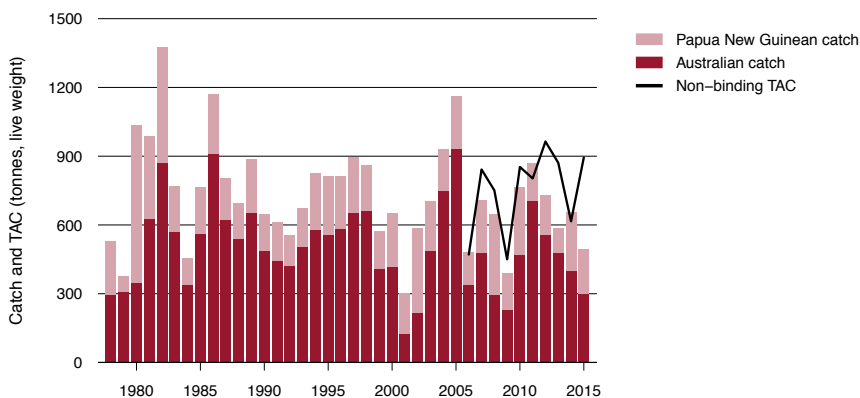
Stock structure

Although post-larval 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 Torres Strait part of the biological stock.

Catch history

Total catch (TVH and TIB) of tropical rock lobster has generally fluctuated between 300 and 900 t per year since 1978 (Figure 17.2). Recent annual catches have declined from nearly 900 t in 2011 to a reported catch of 495 t in 2015, the lowest since 2009.

FIGURE 17.2 Catch and TAC of tropical rock lobster in the TSTRLF, 1978 to 2015



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 2015 assessment (Plagányi et al. 2015a, b). The assessment used a time series of catch data from 1973 to 2015 and incorporates annual fishery-independent pre-season survey and/or mid-season survey data (1989 to 2015), catch-per-unit-effort data from the TVH (1994 to 2015) and TIB (2004 to 2015) sectors (Plagányi et al. 2015b), and Australian and fishery catch data.

The assessment estimated the 2015 spawning biomass to be 3 719 t (90 per cent confidence interval 2 349 to 5 088 t), placing the estimated depletion in 2015 at 80 per cent of the estimated unfished (1973) level ($0.80SB_0$) (Plagányi et al. 2015b). 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 deterministically predicted estimates. 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 2015, the TRLRAG recommended a non-binding TAC of 894 t (Plagányi et al. 2015a), of which 495 t was caught (Table 17.2). The recommended non-binding TAC for 2016 is 796 t (AFMA 2015), based on the outputs from the reference-case assessment model (Plagányi et al. 2015b).

Stock status determination

The model-estimated biomass in 2015 ($0.80SB_0$) was well above the target ($0.65SB_0$) and limit ($0.32SB_0$) reference points. As a result, this stock is classified as **not overfished**. The total catch of 495 t in 2015 was lower than the non-binding TAC of 894 t, and equated to a fishing mortality of 0.12, which is lower than the target reference point of 0.15. Therefore, the stock is assessed as **not subject to overfishing**.

17.3 Economic status

Key economic trends

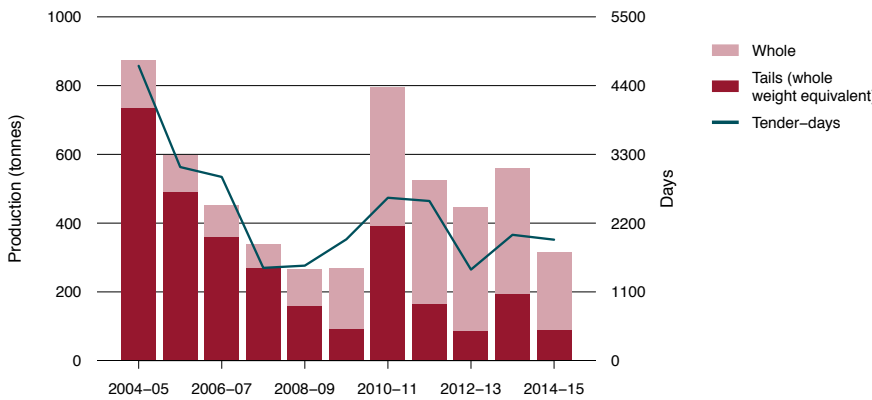
Catch in the fishery is landed as either whole lobster or lobster tails, with whole lobsters generally being landed live. All catch and value figures discussed here have been converted to whole weight to allow comparisons of catch composition.

Landed catch in the fishery declined by 44 per cent in the 2014–15 financial year, from 559 t in 2013–14 to 314 t in 2014–15 (Figure 17.2).¹ The quantity of whole lobster declined from 364 t (whole-weight equivalent) in 2013–14 to 226 t (whole-weight equivalent) in 2014–15. The quantity of tails landed in 2014–15 also declined compared with the previous year (a 54 per cent decrease to 89 t [whole-weight equivalent]; Figure 17.3). Effort in the TVH Sector of the fishery increased by 22 per cent between 2013–14 (3 795 tender-days) and 2014–15 (4 623 tender-days; Figure 17.3). 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.

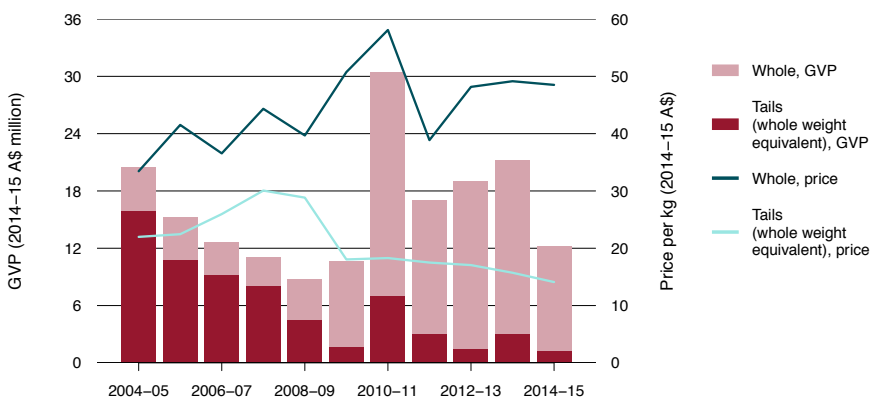
The gross value of production (GVP) of the Australian fishery (not including PNG) decreased by 42 per cent between 2013–14 and 2014–15 (Figure 17.4). This was largely driven by the decline in the volume of production (and slight changes in the price per kilogram for live product). As a result of the decline in the quantity of tails landed, the value of rock lobster tails decreased by 58 per cent, from \$3 million in 2013–14 to \$1.2 million in 2014–15. The increase in effort over the same period suggests an increase in fishing costs. In combination with the decline in GVP, this indicates that net economic returns to the fishery are likely to have decreased.

FIGURE 17.3 Production volumes of whole lobster and lobster tails in Torres Strait, and effort levels measured by TVH tender-days, 2004–05 to 2014–15



Notes: TVH Transferable Vessel Holder. Lobster tail production has been converted to whole weight. Production data classified by product type were not available before 2003–04.

FIGURE 17.4 Real GVP and price for whole lobster and lobster tails (whole-weight equivalent) in the TSTRLF, 2004–05 to 2014–15



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. 2012). 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. Profitability² 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 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, via 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 aspirations 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 a number of 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 was granted export accreditation under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 7 May 2014 for a period of three years until 4 May 2017. Recommendations associated with the recent approvals include improving estimates of tropical rock lobster harvest, developing and implementing long-term management arrangements (management plan), and developing resource-wide assessments of the stock.

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 2015.

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Chapter 18

Torres Strait Prawn Fishery

A Williams and K Mazur

FIGURE 18.1 Relative fishing intensity in the Torres Strait Prawn Fishery, 2015

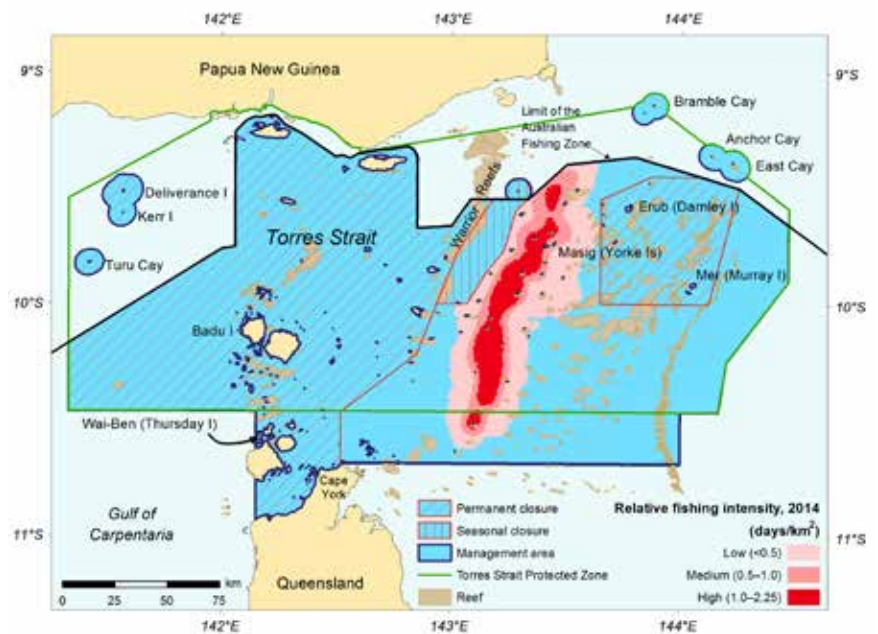


TABLE 18.1 Status of the Torres Strait Prawn Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Brown tiger prawn (<i>Penaeus esculentus</i>)					Catch in recent years is below MSY. Most recent estimate of biomass is above B_{MSY} .
Blue endeavour prawn (<i>Metapenaeus endeavouri</i>)					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 2013–14 and 2014–15. Increases in catch and GVP, similar catch per hour trawled in 2014–15 relative to 2012–13, and lower fuel prices suggest that NER in 2014–15 increased. However, substantial latency in the fishery suggests that NER are below potential.				

Notes: **BMSY** Biomass at maximum sustainable yield. **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

18.1 Description of the fishery

Area fished

The Torres Strait Prawn Fishery (TSPF) operates in the eastern part of the Torres Strait Protected Zone (TSPZ) and south of the TSPZ in nearby Queensland waters (called the ‘outside but near area’) (Figure 18.1). This fishery is shared by Australia and Papua New Guinea (PNG) under formal arrangements in the Torres Strait Treaty (see Chapter 15).

Fishing methods and key species

Prawns are harvested at night using demersal otter trawl (prawn trawl). Fishers usually deploy four nets divided into two pairs, with a pair of nets towed from a boom on each side of the fishing vessel. Trawl tows last between two-and-a-half and four hours at an average speed of around 3 knots. Fishers normally complete three or four tows per night (DSEWPaC 2013; Turnbull et al. 2007).

The target species of the fishery are brown tiger prawn (*Penaeus esculentus*) and blue endeavour prawn (*Metapenaeus endeavouri*). Byproduct species include redspot king prawn (*Melicertus longistylus*),¹ slipper lobster (*Scyllarides* spp.), Moreton Bay bugs (*Thenus* spp.), octopus (Octopodidae), cuttlefish (*Sepia* spp.) and squid (Teuthoidea).

¹ Although small volumes of other king prawn species (*M. latisulcatus*, *M. plebejus*) are recorded in logbook records, research surveys in Torres Strait suggest that the commercial catch largely consists of a single species for each prawn group—that is, brown tiger prawn (*P. esculentus*), blue endeavour prawn (*M. endeavouri*) and redspot king prawn (*M. longistylus*) (C Turnbull, AFMA Consultant, 2015, pers. comm., 23 July).

Management methods

The Australian component of the fishery is managed by the Torres Strait Protected Zone Joint Authority (PZJA), established under the *Torres Strait Fisheries Act 1984* (Cwlth). Currently, all licences in the fishery are held by the non-Indigenous Transferable Vessel Holder Sector.

Under the Torres Strait Treaty, PNG is entitled to 25 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.

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 prawns. A catch trigger also exists for endeavour prawns. 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 potential 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 prawns—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). The proxy used for B_{MEY} is $1.2B_{MSY}$, equating to $0.48B_0$.

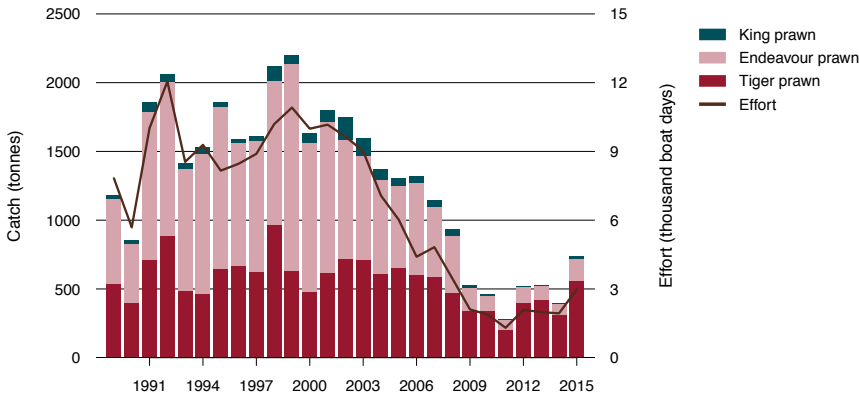
Fishing effort

From 1999 to 2011, fishing effort in the TSPF decreased steadily, largely as a result of economic conditions in the fishery (Figure 18.2). Since 2011, effort has increased to the highest level since 2008, peaking in 2015. Despite this peak, the effort in 2015 represents only 43.4 per cent of the total allowable effort for the Australian fishery.²

Catch

In addition to brown tiger prawn and blue endeavour prawn, king prawn (*Melicertus longistylus*, *M. latisulcatus* and *M. plebejus*) has also been a historically important component of the catch in the fishery. The total combined catch of brown tiger prawn, blue endeavour prawn and king prawn decreased from a historical high of more than 2 000 t in 1999 to less than 300 t in 2011 (Figure 18.2). Since 2011, the total combined catch has increased by more than 100 per cent, reaching 740 t in 2015 (Figure 18.2; Table 18.2). The proportion of brown tiger prawn has increased from below 30 per cent in 1999 to more than 70 per cent in each year since 2010.

FIGURE 18.2 Catch and TAC of tropical rock lobster in the TSTRLF, 1989 to 2015



² The 9 200 days of total allowable effort 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).

TABLE 18.2 Main features and statistics for the TSPF

Fishery statistics a	2014			2015		
	TAC (t)	Catch (t)	Real value (2013–14) b	TAC (t)	Catch (t) b	Real value (2014–15)
Brown tiger prawn	–	314.5	\$4.9 million	–	557.8	\$8.2 million
Blue endeavour prawn	–	75.8	\$0.59 million	–	165.7	\$0.90 million
Total fishery c	–	390.3	\$5.5 million	–	723.5	\$9.1 million
Fishery-level statistics						
Effort (days)	1 954			2 987		
Fishing permits	61 (15 inactive licences not attached to vessels)			60 (15 inactive licences not attached to vessels)		
Active vessels	24			24		
Observer coverage	50 days (2.6% of active effort)			59 days (2% of active effort)		
Fishing methods	Demersal otter trawl					
Primary landing ports	Cairns, Innisfail (Queensland)					
Management methods	Input controls: TAE on fishing nights, individual transferable effort units, limited entry (although licences are transferable), gear restrictions, time and area closures, vessel length restrictions					
Primary markets	Domestic: frozen International: minor to Japan—frozen					
Management plan	Torres Strait Prawn Fishery Management Plan 2009					

a Fishery statistics are provided by fishing season, unless otherwise indicated. Fishing season is 1 March to 1 December. Real-value statistics are provided by financial year. b Includes non-prawn byproduct species. c Total fishery catch includes the catch of brown tiger, endeavour and king prawns only.

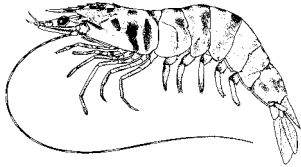
Notes: TAC Total allowable catch. TAE Total allowable effort. – Not applicable.



Tiger prawns
AFMA

18.2 Biological status

Brown tiger prawn (*Penaeus esculentus*)



Line drawing: FAO

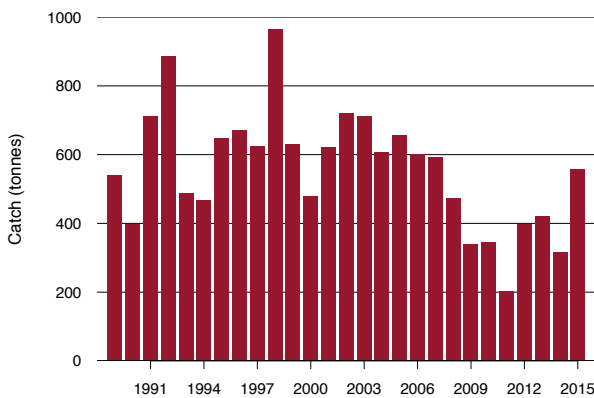
Stock structure

Although there is some evidence of genetic separation of brown tiger prawns from the east and west coasts of Australia (Ward et al. 2006), the biological stock structure for this species is considered uncertain (Roach et al. 2012). Populations of brown tiger prawn are considered to constitute a single stock in Torres Strait for management purposes.

Catch history

Catch of brown tiger prawn has fluctuated over time, peaking in 1998 at nearly 1 000 t. Catch decreased to about 204 t in 2011, but has since increased to 558 t in 2015 (Figure 18.3).

FIGURE 18.3 Brown tiger prawn catch in the TSPF, 1989 to 2015



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 indicate that tiger prawn biomass had steadily increased from 2000 to 2006, and was between $0.6B_0$ and $0.8B_0$ (Turnbull & Rose 2007). 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 nights³ (90 per cent CI 5 932 to 9 823 t) 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 t).

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 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, and catches remaining below MSY levels (Figure 18.3). In addition, the harvest strategy for the fishery (AFMA 2011) imposes conservative trigger points—set at 75 per cent of the Australian portion of effort and catch at B_{34} (B_{MEY}), or 4 000 days and 680 t of tiger prawns. 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 significantly in 2015, catch and effort in the fishery remain below the trigger points.

Stock status determination

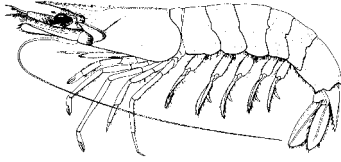
Assessment of brown tiger prawn status in 2015 is based on a comparison of recent catches (Figure 18.3) with estimates of MSY (O'Neill & Turnbull 2006), a comparison of recent effort with estimates of E_{MSY} (O'Neill & Turnbull 2006) and the 2006 estimates of biomass (Turnbull & Rose 2007).

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 for the past 10 seasons. The effort in the fishery has been below the 2006 estimates of E_{MSY} for the Ricker (8 245 nights) and Beverton–Holt (9 197 nights) spawner–recruitment relationships for the past 13 and 12 seasons, respectively. As a result, the stock is classified as **not subject to overfishing**.

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 $0.2B_0$. Since biomass was well above the limit reference point and B_{MSY} in 2006, and fishing effort has been below the estimated E_{MSY} , the stock is classified as **not overfished**. Uncertainty around the current level of biomass is increasing with time since the most recent stock assessment.

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.

Blue endeavour prawn (*Metapenaeus endeavouri*)



Line drawing: FAO

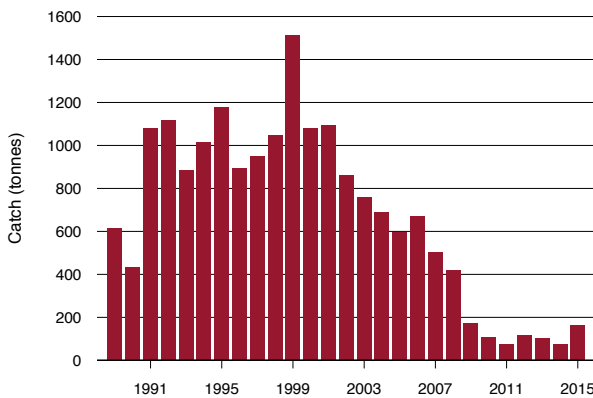
Stock structure

Endeavour prawn fisheries occur in Exmouth Gulf, the Gulf of Carpentaria and Torres Strait, and off the north coast of Western Australia and the east coast of Queensland. Little is known about the biological stock structure of the populations of blue endeavour prawn caught in these areas (Turnbull et al. 2012). They are considered to constitute a single stock for management purposes in Torres Strait.

Catch history

Annual catches of blue endeavour prawn were relatively high during the 1990s at between 800 and 1 200 t, peaking at around 1 500 t in 1999 (Figure 18.4). Annual catches have decreased to below 200 t in recent years, and the catch in 2015 was 165.7 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 2015



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 estimated MSY to be 1 105 t (90 per cent CI 1 060 to 1 184 t) and E_{MSY} to be 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 around $0.8B_0$, which is considerably higher than the estimate of $0.43B_0$ for B_{MSY} .

Blue endeavour prawn catch in 2015 was 165.7 t, a significant increase from the 75.8 t in 2014 (Figure 18.4).

Stock status determination

The stock status classification of blue endeavour prawn in 2015 is based on a comparison of recent catches with estimates of MSY from the 2009 assessment, comparison of 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 inform 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 $0.2B_0$. Since fishing effort has been below the estimated E_{MSY} for some time, the stock is classified as **not overfished**. Uncertainty around the current level of biomass is increasing with time since the most recent stock assessment.

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 of the TSPF. 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. Estimates of NER for 2014–15 are not available; however, increases in catch and gross value of production (GVP) similar catch per hour trawled in 2014–15 relative to 2012–13, and lower fuel prices suggest that NER increased in 2014–15.

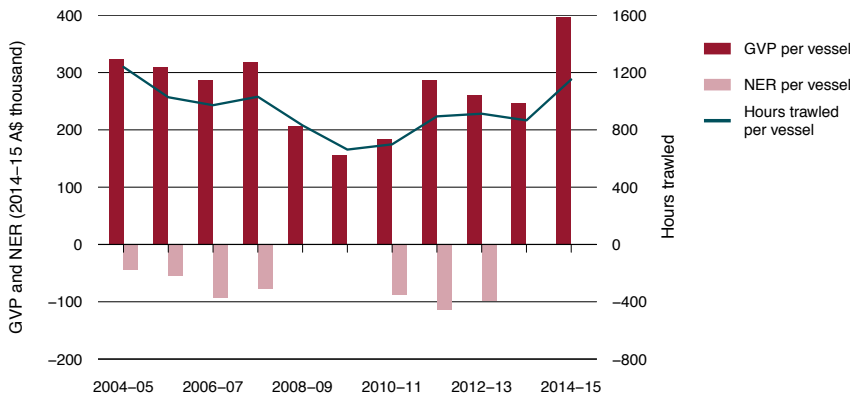
In 2014–15, GVP in the TSPF was \$9.5 million. Tiger prawn accounted for the largest share of GVP (86 per cent; \$8.2 million), followed by endeavour prawn (9 per cent; \$0.9 million) and king prawn (1 per cent; \$65 000).

Between 2003–04 and 2009–10, the number of hours trawled per vessel almost halved in response to declines in profitability. Skirtun and Vieira (2012) analysed the drivers of profitability trends in the TSPF, using a profit decomposition approach. They found that the key drivers of declining profitability from 1998–99 to 2007–08 were falling output prices and rising fuel prices; the negative contribution from these two factors was highest in 2006–07. Figure 18.5 presents the historical data per vessel for GVP, NER and hours trawled between 2003–04 and 2014–15. Estimates of NER are not available for 2008–09, 2009–10, 2013–14 or 2014–15 because economic surveys of the fishery were not done for these years.

The GVP per vessel (an indicator of vessel revenue) also followed a declining trend from 2003–04, reaching its lowest level in 2009–10 before increasing significantly (Figure 18.5). In 2014–15, GVP per vessel increased significantly, to approximately \$396 000, and the effort input for the season averaged 1 152 trawl hours per vessel. This increase in GVP was due to higher prices and increased catch.

High input costs and low prices in 2010–11 and 2011–12 made it difficult to operate profitably in the fishery (Skirtun et al. 2015). However, lower prices for diesel fuel and a lower Australian dollar exchange rate are likely to have improved economic returns and participation in the fishery in 2013–14 (Skirtun et al. 2015). Further reduction in fuel prices, and an increase in prices and catch rates in 2014–15 suggest improvements in NER.

FIGURE 18.5 GVP, NER and hours trawled per vessel in the TSPF, 2004–05 to 2014–15



Note: GVP Gross value of production. NER Net economic returns.

Management arrangements

The fishery is managed using input controls. A limit 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 & Turnbull 2014). 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, restrictions on trade in effort entitlements have been greater in the TSPF until recently (AFMA 2011). These restrictions 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 2015, 24 of the 60 licences in the fishery were active, resulting in a licence latency of 56 per cent.

The TSPF is also managed through limits on maximum vessel size (AFMA 2011). Since 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). The PZJA agreed that further information was needed before any trials could be considered. Consultation through the TSPMAC regarding this recommendation is ongoing. 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 ecologically sustainable development and a precautionary approach. Although these objectives are implicitly consistent with maximising economic yields, the recently implemented 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. Increases in vessel numbers and effort levels in the past five years reflect the increase in the fishery's profitability. This suggests that economic performance in this fishery is improving. Recent NER for the fishery are not available.

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 was reassessed against parts 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999* on 13 March 2013. Recommendations associated with the resulting approvals included that the PZJA agencies set appropriate trigger points in the fishery; that the PZJA ensures that relevant risk assessments for bycatch species, habitats and ecosystems in the TSPF are undertaken when the TSPF harvest strategy trigger points are reached (AFMA 2011); and that the PZJA continues to implement appropriate mitigation measures to ensure sustainability of bycatch species, habitats and ecosystems affected by the fishery.

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 a significant 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 2015, 672 sea snakes of unknown species were caught in the TSPF, of which 391 were released alive, 23 were dead, 2 were injured and the remaining 256 had an unknown life status. One green turtle and six turtles of unknown species were caught, and all were released alive. One narrow sawfish (*Anoxypristis cuspidata*) was caught and did not survive.

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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

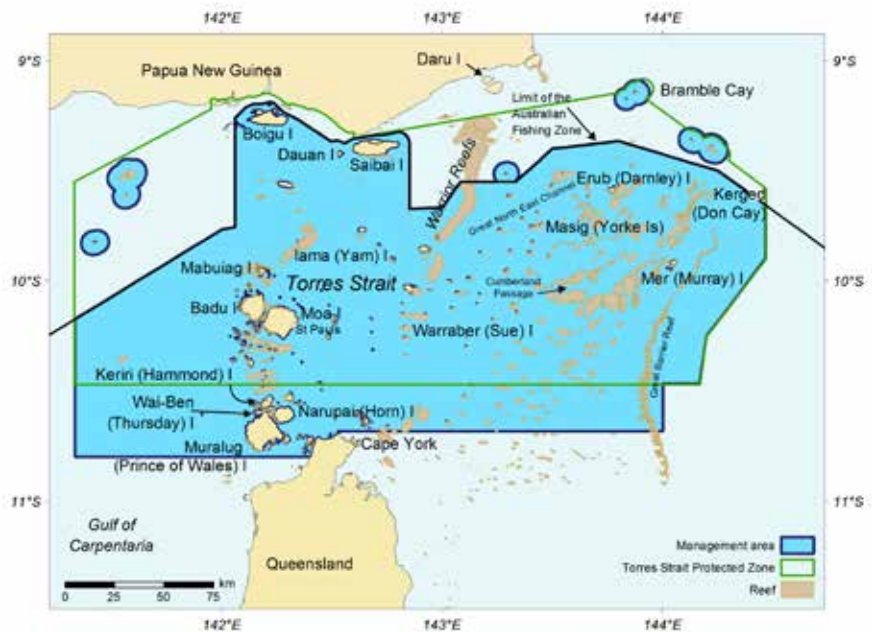


TABLE 19.1 Status of the Torres Strait Bêche-de-mer and Trochus fisheries

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Black teatfish (<i>Holothuria whitmaei</i>)	Green	Green	Green	Green	Catch was above the TAC set, but below the TAC recommended by research. Recent survey indicates a recovering stock.
Prickly redfish (<i>Thelenota ananas</i>)	Green	Green	Green	Green	Catch is below TAC. Survey indicates relatively stable densities.
Sandfish (<i>Holothuria scabra</i>)	Green	Red	Yellow	Red	Uncertain impact of IUU catch in recent years. Most recent full survey (2009) indicated that stock was overfished.
White teatfish (<i>Holothuria fuscogilva</i>)	Green	Green	Green	Green	Catch is below TAC. Survey indicates relatively stable densities.
Other sea cucumbers (up to 18 species)	Yellow	Yellow	Green	Yellow	Catch in 2015 is unlikely to constitute overfishing. Uncertainty in biomass status for a number of species.
Trochus (<i>Trochus niloticus</i>)	Green	Yellow	Green	Yellow	No recorded take in 2015. Uncertain estimates of population size from most recent survey.
Economic status	Estimates of net economic returns are not available.				

Notes: IUU Illegal, unreported and unregulated. TAC Total allowable catch.

Fishing mortality Green Not subject to overfishing Red Subject to overfishing Yellow Uncertain
Biomass Green Not overfished Red Overfished Yellow 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 2013a, 2011).

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 2013a).

No trochus was taken in 2015. Estimates from 2005 indicate that the majority of trochus harvested in that year 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 occurs from dinghies, crewed by two or three fishers. Although the depth range of most targeted species is between 0 and 20 m, a combined ban on hookah (surface-supplied underwater breathing apparatus) and scuba diving limits most fishing effort to a depth of approximately 10 m. Following collection, sea cucumbers are processed for market; typically, this involves gutting, grading, cleaning, boiling, smoking and drying (AFMA 2013a).

Trochus (*Trochus niloticus*) is typically located on high-energy areas of reefs, on substrates dominated by stony or coral pavements and associated with turf algae (Murphy et al. 2010). Trochus is collected by hand while reef-top walking at low tide, or from reef tops and reef edges while free-diving (without scuba or hookah gear) (AFMA 2011).

No byproduct or bycatch occurs in these fisheries because fishing by hand allows preferred species to be selected. Interactions with protected species are minimal. The only concerns relate to physical damage to coral reef structures from walking during collection at low tide (Department of the Environment 2014).

Management methods

The TSBDMF is managed using a range of input and output controls. Input controls include limiting participation in the fishery to Traditional Inhabitant Boat (TIB) licence holders. Traditional Inhabitants who wish to fish commercially for sea cucumbers are required to hold a TIB licence. In addition, fishers are limited to vessels of 7 m, and collection is limited to hand collection, including use of non-mechanical handheld devices. The 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), black teatfish (15 t trial), 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 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.

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, such as the fisheries in Torres Strait. Although 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 bêche-de-mer or trochus fisheries.

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 trochus fishery since 2010.

The Papua New Guinea (PNG) Bêche-de-mer Fishery (all species) has been closed since 2009 (AFMA 2013b; 2016, pers. comm.). However, PNG vessels have been apprehended operating illegally on Warrior Reefs in Australian waters in recent years (since 2013) (AFMA, 2016, pers. comm.).

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 Reefs complex (Figure 19.1). Following a considerable decline in sandfish abundance and the subsequent introduction of a zero TAC in 1998, targeting shifted to black teatfish, and what was thought to be surf redfish but is now understood to be primarily deepwater redfish and blackfish species (Skewes et al. 2010).

Following declines in the abundance of black teatfish, the TAC for this species was set at zero in 2003. The most recent survey (2009) indicated that black teatfish was recovering (Skewes et al. 2010). Based on this evidence, the PZJA endorsed fishing trials for black teatfish in 2014 and 2015, with a 15 t TAC. This TAC was overcaught in both years. In 2012, CSIRO ran a small experimental fishing trial for sandfish on Warrior Reefs, during which just over 2 t of catch was removed (Murphy et al. 2012).

Catch reporting is not mandatory for TIB fishers. The best estimate of commercial sea cucumber catch in the TSBDMF in 2015 is approximately 31 t, including 23.3 t of black teatfish, 4 t of prickly redfish and 1.6 t of white teatfish. There was also an estimated 1 t of sandfish taken on Warrior Reefs by PNG nationals in 2015.

There has been no reported catch of trochus in the fishery since 2010 (Table 19.2). This is understood to be a result of low market demand for trochus products, including mother-of-pearl shell (AFMA 2015).

TABLE 19.2 Main features and statistics for the TSBDMF and the TSTF

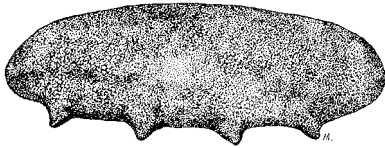
Fishery statistics a		2014			2015		
Stock	TAC (t)	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t)	Real value (2014–15)	
Black teatfish	15	16.5 b	na	15	23.3 b	na	
Prickly redfish	20	4.0	na	20	4	na	
Sandfish	0	0.8 c	0	0	1 c	0	
White teatfish	15	8.0	na	15	1.6	na	
Other sea cucumber species (18 species)	80	0.2	na	80	1	na	
Total fishery (TSBDMF)	130	29.5	na	130	30.9	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: na Trochus: 0			Bêche-de-mer: na Trochus: 0			
Fishing permits (as at 30 June)	Bêche-de-mer: 70 Trochus: 52			Bêche-de-mer: 95 Trochus: 77			
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						
<i>Management methods</i>							
Bêche-de-mer	Input controls: limited entry, gear restrictions, vessel length restrictions Output controls: TACs, size limits						
Trochus	Input controls: limited entry, gear restrictions, vessel length restrictions Output controls: TACs, size limits						
<i>Primary markets</i>							
Bêche-de-mer	Domestic: minimal International: Asia—predominantly as a dried product; small amounts frozen or salted						
Trochus	Domestic: minimal International: historically, markets have included China, France, Germany, Italy, Japan, the Philippines, Spain, the United Kingdom, the United States and Thailand						
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.

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 an increase 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 was noted that increasing the TAC would result in increased targeting of this species, which would likely stimulate interest in the fishery. It was also acknowledged that a level of precaution is required in developing the fishery, to minimise the risk 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. Trials were undertaken in 2014 and repeated in 2015 with a 15 t TAC. Some overcatch was experienced in both years (see Table 19.2).

Stock status determination

Although it exceeded the trial TAC, the catch in 2015 (23.3 t) was below the 25 t TAC recommended by Skewes et al. (2010). 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*)



Line drawing: FAO

Stock structure

Prickly redfish in the 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.

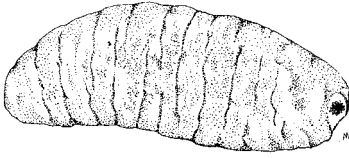
The current TAC for prickly redfish (20 t) is based on an estimate of maximum sustainable yield (MSY), using a biomass estimate from the 2002 survey (Skewes et al. 2004). MSY was estimated using a simplified surplus production model that relies on estimates of biomass and natural mortality (M). The surplus production model assumed an MSY of $0.2MB_0$ and used the lower 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 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 recorded only sporadically. Reported catch¹ has been below the 20 t TAC every year since 2004, with the largest catch (9.9 t) being taken in 2011. Catch in 2015 was 4 t. Densities, lengths and weights of prickly redfish remained relatively stable between 1995 and 2009. As a result, the stock is classified as **not overfished** and **not subject to overfishing**.

¹ Reported catches of sea cucumbers are understood to be gutted wet weight.

Sandfish (*Holothuria scabra*)



Line drawing: FAO

Stock structure

Sandfish in the 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 that the mean density (\pm standard error [SE])— 94 ± 50 sandfish per hectare— 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, it has been hypothesised that the relatively low density of sandfish remaining on Warrior Reefs may have reduced fertilisation success, because sandfish are widely dispersed (Murphy et al. 2011). 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 that it is unlikely that the proportion of buried sandfish would have differed from one survey to the next. 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 the Australian Fisheries Management Authority (AFMA) conducted a small-scale experimental fishing trial of sandfish on Warrior Reefs (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 and 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 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 the Warrior Reefs by PNG nationals in recent years (AFMA, 2016, pers. comm.). Approximately 1 t of catch was found on apprehended vessels in 2015, and approximately 0.8 t of catch in 2014. These catches are understood to be primarily made up 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 carried out 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 the Torres Strait is assumed to represent a single biological stock (T Skewes, CSIRO, 2013, pers. comm.).

Stock assessment

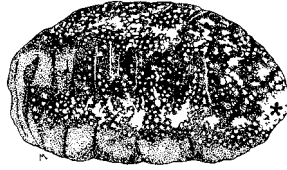
The Torres Strait white teatfish stock was last surveyed in 2009 (Skewes et al. 2010). The results of this survey indicated that white teatfish density was relatively stable (or possibly increased) between surveys in 1995, 2002 and 2005. Mean density (\pm SE) increased from 0.47 (\pm 0.20) to 0.85 (\pm 0.43) per hectare between 2005 and 2009 (Skewes et al. 2010). 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. 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 are known to 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. The TAC for white teatfish is 15 t. Reported catch was 1.6 t in 2015.

Stock status determination

The reported catch in 2015 was 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 the surveys indicate that the portion of stock available to the fishery appears to have remained stable. On this basis, 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

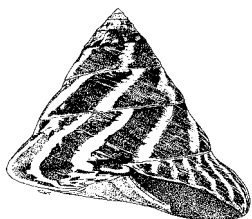
Many of the individual species within this multispecies stock have been included in previous surveys (1995, 2002, 2005 and 2009) of sea cucumbers in Torres Strait. The results of the 2002 survey were used to estimate MSY, and subsequently TACs, for 15 of the species (see section on prickly redfish for 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, zero TACs were recommended. 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 1 t.

Stock status determination

Catch of this stock is made up of 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 were 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 have 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 were 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 2015. 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 bêche-de-mer or trochus fisheries. Estimates of the gross value of production are also not available for either fishery.

As a result of relatively easy collection of sea cucumbers, and increasing value of, and demand for, sea cucumber (mostly from Asia), the stock needs to be closely monitored to avoid overfishing. The majority of Australian export of sea cucumber is to Hong Kong, Singapore and China. The level of participation in the trochus fishery is relatively low because of a decline in overseas market demand for shells.

Management arrangements

Both fisheries are managed under TACs, together with a range of input controls. For the bêche-de-mer fishery, only the trial TAC for black teatfish was significantly caught in 2015. For the trochus fishery, no catch has been recorded since 2010, suggesting that it is not profitable in the current environment.

The trial of black teatfish in the bêche-de-mer fishery has contributed to the recent increase in catch. This is likely to have been associated with increased NER. The use of hookah gear would be expected to enable collectors to access species that cannot be reached by free-diving, and may be a more efficient harvesting method. If this is the case, allowing this method on an ongoing basis may generate higher NER in Torres Strait.

Performance against economic objective

The HSP is not prescribed for Torres Strait fisheries, and there are no explicit economic targets for the bêche-de-mer or trochus fisheries. For the bêche-de-mer fishery, 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 bêche-de-mer fishery. Rebuilding the sandfish stock should increase the potential benefits to local communities from the fishery.

For the trochus fishery, 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

The bêche-de-mer fishery was assessed against parts 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 18 June 2014, and was declared an approved Wildlife Trade Operation until 15 June 2017. The approval states that it is unlikely that fishing operations conducted in accordance with the current management policy for the fishery would adversely affect the conservation status of listed marine species, listed migratory species or cetaceans, or adversely affect the survival or recovery in nature of listed or threatened species. Recommendations that accompanied the assessment included that the PZJA implement strategies to improve estimates of community harvest; progress with developing harvest strategies, performance measures and management responses; continue to pursue opportunities for further research; and develop complementary management arrangements for stocks across fisheries and across jurisdictions.

The trochus fishery was assessed against parts 13 and 13A of the EPBC Act on 5 October 2012. Recommendations that accompanied the approval included that the PZJA implement strategies to improve estimates of all fishery-related removals from the fishery, review the fishery-dependent data collection processes on a regular basis, review and consider implementing management measures proposed in the CSIRO report (Murphy et al. 2010), investigate methods to improve stock estimates, and review stock assessments on a regular basis.

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 via 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. There were no reported interactions with species protected under the EPBC Act in the bêche-de-mer or the trochus fisheries in 2015.

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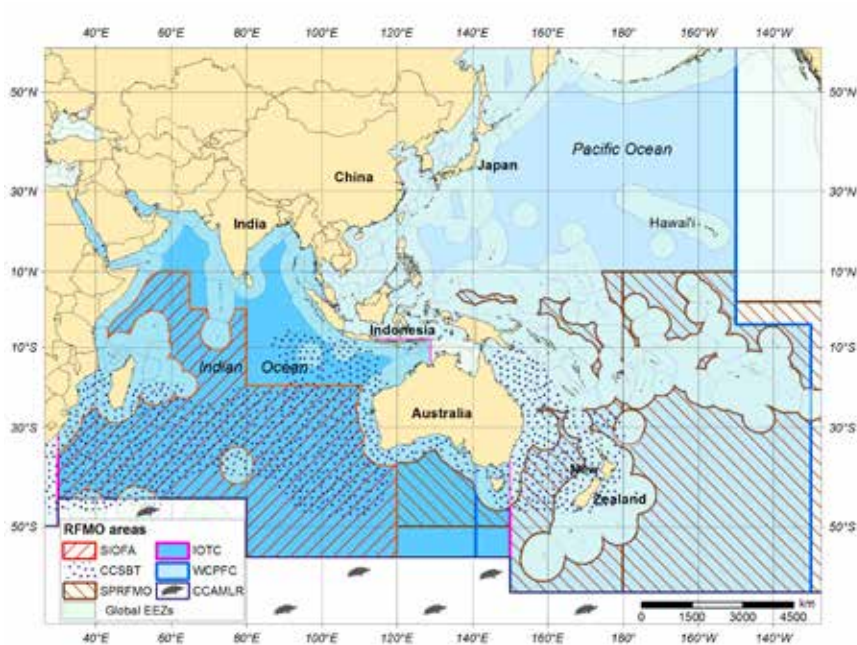
Processed sea cucumber
Tim Skewes, CSIRO

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 21–29. 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
- 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 to 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 2014, the total tuna catch of the fishery was worth more than US\$5.8 billion and constituted about 60 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 saurians (Scomberesocidae). See Chapter 21 for more information.

Commission for the Conservation of Southern Bluefin Tuna

The Convention for the Conservation of Southern Bluefin Tuna, which established the CCSBT, originated from discussions between Australia, Japan and New Zealand in the mid 1980s, following an observed decline in stock biomass. The convention applies to southern bluefin tuna (*Thunnus maccoyii*) throughout its range, rather than within a specified geographic area. Therefore, it covers areas of the Indian, Atlantic and Pacific oceans (Figure 20.1), overlapping with the areas of competence of the CCAMLR, the WCPFC and the IOTC. The CCSBT's primary management measure is a global total allowable catch (TAC), which is allocated to members and cooperating non-members. Currently, Australia, Japan, New Zealand, the Republic of Korea and the Fishing Entity of Taiwan hold the majority (94 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 20.1). The IOTC's area of competence covers a large number of countries, and both artisanal and industrial fishing vessels. Membership of the IOTC is open to Indian Ocean coastal countries, and countries or regional economic integration organisations that 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 Southern Indian Ocean Fisheries Agreement (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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Fish market in Oman
Heather Patterson, ABARES

Chapter 21

Eastern Tuna and Billfish Fishery

J Larcombe, A Williams and J Savage

FIGURE 21.1 Relative fishing intensity in the Eastern Tuna and Billfish Fishery, 2015

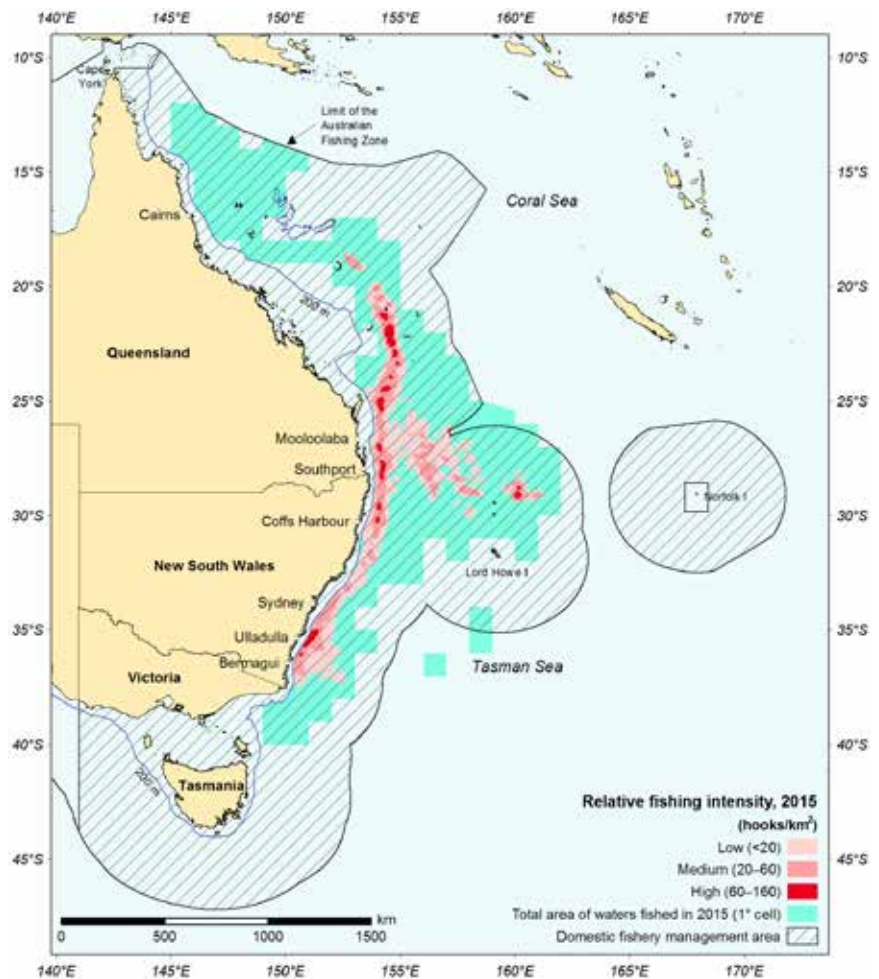


TABLE 21.1 Status of the Eastern Tuna and Billfish Fishery

Status	2014		2015		Comments a
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Striped marlin (<i>Tetrapturus audax</i>), 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 that required to achieve MSY.
Swordfish (<i>Xiphias gladius</i>), south-west Pacific					Most recent estimate of biomass (2013) is above the default limit reference point of B_{20} . Fishing mortality estimates vary depending on uncertain growth schedule.
Albacore (<i>Thunnus alalunga</i>), 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 (<i>Thunnus obesus</i>), 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 (<i>Thunnus albacares</i>), 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) after a long period of negative NER (2001–02 to 2009–10). NER for 2014–15 are likely to have increased as a result of higher GVP, lower fuel prices and reduced latency. The move to individual transferable quotas and a new harvest strategy may 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_{MSY} Biomass at maximum sustainable yield. 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 nigricans*) 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 of 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 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.

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 tuna stocks, but, in the absence of agreed limit reference points, status determination was informed by the proxies specified in the HSP.

From 1 July 2015, electronic monitoring (e-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.

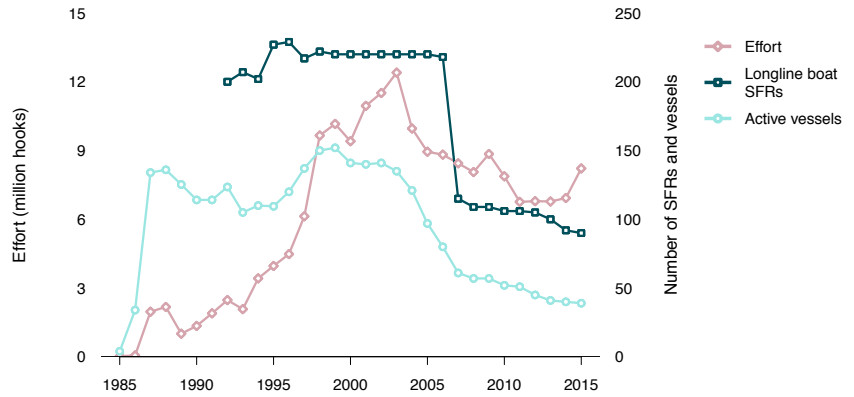
Fishing effort

The number of active vessels in the fishery (Figure 21.2) has decreased substantially in the past decade (from around 150 in 2002 to 39 in 2015), 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).



Tori lines
AFMA

FIGURE 21.2 Longline fishing effort, number of boat SFRs and active vessels in the ETBF, 1985 to 2015

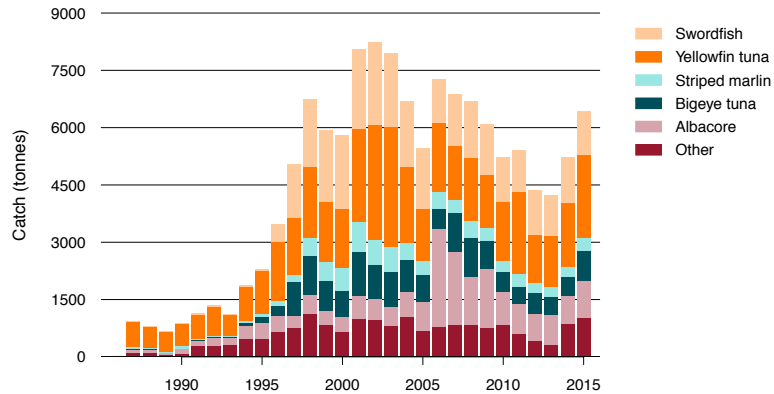


Note: SFR Statutory fishing right.
 Source: Australian Fisheries Management Authority

Catch

As a result of a decrease in effort, the total catch in the ETBF declined from a high of more than 8 000 t in 2003 to around 4 200 t in 2013, but has since increased (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 2015



Source: Australian Fisheries Management Authority

TABLE 21.2 Main features and statistics for the ETBF

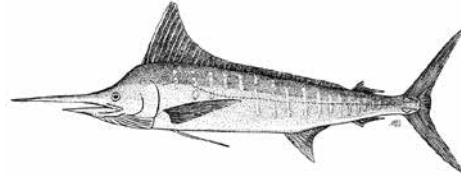
Fishery statistics ^a	2014			2015		
	TACC	Catch (t)	Real value (2013–14)	TACC	Catch (t)	Real value (2014–15)
Striped marlin	351	273	\$1.2 million	351	347	\$1.4 million
Swordfish	1 378	1 183	\$7.1 million	1 381	1 150	\$6.8 million
Albacore	2 500	737	\$1.9 million	2 500	949	\$2.0 million
Bigeye tuna	1 056	490	\$4.6 million	1 056	785	\$5.4 million
Yellowfin tuna	2 200	1 685	\$14.2 million	2 200	2 177	\$17.4 million
Total fishery	7 485	4 368	\$30.7 million	7 488	5 408	\$35.0 million
Fishery-level statistics						
Effort	Longline: 6.96 million hooks Minor line: na			Longline: 8.22 million hooks Minor line: na		
Fishing permits	Longline boat SFRs: 92 Minor line boat SFRs: 112			Longline boat SFRs: 90 Minor line boat SFRs: 101		
Active vessels	Longline: 40 Minor line: 4			Longline: 39 Minor line: 2		
Observer coverage	Longline: 195 032 (2.8%) Minor line: zero			Longline: 5.87% ^b Minor line: zero		
Fishing methods	Pelagic longline, Minor line (trolling, rod and reel, handline)					
Primary landing ports	Bermagui, Coffs Harbour, Ulladulla (New South Wales); Cairns, Mooloolaba, Southport (Queensland),					
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 (*Tetrapturus audax*)



Line drawing: FAO

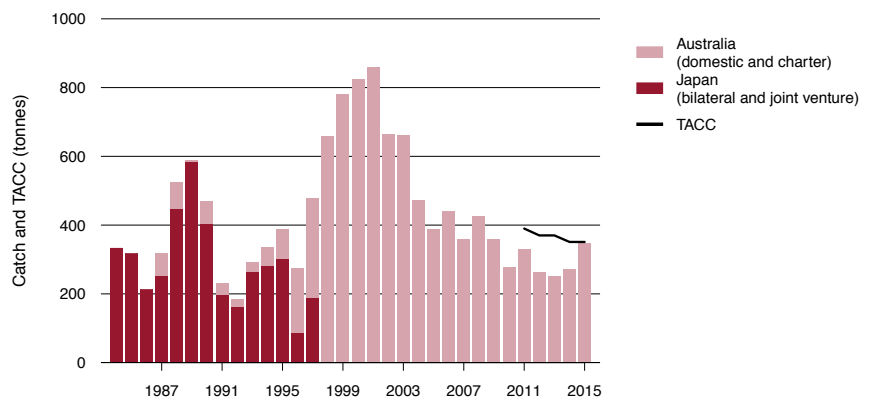
Stock structure

Genetic studies have identified multiple stocks of striped marlin in the Pacific Ocean (for example, McDowell & Graves 2008; Purcell & Edmands 2011). As a result, the north Pacific Ocean and south-west Pacific Ocean (SWPO) stocks are assessed separately (WCPFC 2013). Information for the SWPO stock is reported here.

Catch history

Catch for the ETBF increased slightly in 2015 to 347 t (Figure 21.4), while catches in the south Pacific decreased slightly from 2 313 t in 2013 to 2 251 t in 2014 (Figure 21.5). An increase in south Pacific catches 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.

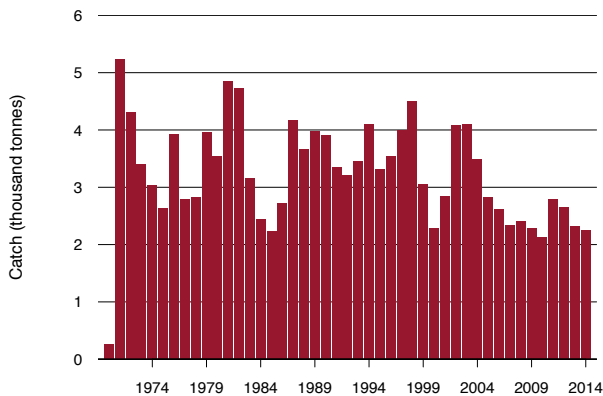
FIGURE 21.4 Striped marlin catch and TACC in the ETBF, 1984 to 2015



Note: TACC Total allowable commercial catch.

Source: Australian Fisheries Management Authority

FIGURE 21.5 Striped marlin catch in the south Pacific, 1970 to 2014



Source: Western and Central Pacific Fisheries Commission

Stock assessment

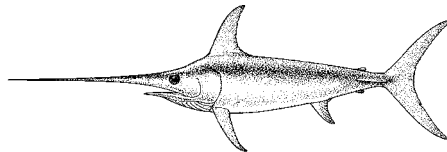
The last stock assessment for striped marlin in the SWPO was conducted in 2012 (Davies et al. 2012). Significant changes in the base case from the previous (2006) assessment included a 50 per cent reduction in Japanese longline catches over the entire model time period, faster growth rates, and the steepness 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 37 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 four years since the assessment (2011 to 2014) have averaged 2 500 t, which is in excess of 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 together with the age of the stock assessment 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; this recommendation has not yet been adopted by the Commission.

Swordfish (*Xiphias gladius*)



Line drawing: Gavin Ryan

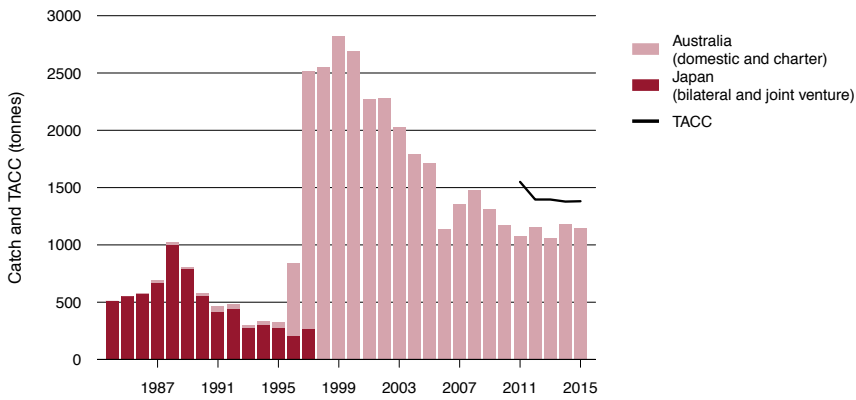
Stock structure

Although studies of swordfish have generally indicated a low level of genetic variation in the Pacific Ocean (Kasapidis et al. 2008), the WCPFC assesses two stocks separately: a north Pacific stock and an SWPO stock. The information reported here is for the SWPO stock.

Catch history

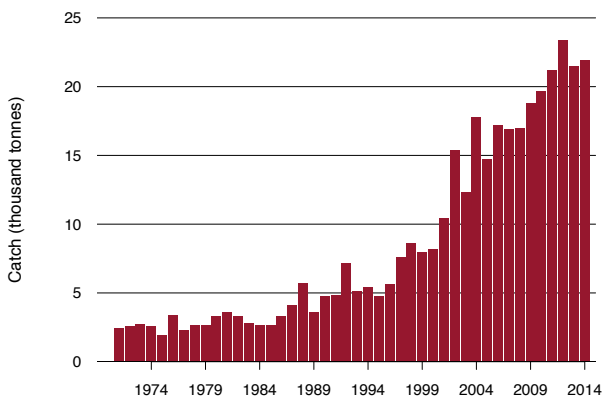
Swordfish catch in the ETBF decreased slightly in 2015 (Figure 21.6). Catch in the south Pacific has generally been increasing since 2001 and was just under 22 000 t in 2014 (Figure 21.7).

FIGURE 21.6 Swordfish catch and TACC in the ETBF, 1984 to 2015



Note: TACC Total allowable commercial catch.
 Source: Australian Fisheries Management Authority

FIGURE 21.7 Swordfish catch in the south Pacific, 1970 to 2014



Source: Western and Central Pacific Fisheries Commission

Stock assessment

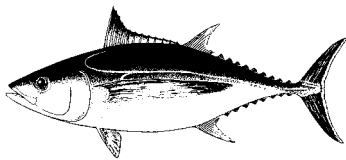
The SWPO stock of swordfish was most recently assessed in 2013 (Davies et al. 2013) using the assessment package MULTIFAN-CL. This assessment builds on the 2008 assessment and is underpinned by several other analyses examining standardised CPUE series (for example, Campbell 2012b; Hoyle et al. 2013). 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: $SB_{\text{CURRENT}}/SB_{\text{MSY}} = 1.15\text{--}1.80$; Hawaiian estimate: $SB_{\text{CURRENT}}/SB_{\text{MSY}} = 1.86\text{--}2.54$). 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 ($SB_{\text{CURRENT}}/SB_{\text{F=0}} = 0.26\text{--}0.60$). However, estimates of fishing mortality relative to F_{MSY} varied under the growth schedules, with the Hawaiian schedule indicating that overfishing was not occurring ($F_{\text{CURRENT}}/F_{\text{MSY}} = 0.40\text{--}0.70$) and the Australian schedule indicating that overfishing was occurring ($F_{\text{CURRENT}}/F_{\text{MSY}} = 1.06\text{--}1.77$).

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.

Albacore (*Thunnus alalunga*)



Line drawing: FAO

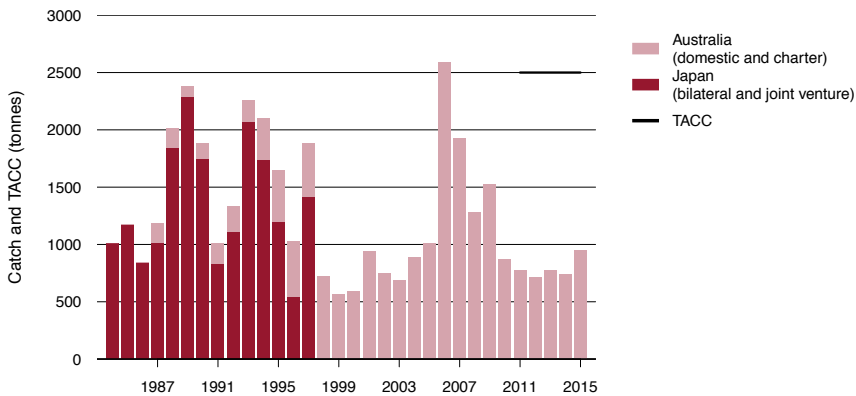
Stock structure

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

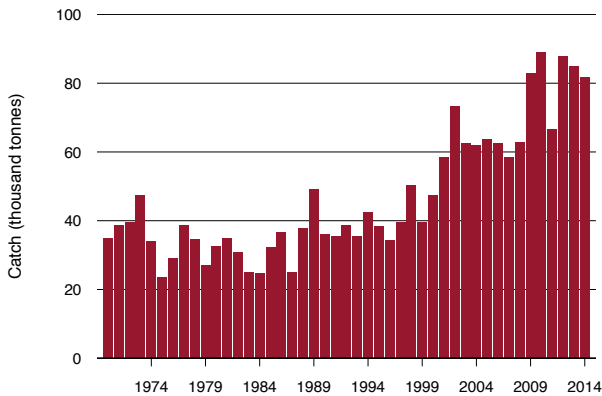
Catches in the ETBF increased slightly in 2015 (Figure 21.8). Catches in the south Pacific have increased in recent years, but decreased slightly in 2014 to 81 658 t (Figure 21.9). The WCPFC Scientific Committee recommended that longline fishing mortality be reduced if the WCPFC’s goal is to maintain economically viable catch rates.

FIGURE 21.8 Albacore catch and TACC in the ETBF, 1984 to 2015



Note: TACC Total allowable commercial catch.
Source: Australian Fisheries Management Authority

FIGURE 21.9 Albacore catch in the south Pacific, 1970 to 2014



Source: Western and Central Pacific Fisheries Commission

Stock assessment

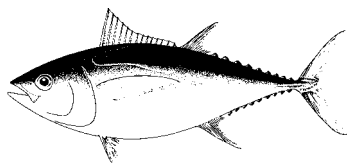
The assessment for albacore in the south Pacific was updated in 2015 using MULTIFAN-CL (Harley et al. 2015). Substantial improvements in the 2015 stock assessment included improvements to the MULTIFAN-CL modelling framework, use of a regional disaggregated framework, use of operational data for construction 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

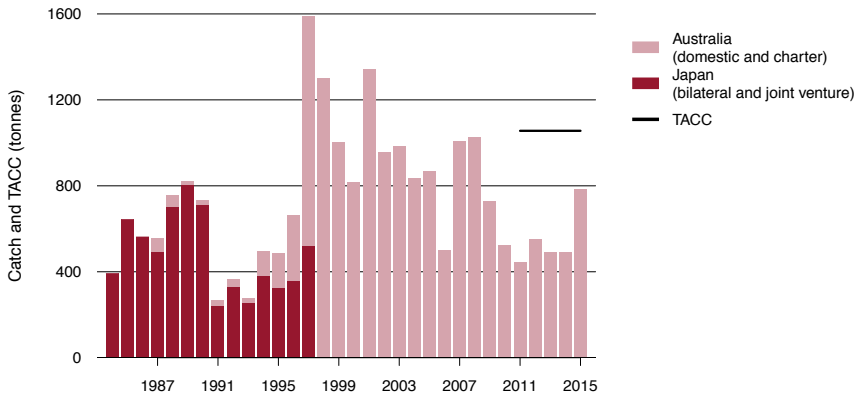
Stock structure

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 in the ETBF in 2015 (Figure 21.10) and in the WCPFC area in 2014 (Figure 21.11). Recent bigeye tuna catch in the WCPFC area (160 755 t in 2014) is well above the estimated MSY (108 520 t). Catch has been above this level since around 1987–88 (Figure 21.11).

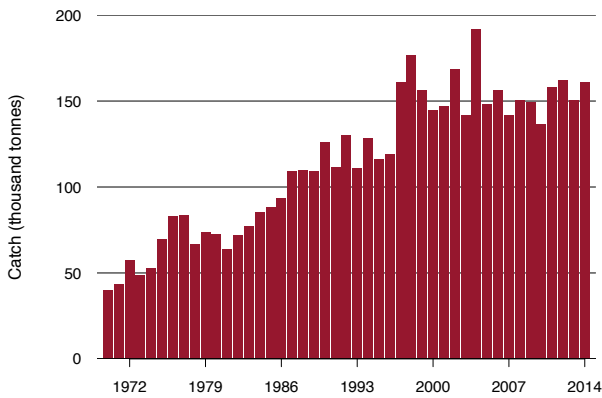
FIGURE 21.10 Bigeye tuna catch and TACC in the ETBF, 1984 to 2015



Note: TACC Total allowable catch.

Source: Australian Fisheries Management Authority

FIGURE 21.11 Bigeye tuna catch in the WCPFC area, 1970 to 2014



Source: Western and Central Pacific Fisheries Commission

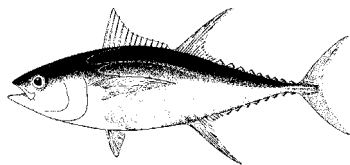
Stock assessment

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 ($SB_{\text{LATEST}}/SB_{F=0} = 0.16$ 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 ($SB_{\text{LATEST}}/SB_{\text{MSY}} = 0.77$ 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 ($F_{\text{CURRENT}}/F_{\text{MSY}} = 1.57$ 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

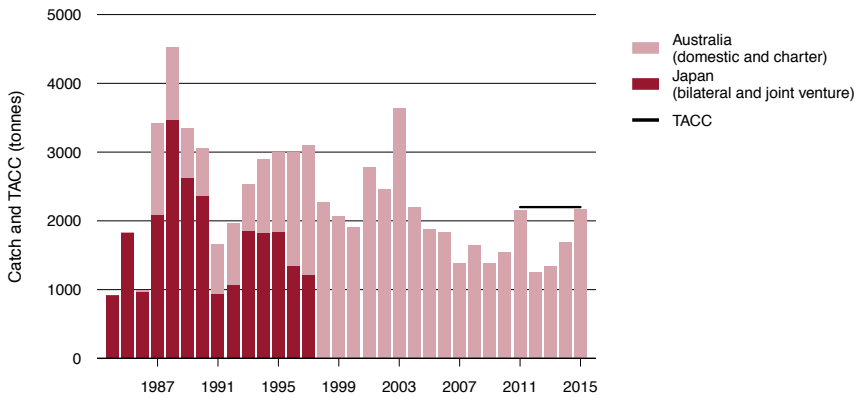
Stock structure

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 increased in the ETBF in 2015 (Figure 21.12). In the wider WCPFC area, the 2014 catch was the highest ever recorded, at 611 876 t (Figure 21.13), which is above the estimated MSY (586 400 t).

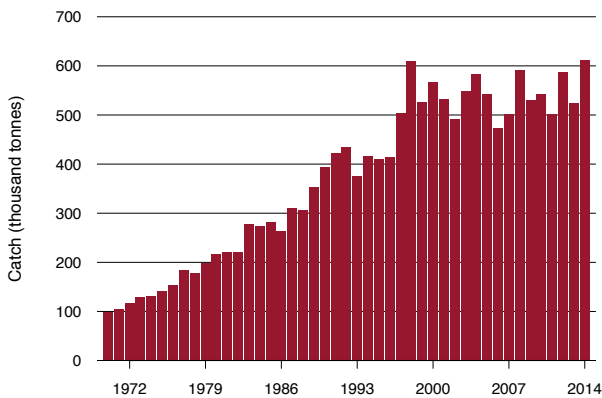
FIGURE 21.12 Yellowfin tuna catch and TACC in the ETBF, 1984 to 2015



Note: TACC Total allowable catch.

Source: Australian Fisheries Management Authority

FIGURE 21.13 Yellowfin tuna catch in the WCPFC area, 1970 to 2014



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 ETBF was most recently surveyed in 2014. Survey-based estimates were provided for the 2011–12 and 2012–13 financial years, and non-survey based estimates for economic performance were provided for 2013–14. Survey results showed that NER were positive from 2010–11 to 2012–13 (Figure 21.14); 2010–11 was the first year with positive NER since 2000–01 (Bath et al. 2016). 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 driver for the reduction in operating costs was a fall 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. 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.

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.

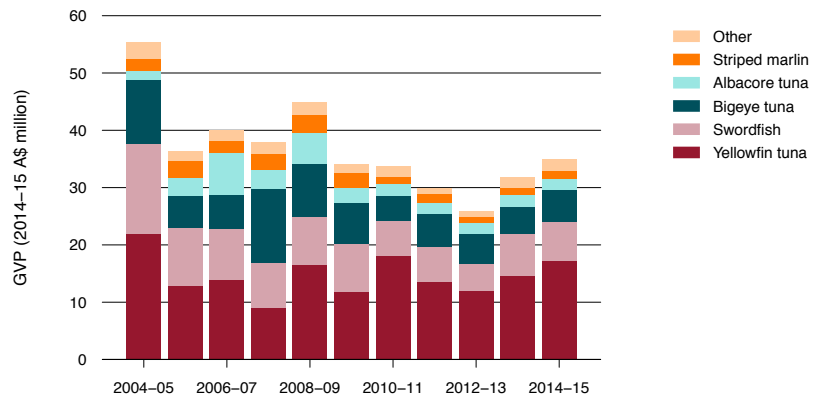
Cost and NER estimates are not yet available for 2014–15. Between 2013–14 and 2014–15, effort rose (from 6.96 million hooks to 8.22 million hooks), and the number of active vessels in the fishery fell from 40 to 39. Consistent with the increase in effort, the catch in the fishery increased from 4 365 t to 5 408 t in 2014–15, indicating potential slight improvements in productivity, in terms of quantity of fish caught per hook deployed. Fuel costs are also likely to have declined for the fleet in 2014–15 because fuel prices decreased significantly during the year. Latency in the fishery has fallen each year since 2013, further indicating improving conditions and positive NER. The gross value of production increased in 2014–15 by 12 per cent (Figure 21.15). NER in 2014–15 are still uncertain; however, the available economic information indicates that NER in the fishery increased in 2014–15.

FIGURE 21.14 NER for the ETBF, 2003–04 to 2013–14



Notes: NER Net economic returns. Data for 2013–14 is preliminary.
Source: Bath et al. 2016

FIGURE 21.15 Real GVP for the ETBF, 2004–05 to 2014–15



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 move to ITQs may have benefits for some species; however, since ITQs were only introduced in 2011, it is too early to assess their impact on NER. 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 taken 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 these species, a reduction in the Australian catch may not necessarily lead to an increase in stock and, therefore, profitability in the long term. The potential lack of association between domestic management actions and changes in stock biomass 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 turned 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 until 2019. Several conditions were imposed as part of the previous approval (which expired on 28 August 2014), including AFMA ensuring that the catch of bigeye tuna is sustainable and implementing measures to ensure that the take of sharks in the fishery is sustainable. To meet these conditions, AFMA, through TTRAG, undertook research into the consequences of different bigeye stock structures for the harvest strategy. For sharks, operators must not take more sharks than the number of fish of the quota species retained, up to a maximum of 20 sharks per trip. This excludes species that are subject to other catch limits—for example, white shark (*Carcharodon carcharias*) and other shark species that are no-take in the ETBF. AFMA has implemented a ban on retaining oceanic whitetip sharks (*Carcharhinus longimanus*), which was agreed by the WCPFC in early 2012. The use of wire trace leaders is prohibited in the ETBF.

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 species of sunfish (*Mola mola* and *M. ramsayi*) 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.

In 2015, logbooks indicated that 2 083 shortfin mako sharks (*Isurus oxyrinchus*) were hooked in the ETBF. Of these, 1 was released alive, 1 016 were dead, and 1 066 were released in unknown condition. Six longfin mako sharks (*I. paucus*) were also hooked; one was dead and five were in unknown condition. Seven porbeagle sharks (*Lamna nasus*) were hooked and released in unknown condition. Six green turtles (*Chelonia mydas*) were hooked; five were released alive and one was dead. Thirteen leatherback turtles (*Dermochelys coriacea*) and three loggerhead turtles (*Caretta caretta*) were also hooked and released alive. Two hawksbill turtles (*Eretmochelys imbricata*) were hooked and were dead. Six unidentified turtles were hooked, with four alive, one dead and one released in unknown condition. Five black-browed albatross (*Thalassarche melanophris*) were caught, with three released alive and two dead. One flesh-footed shearwater (*Ardenna carneipes*), six unclassified albatrosses and two unidentified birds were dead after being hooked. Several interactions with marine mammals were also recorded; these comprised four common dolphins (*Delphinus* spp.; three released alive and one dead), one melon-headed whale (*Peponocephala electra*; released alive), three short-finned pilot whales (*Globicephala macrorhynchus*; all released alive) and three unidentified whales (all released alive).



Yellowfin tuna
Lee Georgeson, ABARES

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Chapter 22

Skipjack Tuna Fishery

H Patterson and A Bath

FIGURE 22.1 Area fished in the Skipjack Tuna Fishery, 2008–09

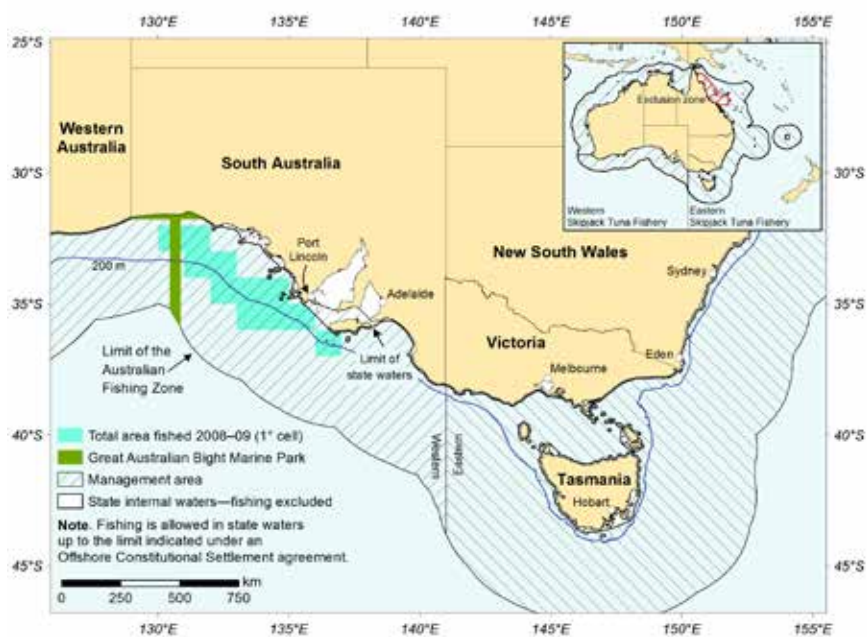


TABLE 22.1 Status of the Skipjack Tuna Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Indian Ocean skipjack tuna (<i>Katsuwonus pelamis</i>)					No Australian vessels fished in 2015. Current estimates of catch in the Indian Ocean are less than MSY. Spawning biomass is above the default limit reference point.
Western and central Pacific Ocean skipjack tuna (<i>Katsuwonus pelamis</i>)					No Australian vessels fished in 2015. Current estimates of fishing mortality in the WCPO are below F_{MSY} . Spawning biomass is above the default limit reference point.
Economic status	No Australian vessels fished in 2014 or 2015. 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



Skipjack tuna
 Kevin McLoughlin, ABARES

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 during 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

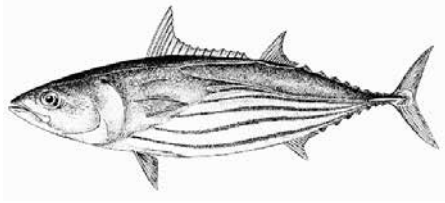
Fishery statistics ^a						
Fishery	2013–14 fishing season			2014–15 fishing season		
	TAC (t)	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t)	Real value (2014–15)
ESTF	–	0	\$0	–	0	\$0
WSTF	–	0	\$0	–	0	\$0
Total fishery	–	0	\$0	–	0	\$0
Fishery-level statistics						
Effort	0			0		
Fishing permits	ESTF: 18; WSTF: 14			ESTF: 18; 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, transshipment controls Output controls: bycatch limits					
Primary markets	Domestic and international: currently none					
Management plan	<i>Skipjack Tuna Fishery management arrangements 2009</i> (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.

22.2 Biological status

Indian Ocean skipjack tuna (*Katsuwonus pelamis*)



Line drawing: FAO

Stock structure

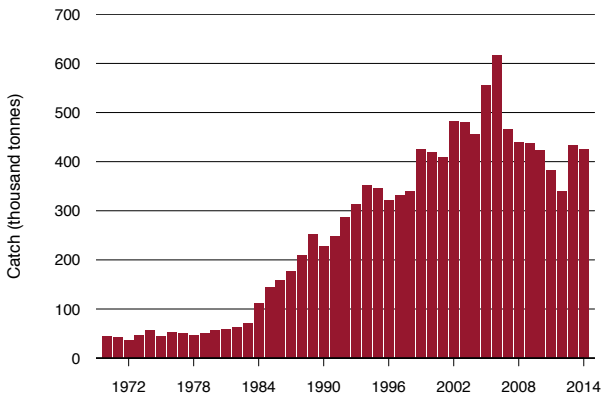
Skipjack tuna in the Indian Ocean is considered to be a single stock for stock assessment purposes. Tagging studies have shown large movements of skipjack tuna in the Indian Ocean and support the assumption of a single biological stock (IOTC 2014).

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. However, total catch in the IOTC area increased to 424 866 t in 2014 (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 2014



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 2014 (424 866 t) was below the estimated level of MSY (684 000 t; range 550 000–849 000 t; Figure 22.2), but above the five-year average of 400 778 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

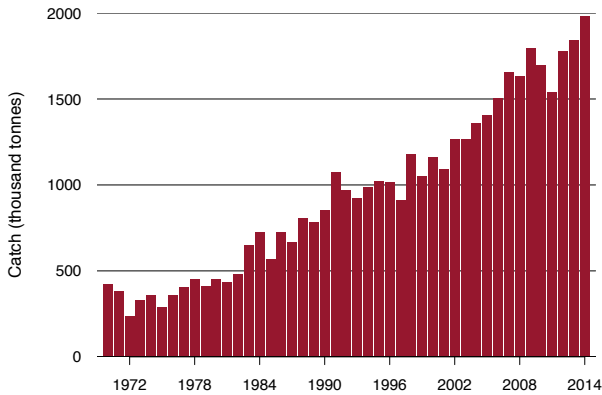
Skipjack tuna in the WCPO is considered to be a single stock for stock assessment purposes (Rice et al. 2014).

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 nine 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 2014



Note: **WCPFC** Western and Central Pacific Fisheries Commission
Source: WCPFC

Stock assessment

The 2011 skipjack tuna stock assessment for the WCPO was updated in 2014 using MULTIFAN-CL software (Rice et al. 2014). The update used data up to 2012, including updated CPUE indices and weighted purse-seine length-frequency samples. Several outlying recruitment estimates were also removed from parameter estimation (Rice et al. 2014). Five regions (instead of three) and 23 fisheries (instead of 18) were used in the assessment. The base case in the assessment estimated that the 2011 spawning biomass was 48 per cent of the level predicted to occur in the absence of fishing ($SB_{2011}/SB_{F=0} = 0.48$; range 0.46–0.73 across the base case and sensitivities) and well above the biomass required to achieve MSY ($SB_{2011}/SB_{MSY} = 1.81$; range 1.53–3.61 across the base case and sensitivities). Current fishing mortality (2008 to 2011 average) was estimated to be below the fishing mortality that will support MSY ($F_{CURRENT}/F_{MSY} = 0.62$; range 0.17–0.84 across the base case and sensitivities). In 2014, the catch in the WCPFC area was 1 982 578 t; this was above the estimate of MSY (1 532 000 t) but within the estimated range (1 334 400–3 051 900 t; Figure 22.3). The 2014 catch was above the five-year average of 1 767 130 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 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, 18 permits are issued in the ESTF and 14 in the WSTF. These are held by 19 companies, 8 of which hold one or more permits for both fisheries (AFMA 2016a, b). This implies that, if operational and market conditions were to change dramatically, fishing effort could be activated. It is unlikely that an increase in effort in the Australian skipjack 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 2012, the STF received a five-year exemption from export provisions (until 30 November 2016) and was accredited under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). No conditions specific to the fishery were attached to the accreditation.

The STF underwent 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.

22.5 References

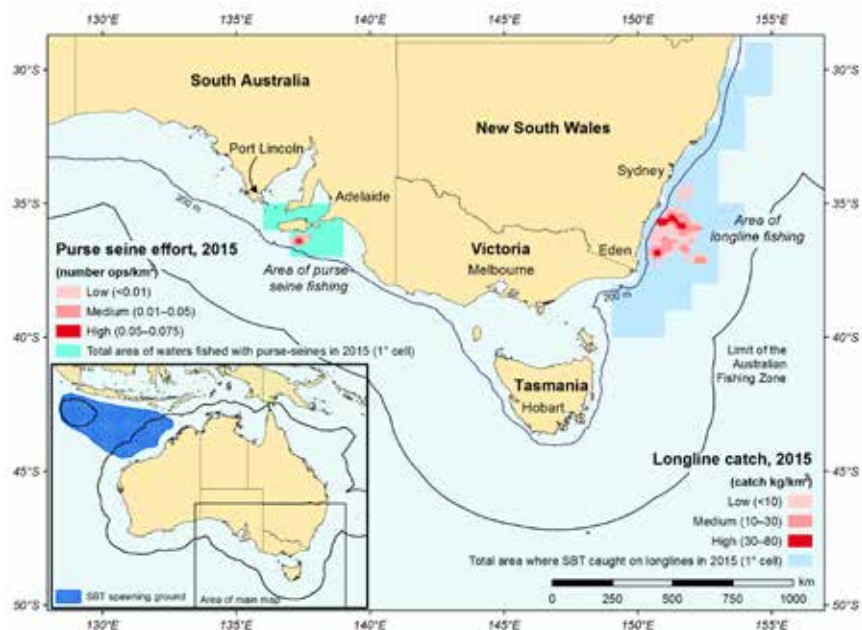
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Chapter 23

Southern Bluefin Tuna Fishery

H Patterson, I Stobutzki and R Curtotti

FIGURE 23.1 Purse-seine effort and longline catch in the Southern Bluefin Tuna Fishery, 2015



Note: SBT Southern Bluefin Tuna.

TABLE 23.1 Status of the Southern Bluefin Tuna Fishery

Status	2014		2015		Comments a
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Southern bluefin tuna (<i>Thunnus maccoyii</i>)					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.
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 being unloaded
 Matt Daniel, AFMA

23.1 Description of the fishery

Area fished

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 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 Fishing Zone 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 the majority of 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).

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 longliners operating along the east coast catch some southern bluefin tuna. Throughout the rest of its range, southern bluefin tuna is targeted by pelagic longliners from other fishing nations.

Recreational angling for southern bluefin tuna has been popular among gamefishers for many years, and activity among the general recreational fishing sector has increased and spread in recent years (for example, Rowsell et al. 2008). A survey of recreational southern bluefin tuna fishers in western Victoria from March to July 2011 (Green et al. 2012) estimated that 19 700 southern bluefin tuna were retained during the survey period, with an estimated weight of 240 t, and a further 6 900 southern bluefin tuna were estimated to have been caught and released.

A survey of recreational fishers in Tasmania, including a charter boat component, from November 2011 to October 2012 (Tracey et al. 2013) estimated that 75.8 t of southern bluefin tuna was caught and retained during the survey period, and that 1 035 southern bluefin tuna were caught and released. The survey also estimated that approximately 27 t was taken by seals. Post-release survival of southern bluefin tuna caught recreationally has been estimated as relatively high (83 per cent; range 75.9–90.7 per cent) (Tracey et al. 2016), indicating that released fish are likely to survive, depending on the gear that is used.

A state-wide survey of recreational fishers in South Australia in 2013–14 estimated a total catch of southern bluefin tuna of 16 261 fish, of which an estimated 10 427 fish were retained (Giri & Hall 2015). Using an average weight estimate of 14.46 kg for retained fish, the study derived a total catch estimate of 150.78 t. However, the error associated with the estimate is 47 per cent.

A recent study examined methods for estimating recreational catch of southern bluefin tuna and provided recommendations on methods to obtain a robust estimate (Moore et al. 2015). 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.

Management methods

The Commonwealth Fisheries Harvest Strategy Policy (DAFF 2007) is not prescribed for fisheries managed jointly under international management arrangements, such as the Southern Bluefin Tuna Fishery (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 Bali 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 sets the TAC for the SBTF in accordance with Australia's allocation.

The Commission has noted that levels of unaccounted mortality may be substantial. If this is correct, it may constitute exceptional circumstances because it was not taken into consideration when the management procedure was developed. In response, the Commission has agreed to a definition of attributable mortality, and work to account for non-member catch is being undertaken.

Fishing effort

Most of the Australian catch is taken 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 2015, 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 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 dramatically declined since the peak catches in the late 1950s, 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 in recent years. Australia's TAC and catch increased in 2015.

TABLE 23.2 Main features and statistics for the SBTF

Fishery statistics ^a		2013–14 fishing season			2014–15 fishing season		
Fishery/sector	TAC (t)	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t)	Real value (2014–15)	
Purse seine	5 312 ^b	5 039	\$38.1 million	5 557 ^c	4 947	\$33.44 million	
Pelagic longline	–	381	\$2.0 million	–	572 ^d	\$3.34 million	
Total fishery	5 312	5 420	\$40.1 million		5 519	\$36.8 million	
Fishery-level statistics							
Effort ^e	Purse seine: 752 search hours; 101 shots			Purse seine: 1 016 search hours; 154 shots			
Fishing permits	91 SFR owners initially allocated			89 SFR owners initially allocated			
Active vessels	Purse seine: 6 Longline: 15			Purse seine: 6 Longline: 18			
Observer coverage ^f	Purse seine: 16 shots (17.0%) Longline: 2.8% in ETBF; 9.1% in WTBF			Purse seine: 14 shots (9.1%) Longline: 5.87% (of hooks) in ETBF; 7.22 % (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						

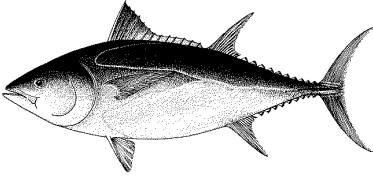
^a Fishery statistics are provided by fishing season, unless otherwise indicated. Season is 1 December to 30 November. Real-value statistics are by financial year. ^b Includes undercatch from the previous season. ^c Australia voluntarily reduced its effective TAC for 2014–15 by 108 t, to account for overcatch in the 2013–14 season. The actual TAC set by the Australian Fisheries Management Authority Commission was 5 665 t. ^d Includes some minor-line catch. ^e Effort only for where southern bluefin tuna were caught. ^f Longline observer coverage is provided by calendar year and includes hooks observed by both human observers and the electronic monitoring system.

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

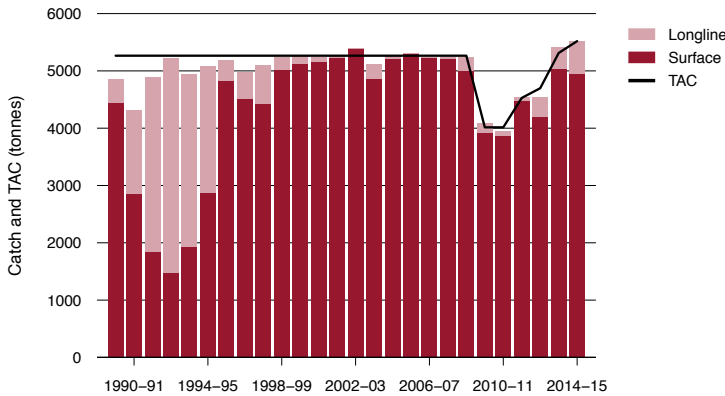
Stock structure

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

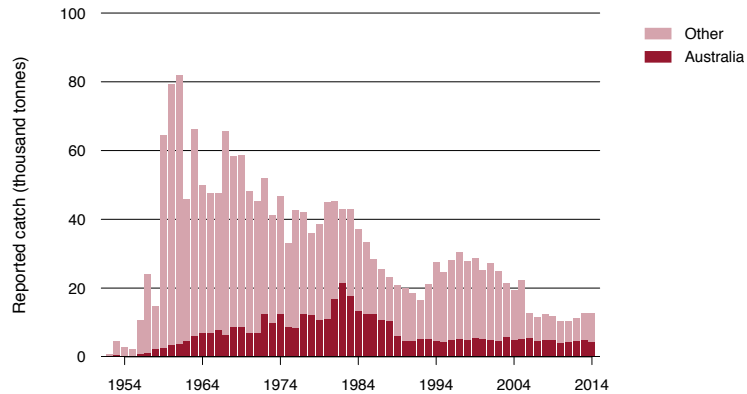
Australia's catch of southern bluefin tuna was relatively stable from 1989 to 2009 when the global TAC, and Australia's TAC, were reduced because of the poor state of the biological stock (Figure 23.2). However, the TAC has been slowly increasing with the implementation of the management procedure. Reported global catch peaked in the late 1950s before declining steadily (Figure 23.3).

FIGURE 23.2 Southern bluefin tuna catch and TAC (Australia), 1989–90 to 2014–15



Note: TAC Total allowable catch.

Source: Australian Fisheries Management Authority

FIGURE 23.3 Southern bluefin tuna catch (global), 1952 to 2014

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 specified 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 at a low level and 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 (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 spawning stock biomass of southern bluefin tuna remains at a low level—9 per cent of unfished levels. As a result, the stock remains classified as **overfished**.

The global TAC for 2015 was set 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 in 2016.

23.3 Economic status

Key economic trends

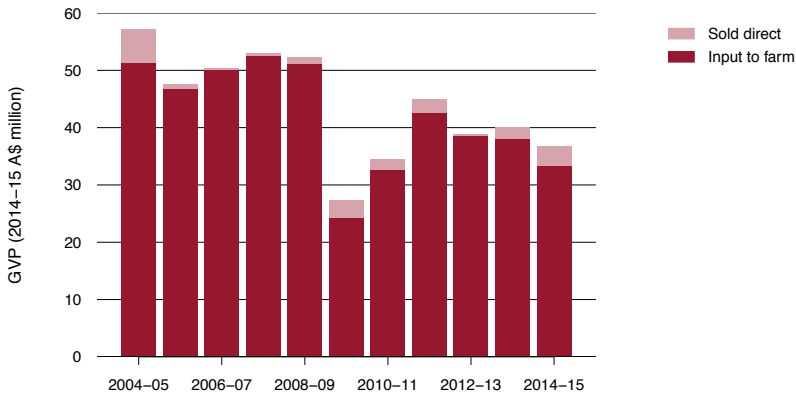
Assessment of economic performance in the wild-catch sector is complicated by the vertical integration of the wild-catch and aquaculture sectors. As noted above, most southern bluefin tuna caught are transferred to aquaculture farms off Port Lincoln. The beach price paid for live fish at the point of 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 2014–15, 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 \$36.8 million (Figure 23.4). This is 8 per cent lower (in real terms, 2014–15 dollars) than the value of production estimated for 2013–14. In 2014–15, prices declined significantly—by 11 per cent, to \$6.76 per kilogram—putting beach prices near the low levels experienced in 2009–10. The estimated value of the SBTF catch declined substantially (by 48 per cent) in 2009–10, to \$27 million, following a reduction in the estimated average unit beach price from \$10.33 per kilogram in 2008–09 to \$6.62 per kilogram in 2009–10 (in real terms, 2014–15 dollars), and a 19 per cent fall in the quantity of southern bluefin tuna caught in the fishery. Prices then recovered, with the estimated average beach price being around \$8.74 per kilogram from 2010–11 to 2013–14, and production quotas increased. As a result, the GVP estimated for the fishery has increased since 2009–10, with most of this increase occurring in 2010–11 and 2011–12.

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 2014–15, effort (search hours) increased by 35 per cent and at a faster rate than catch, indicating an increase in fishing cost per kilogram caught. In the same year, GVP declined, largely as a result of a decline in the beach price achieved for catch. Together, these figures indicate that the NER of the fishery are likely to have declined in 2014–15.

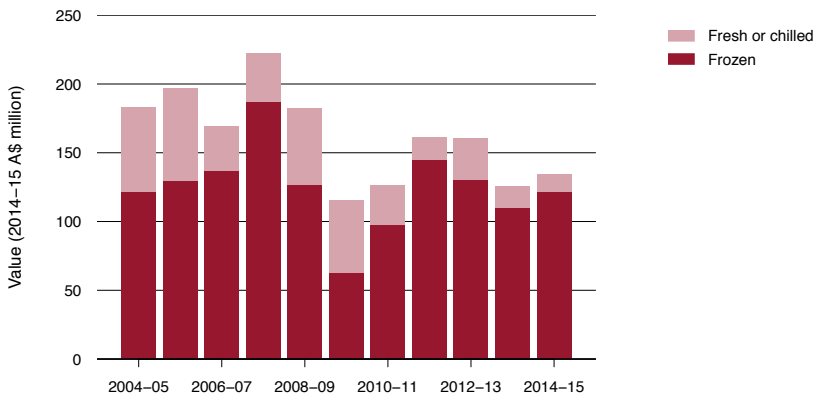
The value of farmed southern bluefin tuna exports in 2014–15 (after ranching) was \$131 million, a decrease of \$3 million from the value achieved in 2014–15 (\$134 million). Most of the farmed southern bluefin tuna is exported, mainly to Japan. In 2014–15, the Australian dollar unit price for exported southern bluefin tuna decreased by 5 per cent. Most of this decline was attributable to appreciation in the exchange rate of the Australian dollar relative to the yen. An increase in volume exported offset the negative effect on GVP of the decline in price, leading to a 7 per cent increase in the real value of southern bluefin tuna exports in 2014–15 (Figure 23.5).

FIGURE 23.4 Real GVP of southern bluefin tuna production, 2004–05 to 2014–15



Note: GVP gross value of production.

FIGURE 23.5 Real value of southern bluefin tuna exports, by processing method, 2004–05 to 2014–15



Management arrangements

The Australian TAC is allocated to holders of statutory fishing rights in the fishery through individual transferable quotas (ITQs). The ITQs give fishers flexibility to use input combinations that result in the most efficient operation. Theoretically, transferability of ITQs between fishers also allows the catch to be taken by the most efficient operators in the fishery, since quota is expected to gravitate to the most efficient operators. However, other factors are often considered by quota holders when deciding to lease or sell quota, sometimes resulting in quota not being allocated to the most efficient user. This may limit quota transaction activity between the purse-seine operators and longline operators in some years.

Performance against economic objective

The SBTF 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 new 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 24 July 2016. Conditions placed on the export approval include increasing confidence in the estimates of purse-seine catches, and developing and using a methodology to derive robust estimates of recreational and charter catch in Australian waters. ABARES, in collaboration with several states, has developed methods to derive robust estimates of the national recreational catch of southern bluefin tuna in Australian waters (Moore et al. 2015). Options for the implementation of these methods are now being considered.



Southern bluefin tuna
Matt Daniel, AFMA

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 2015. Interactions with sharks and other protected species using longline gear are discussed in Chapters 21 and 24.

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, 2015

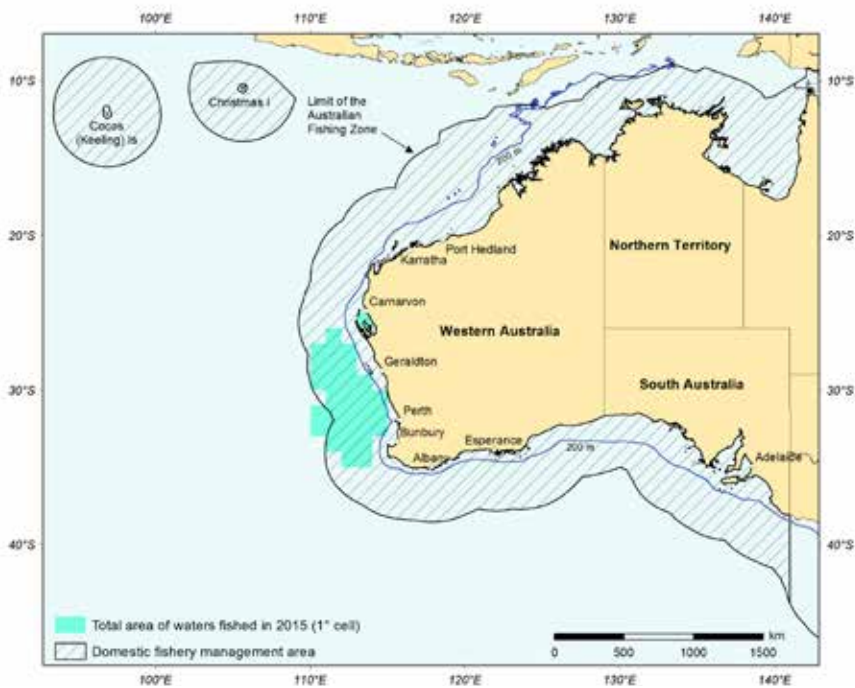


TABLE 24.1 Status of the Western Tuna and Billfish Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Striped marlin (<i>Tetrapturus audax</i>)					Most recent estimate of biomass is above the default limit reference point. Current fishing mortality rate exceeds that required to produce MSY.
Swordfish (<i>Xiphias gladius</i>)					Most recent estimate of spawning biomass is above the default limit reference point. Current fishing mortality rate is below that required to produce MSY.
Albacore (<i>Thunnus alalunga</i>)					Most recent estimate of spawning biomass is above the default limit reference point. Current fishing mortality rate is below that required to produce MSY.
Bigeye tuna (<i>Thunnus obesus</i>)					Most recent estimate of spawning biomass is above the default limit reference point. Current fishing mortality rate is below that required to produce MSY.
Yellowfin tuna (<i>Thunnus albacares</i>)					Most recent estimate of spawning biomass is above the default limit reference point. Current fishing mortality rate is above that required to produce MSY.
Economic status	Latency remained high in 2015, 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) and the Indian Ocean Tuna Commission 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 the Exclusive Economic Zone and 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 (*Tetrapturus audax*) and swordfish (*Xiphias gladius*). There is also some albacore (*Thunnus alalunga*) taken. Fishing in the WTBF mainly uses pelagic longline; some minor-line fishing also occurs (Table 24.2).

Management methods

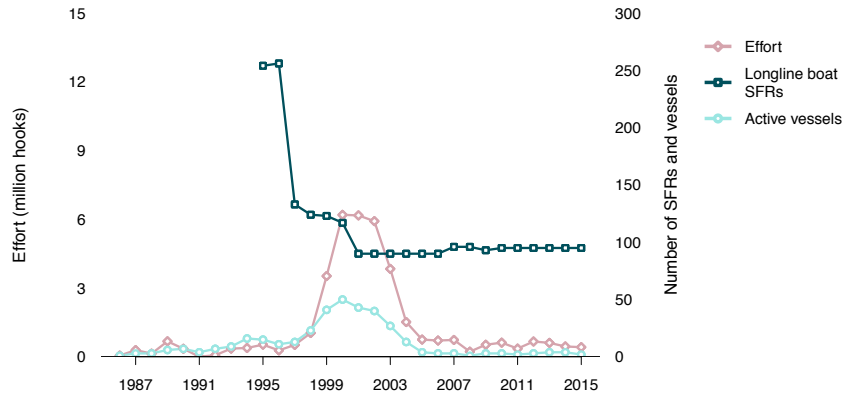
The management plan for the fishery began in 2005, although the Australian Fisheries Management Authority (AFMA) first granted statutory fishing rights in 2010. Under the management plan, output controls have been implemented in the fishery through individual transferable quotas (ITQs) for the four key commercial species: bigeye tuna, yellowfin tuna, striped marlin and swordfish. Determinations of total allowable commercial catch (TACC) are made in accordance with Australia's domestic policies, and apply to the Australian Fishing Zone (AFZ) 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. Overfished status is determined by the default limit reference point (a depletion to 20 per cent of the unfished biomass level) contained in the Commonwealth Fisheries Harvest Strategy Policy (HSP; DAFF 2007). The same limit reference point has recently been adopted by the IOTC. However, the IOTC still determines overfished status relative to maximum sustainable yield (MSY), not the limit reference point. Overfishing status is informed by the total fishing mortality relative to fishing mortality that would achieve MSY (F_{MSY}) as adopted by the IOTC.

As of 1 July 2015, electronic monitoring (e-monitoring) was made mandatory for all full-time pelagic longline vessels in the WTBF. At least 10 per cent of video footage of all hauls are 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 from the mid 1980s to the mid 1990s (Figure 24.2). Effort then started to increase, peaking in 2000 with 50 active vessels, but declined steadily after then. 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 2015

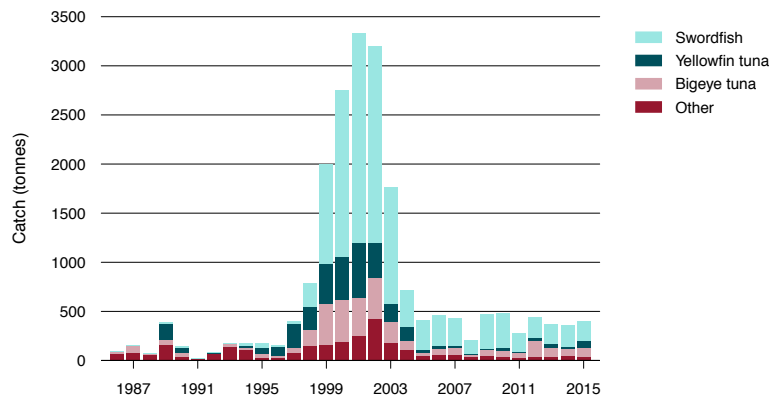


Note: SFR Statutory fishing rights.
 Source: Australian Fisheries Management Authority

Catch

The main target species in the WTBF is swordfish, with 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 swordfish and have been more variable.

FIGURE 24.3 Total annual catch by species in the WTBF, 1986 to 2015



Source: Australian Fisheries Management Authority

TABLE 24.2 Main features and statistics for the WTBF

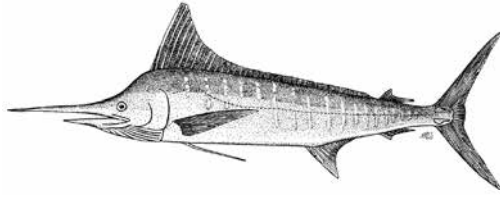
Fishery statistics a	2014			2015		
	TACC (t)	Catch (t)	Real value (2013–14)	TACC (t)	Catch (t)	Real value (2014–15)
Striped marlin	125	<1	Confidential	125	2	Confidential
Swordfish	3 000	233	Confidential	3 000	220	Confidential
Albacore	–	16	Confidential	–	27	Confidential
Bigeye tuna	2 000	90	Confidential	2 000	109	Confidential
Yellowfin tuna	5 000	22	Confidential	5 000	82	Confidential
Total	10 125	361	Confidential	10 125	440	Confidential
Fishery-level statistics						
Effort	Pelagic longline: 452 658 Minor line: na			Pelagic longline: 421 185 Minor line: na		
Fishing permits	95 boat SFRs			95 boat SFRs		
Active vessels	Pelagic longline: 4 Minor line: 3			Pelagic longline: 2 Minor line: 1		
Observer coverage	41 066 hooks (9.1%)			7.2% b		
Fishing methods	Pelagic longline (monofilament mainline), minor line (handline, rod and reel, troll and poling), purse seine					
Primary landing ports	Fremantle, 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 2012); SFRs issued 2010					

a Fishery statistics are provided by calendar year to align with international reporting requirements. Real-value statistics are by financial year. **b** Since 1 July 2015, e-monitoring is mandatory for all full-time pelagic longline vessels in the WTBF. At least 10% of video footage of all hauls is reviewed to verify the accuracy of logbooks which are required to be completed for 100% of shots.

Notes: **ITQ** Individual transferable quota. **na** Not available. **SFR** Statutory fishing right. **TACC** Total allowable commercial catch. – Not applicable.

24.2 Biological status

Striped marlin (*Tetrapturus audax*)



Line drawing: FAO

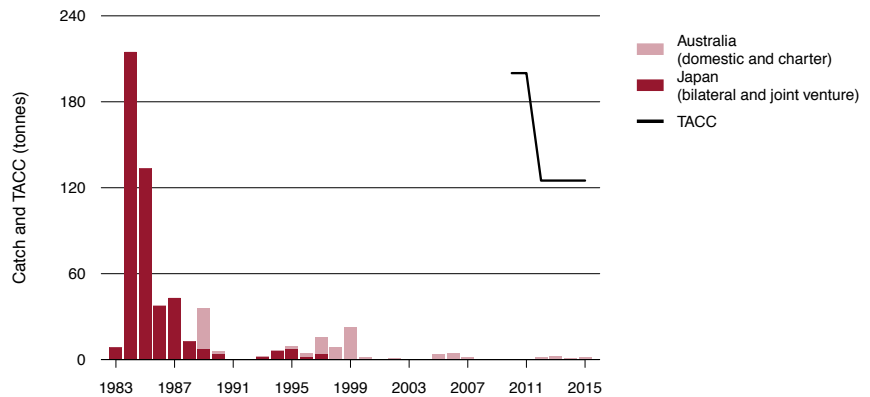
Stock structure

Striped marlin in the Indian Ocean is considered to be a distinct biological stock. Tagging studies have demonstrated large-scale movements of striped marlin in the Indian Ocean that support the assumption of a single biological stock (IOTC 2015).

Catch history

Catches of striped marlin in the WTBF have always been relatively low—less than 60 t since the mid 1980s and very low in recent years, with <1 t taken in 2014 and 2 t in 2015 (Figure 24.4). Total international catches in the IOTC area of competence have declined from around 6 000 t in 1995 to 4 647 t in 2013 and 3 874 t in 2014 (Figure 24.5), which is above the estimated MSY.

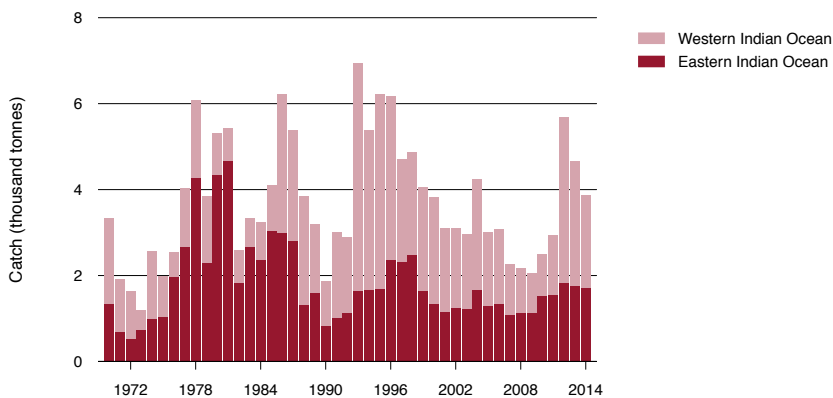
FIGURE 24.4 Striped marlin catch and TACC in the WTBF, 1983 to 2015



Note: TACC Total allowable commercial catch; initial TACC for a period of 19 months.

Source: Australian Fisheries Management Authority

FIGURE 24.5 Striped marlin catch in the IOTC area, 1970 to 2014



Note: IOTC Indian Ocean Tuna Commission.
Source: IOTC

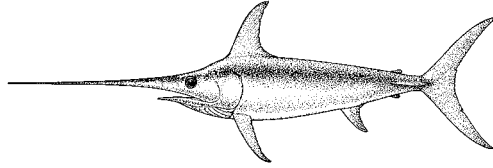
Stock assessment

The most recent stock assessments for striped marlin were undertaken 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 levels ($B_{2014}/B_0 = 0.24$) and below the level that would support MSY ($B_{2014}/B_{MSY} = 0.65$; range 0.45–1.17) (IOTC 2015). 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). Improved data collection and recording, and further development of methods for data-poor fisheries would improve future assessments of this species.

Stock status determination

The ASPIC assessment indicates that the current biomass is above the default limit reference point of 20 per cent of initial unfished levels. 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

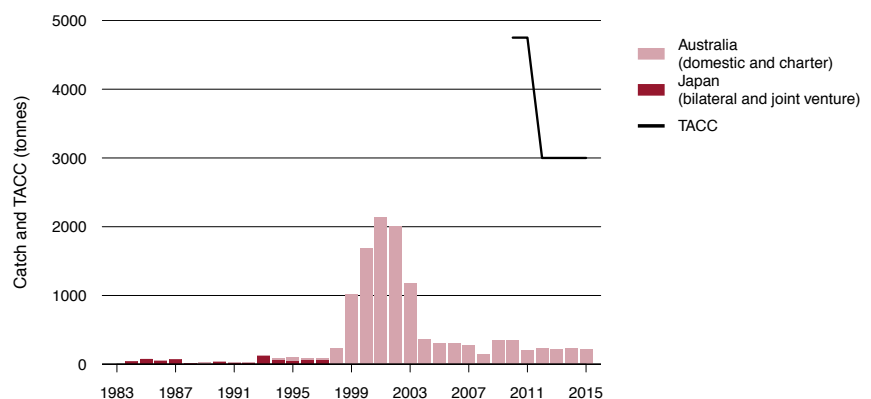
Stock structure

Swordfish in the Indian Ocean is considered to be a 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). Subject to any further research on stock structure, the best information indicates that swordfish in the Indian Ocean should be managed as a single stock.

Catch history

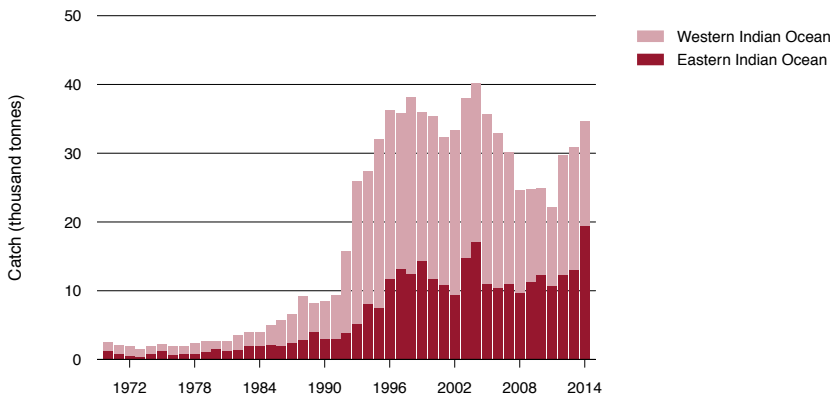
Swordfish catch in the WTBF peaked in the early 2000s but has declined since then with declining effort in the fishery. Catches in the WTBF decreased slightly from 233 t in 2014 to 220 t in 2015 (Figure 24.6). Swordfish catch in the IOTC area of competence peaked in 2004 but has declined since then, likely as a result of the impacts of piracy in the western Indian Ocean. Catches in the IOTC increased from 30 887 t in 2013 to 34 695 t in 2014 (Figure 24.7). Recent catches are within, or slightly in excess of, the estimated MSY range (29 900–34 200 t).

FIGURE 24.6 Swordfish catch and TACC in the WTBF, 1983 to 2015



Note: TACC Total allowable commercial catch; initial TACC for a period of 19 months.
Source: Australian Fisheries Management Authority

FIGURE 24.7 Swordfish catch in the IOTC area, 1970 to 2014



Note: IOTC Indian Ocean Tuna Commission.
Source: IOTC

Stock assessment

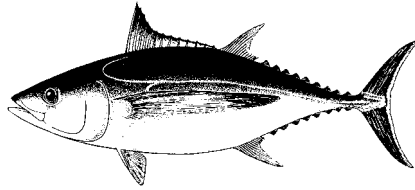
In 2014, a range of ocean-wide stock assessment models (Stock Synthesis 3 [SS3], ASPIC, Bayesian Biomass Dynamic Modelling [BBDM], Age-Structured Integrated Analysis) were applied to the Indian Ocean-wide swordfish stock (IOTC 2015). The SS3 assessment was considered to be the most reliable and informative 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 2015). Fishing mortality was estimated to be well below MSY ($F_{2013}/F_{MSY} = 0.34$; range 0.28–0.40).

Concerns about historical overfishing in the south-west Indian Ocean region led to a separate assessment for that area (IOTC 2015). The results indicated local spawning biomass depletion levels of 16 per cent of the initial unfished level. This is more optimistic than previous assessments of the south-west region and suggests that the state of the stock in the south-west is not as poor as previously believed.

Stock status determination

Assessments of the ocean-wide stock indicate that swordfish biomass is above the HSP default limit reference point 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

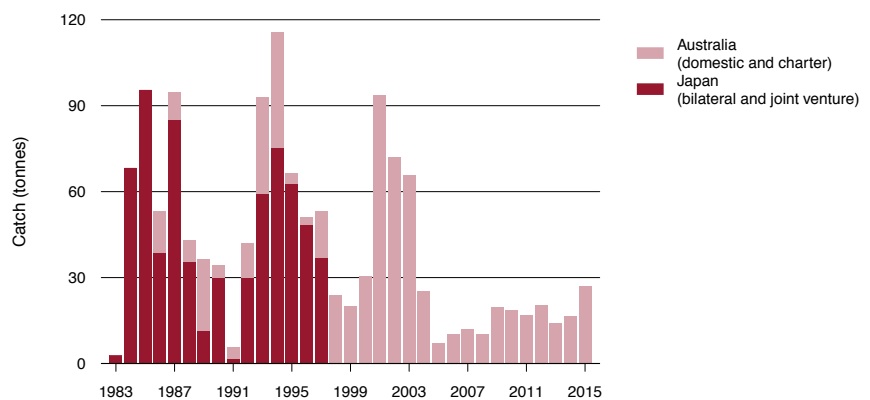
Stock structure

Albacore in the Indian Ocean is considered to be a distinct biological stock. In the Atlantic and Pacific oceans, two distinct stocks occur, due to the presence of northern and southern ocean gyres. Because no northern gyre exists in the Indian Ocean, it is likely that only a single stock exists (IOTC 2015). A genetic study of albacore found that the Atlantic Ocean and Indian Ocean populations were not distinguishable (Montes et al. 2012). This homogeneity may be driven by albacore migrating between the Indian and southern Atlantic oceans off South Africa.

Catch history

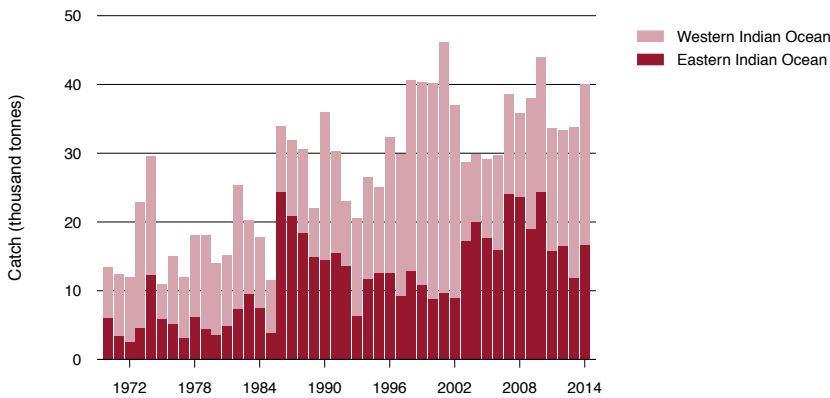
Historically, albacore catches in the WTBF have been low, and since 2004 annual catches have been below 30 t. Catches increased slightly from 16 t in 2014 to 27 t in 2015 (Figure 24.8). Total catches in the IOTC area of competence have increased from 33 720 t in 2013 to 40 091 t in 2014 (Figure 24.9). Recent catches are considered to be approaching or exceeding MSY, depending on the assessment model.

FIGURE 24.8 Albacore catch in the WTBF, 1983 to 2015



Source: Australian Fisheries Management Authority

FIGURE 24.9 Albacore catch in the IOTC area, 1970 to 2014



Note: IOTC Indian Ocean Tuna Commission.
Source: IOTC

Stock assessment

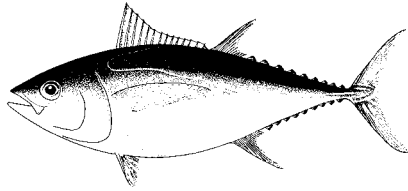
In 2014, a range of assessment models were applied to the Indian Ocean albacore stock to allow comparison, including ASPIC, Age-Structured Production Model (ASPM), Age-Structured Assessment Program (ASAP), SS3 and BBDM. The results from the ASPIC and SS3 models were used to represent the current status of albacore (IOTC 2015). Considerable uncertainty exists about standardised catch-per-unit-effort (CPUE) and total catches, and this uncertainty requires further investigation (IOTC 2015).

The current (2012) biomass was estimated to be between 21 and 43 per cent of the unfished (1950) levels (SS3: $SB_{2012}/SB_{1950} = 0.21$, range 0.11–0.33; ASPIC: $B_{2012}/B_{1950} = 0.43$) and close to the level that supports MSY (SS3: $SB_{2012}/SB_{MSY} = 1.09$, range 0.34–2.20; ASPIC: $B_{2012}/B_{MSY} = 1.05$, range 0.73–1.35). Fishing mortality was estimated to be at or below the level that results in MSY (SS3: $F_{2012}/F_{MSY} = 0.69$, range 0.23–1.39; ASPIC: $F_{2012}/F_{MSY} = 0.94$, range 0.68–1.61) (IOTC 2015).

Stock status determination

The assessment indicates that the spawning biomass is above the HSP default limit reference point (SB_{20}), and so the stock is classified as **not overfished**. Fishing mortality across the entire IOTC area has also decreased and is below F_{MSY} , and so the stock is classified as **not subject to overfishing**.

Bigeye tuna (*Thunnus obesus*)



Line drawing: FAO

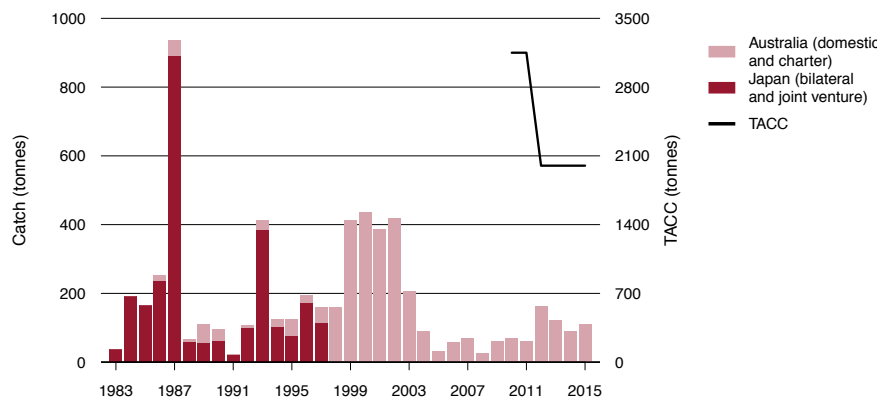
Stock structure

Bigeye tuna in the Indian Ocean is considered to be a distinct biological stock, based on a genetic study (Chiang et al. 2008), and tagging studies that have demonstrated large-scale movements of bigeye tuna (IOTC 2015).

Catch history

Catches of bigeye tuna in the WTBF were relatively stable from 2007 to 2011, before increasing in 2012 and 2013, and then decreasing again. Catches increased slightly from 90 t in 2014 to 109 t in 2015 (Figure 24.10). Total catches in the IOTC area of competence have been slowly declining as a result of the impacts of piracy in the western Indian Ocean, which has displaced fishing effort to areas further south and east. Bigeye catch decreased from 117 796 t in 2013 to 96 158 t in 2014 (Figure 24.11). The catch in 2013 was below the estimated MSY of 132 000 t, as is the five-year average catch.

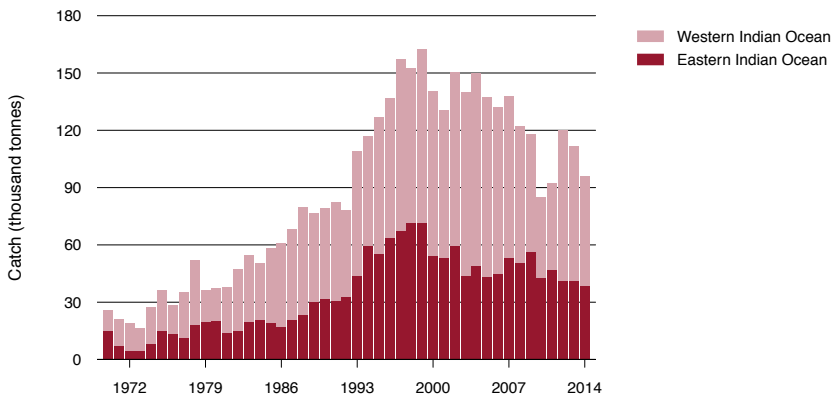
FIGURE 24.10 Bigeye tuna catch and TACC in the WTBF, 1983 to 2015



Note: TACC Total allowable commercial catch; initial TACC for a period of 19 months.

Source: Australian Fisheries Management Authority

FIGURE 24.11 Bigeye tuna catch in the IOTC area, 1970 to 2014



Note: IOTC Indian Ocean Tuna Commission.
Source: IOTC

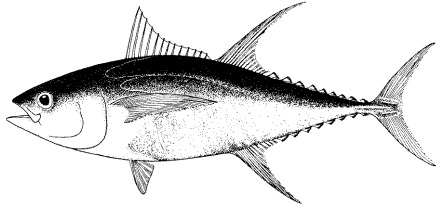
Stock assessment

The most recent stock assessment (2013) used three models (SS3, ASAP and ASPM), using data up to 2012 (IOTC 2015). The results were similar to previous assessments, although a revised catch history and CPUE series were used. The IOTC Working Party on Tropical Tunas (2013) agreed that management advice for bigeye tuna should be based on the SS3 model because the results examined a range of options and demonstrated a relatively good fit to the data. The results from the SS3 assessment indicate that the current spawning stock biomass is above the level that would produce MSY ($SB_{2012}/SB_{MSY} = 1.44$; range 0.87–2.22). Similarly, the assessment indicated that spawning biomass is above 20 per cent of the initial unfished level ($SB_{2012}/SB_0 = 0.40$; range 0.27–0.54). Fishing mortality was below the level associated with MSY ($F_{2012}/F_{MSY} = 0.42$; range 0.21–0.80).

Stock status determination

The updated SS3 assessment indicates that bigeye tuna spawning stock biomass is above the HSP default limit reference point of 20 per cent of initial unfished levels. 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

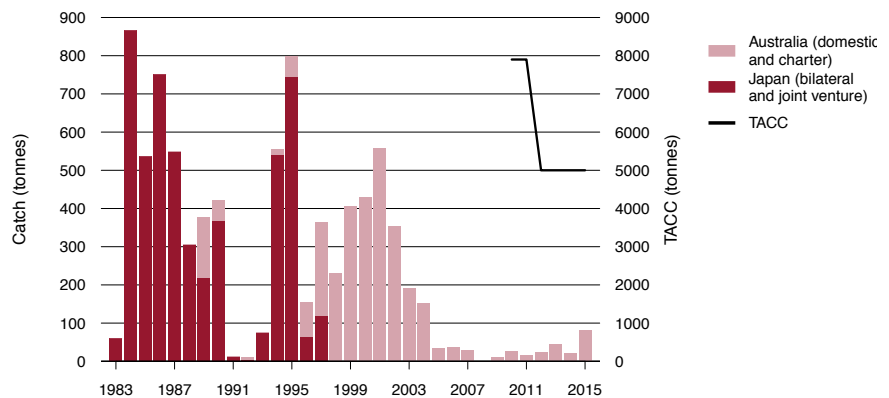
Stock structure

Yellowfin tuna in the Indian Ocean is considered to be a single biological stock. Tagging studies have demonstrated large-scale movements of yellowfin tuna in the Indian Ocean that support this assumption (Langley et al. 2012).

Catch history

Since the early 2000s, declining effort in the WTBF has generally resulted in reduced catches of yellowfin tuna. Catches increased from 22 t in 2014 to 82 t in 2015 (Figure 24.12). Total catches in the IOTC area of competence have generally increased with increasing demand, but declined for several years because of the impacts of piracy. Catches have increased again in recent years to 408 008 t in 2013 and 414 341 t in 2014 (Figure 24.13), and remain within the range of MSY values (421 000 t; range 404 000–439 000 t).

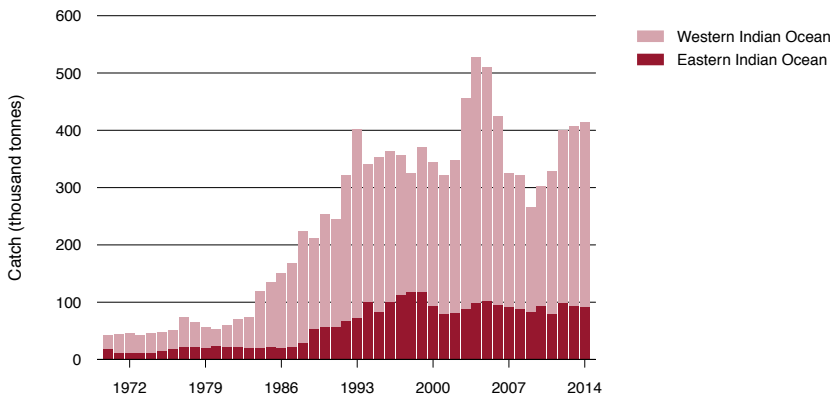
FIGURE 24.12 Yellowfin tuna catch and TACC in the WTBF, 1983 to 2015



Note: TACC Total allowable commercial catch; initial TACC for a period of 19 months.

Source: Australian Fisheries Management Authority

FIGURE 24.13 Yellowfin tuna catch in the IOTC area, 1970 to 2014



Note: IOTC Indian Ocean Tuna Commission.
Source: IOTC

Stock assessment

In 2015, yellowfin tuna was assessed using three quantitative methods: statistical catch-at-age analysis, Bayesian biomass production model, and SS3. It was agreed by the Working Party on Tropical Tunas that management advice for the stock would be based on the results of the SS3 analysis, although all models produced similar results (IOTC 2015). The results indicate that 2014 levels of fishing mortality were above the level that would achieve MSY ($F_{2014}/F_{MSY} = 1.34$; range 1.02–1.67). Current spawning biomass was also estimated to be below the level associated with MSY ($SB_{2014}/SB_{MSY} = 0.66$; range 0.58–0.74) but above the default limit reference point ($SB_{2014}/SB_0 = 0.23$; range 0.21–0.36).

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 limit reference point of 20 per cent of initial unfished biomass, 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 2014 and 2015, 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 2015. Despite effort decreasing from 2014 to 2015, total catch increased from 361 t to 440 t. However, as in 2014, landed catch in the fishery continues to be a small proportion of the TACC. 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 a 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.

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 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). There is a limit of 20 sharks per trip when operating in the AFZ.

AFMA publishes quarterly reports of logbook interactions with protected species on its website. In 2015, 358 shortfin mako sharks (*Isurus oxyrinchus*) were hooked in the WTBF; all were released in an unknown condition. Three porbeagles (*Lamna nasus*) were hooked and released in an unknown condition. Sixteen leatherback turtles (*Derموchelys coriacea*) were also hooked, with 14 released alive and 2 dead. One loggerhead turtle (*Caretta caretta*) and one olive Ridley turtle (*Lepidochelys olivacea*) were hooked and released alive. Finally, two unidentified albatrosses were hooked and found to be dead.

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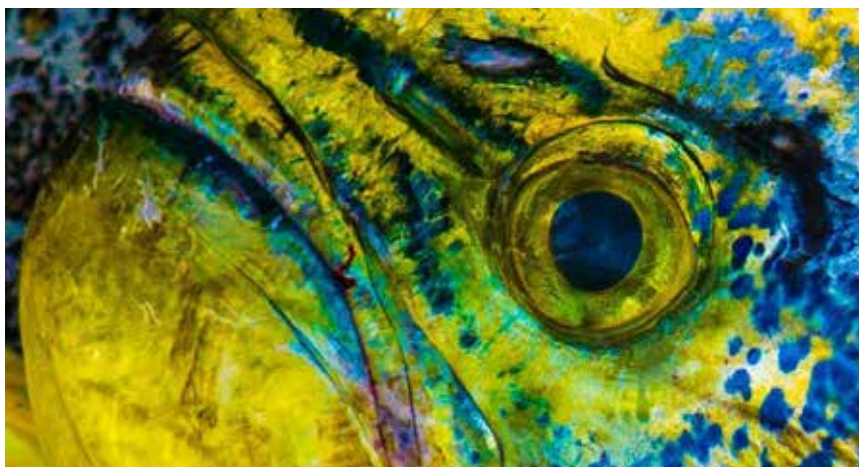
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Mahi mahi
Matt Daniel, AFMA

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, 2015

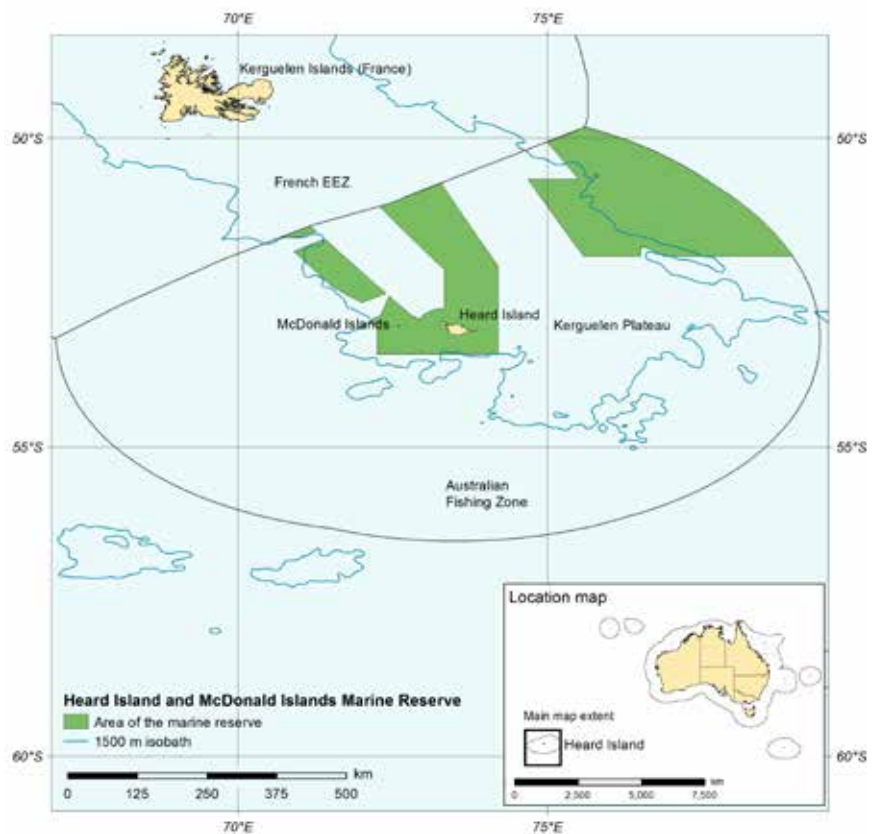


TABLE 25.1 Status of the Heard Island and McDonald Islands Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Biological status					
Mackerel icefish (<i>Champsocephalus gunnari</i>)					TACs are set in accordance with a precautionary harvest strategy.
Patagonian toothfish (<i>Dissostichus eleginoides</i>)					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 positive for 2013–14 and 2014–15 because the TACs for Patagonian toothfish were mostly caught.				

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. A 1 nm buffer zone around the territorial waters of HIMI extends the area closed to fishing to 13 nm. The HIMI Marine Reserve was declared in October 2002 and then expanded in March 2014 by proclamation after scientific assessment. The reserve now totals 71 200 km². Waters between 12 and 200 nm from HIMI are part of the Australian Fishing Zone (AFZ). The *Heard Island and McDonald Islands Marine Reserve management plan 2014–2024* (Department of the Environment), 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

Demersal trawl and demersal longline are the main methods used in the fishery, although trawl is being phased out. 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 are considered precautionary.

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 McDonald 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 June 2011. Patagonian toothfish in the HIMIF was certified as sustainable by the MSC in March 2012.

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.

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 since 2000–01, although the catch in 2014–15 increased in response to the increased TAC.

TABLE 25.2 Main features and statistics for the HIMIF

Fishery statistics a	2013–14 fishing season			2014–15 fishing season		
	TAC (t)	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t)	Real value (2014–15)
Mackerel icefish	1 267	1 074	Confidential	309	10	Confidential
Patagonian toothfish	2 730	2 744 b	Confidential	4 410	4 279	Confidential
Fishery-level statistics						
Effort	97 trawl days 8 765 910 hooks 0 pots hauled			57 trawl days 16 139 770 hooks 0 pots hauled		
Fishing permits	4 quota SFR holders			4 quota SFR holders		
Active vessels c	4			7		
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 14 t was deducted from the 2014–15 season quota to take account of the overcatch of the previous year. c All vessels carry two observers on each trip.

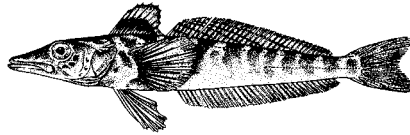
Notes: ITQ Individual transferable quota. SFR Statutory fishing right. TAC Total allowable catch.



Rough seas
Austral Fisheries

25.2 Biological status

Mackerel icefish (*Champscephalus 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 season, and growth rates (Williams et al. 2001).

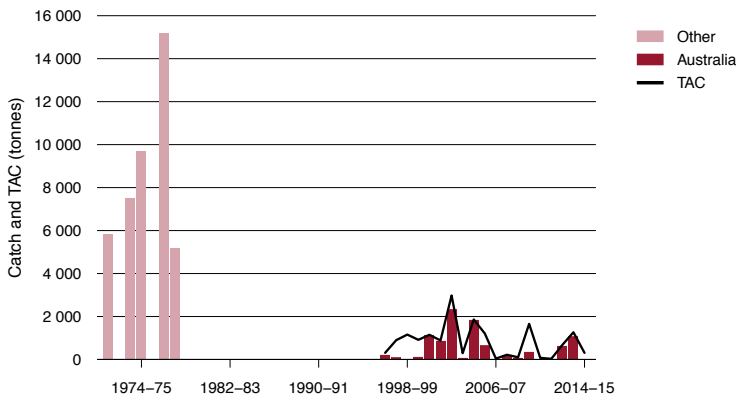
Catch history

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 as to where these earlier catches were taken relative to the current maritime boundaries. The initial TAC for icefish was set by the CCAMLR in 1995. 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.

Stock assessment

A random stratified trawl survey in May 2015 provided information on the abundance and age structure of the mackerel icefish stock (Nowara et al. 2015). As noted in previous years, multiple year-classes were present, with the 2+ year-class estimated to account for 69 per cent of the biomass (Welsford 2015). The stock assessment estimated the current biomass at 5 123 t (Welsford 2015). Yields of 482 t for the 2015–16 season and 357 t for the 2016–17 season were estimated to satisfy the CCAMLR decision rules, assuming that the entire 2014–15 TAC was taken. In 2014–15, only 3 per cent of the TAC was taken, due to the focus on Patagonian toothfish. 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 2016 survey. A TAC of 482 t for the 2015–16 season was endorsed by the CCAMLR (CCAMLR 2015a, b).

FIGURE 25.2 Catch and TAC of mackerel icefish in the HIMIF, 1971–72 to 2014–15



Note: TAC Total allowable catch.

Source: Australian Fisheries Management Authority

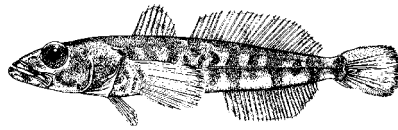
Stock status determination

Based on the low 2014–15 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**.



Fishing vessel
Austral Fisheries

Patagonian toothfish (*Dissostichus eleginoides*)



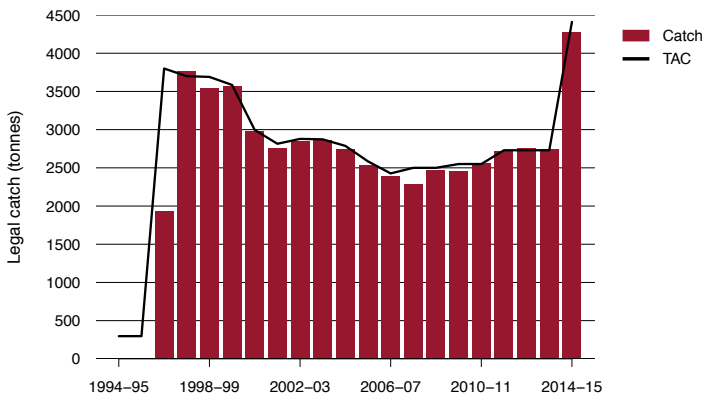
Line drawing: FAO

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, no 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). Data from tagging studies (for example, Welsford et al. 2011; Williams et al. 2002) 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 (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.

FIGURE 25.3 Catch and TAC of Patagonian toothfish in the HIMIF, 1994–95 to 2014–15

Note: TAC Total allowable catch.

Source: Australian Fisheries Management Authority

Stock assessment

The 2015 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. In addition, 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, full tagging data from 2014 and partial tagging data from 2015; updating the growth model; and changing the 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), although the unfished spawning biomass estimate was less than the previous estimate (CCAMLR 2015a). A catch limit of 3 405 t satisfied the CCAMLR decision rules and was the recommended TAC for 2015–16 and 2016–17 (CCAMLR 2015a, b). This TAC is lower than that set for 2014–15 because of the inclusion of tagging data in the model, which drives 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. The stock biomass of mackerel icefish varies naturally from year to year, and, as a result of low estimated biomass, mackerel icefish was not targeted in the 2010–11 and 2011–12 fishing seasons; in 2010–11, only a research TAC was in place, and industry opted not to target icefish given this low TAC. 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. In 2014–15, there was an increase in the TAC for Patagonian toothfish, which was mostly caught, indicating that NER for the fishery are positive.

In contrast, mackerel icefish catch fell significantly in 2014–15 as its TAC was sharply reduced because of the natural fluctuation in the stock size. Patagonian toothfish was targeted at the expense of the mackerel icefish catch because of its higher value and increased TAC.

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 May 2017. Recommendations associated with this exemption include continuing to investigate Patagonian toothfish population dynamics and connectivity in the wider Kerguelen area, building on the cooperative work that has been developed over the past several years, and ensuring that this cooperative work is considered in toothfish assessments and management actions. Australia continues to work with France on toothfish stocks on the Kerguelen Plateau. For example, in 2011, a joint population status assessment in both EEZs on the Kerguelen Plateau was presented to the CCAMLR (Candy et al. 2011), and a workplan for ongoing cooperative work to improve toothfish stock assessments was agreed.

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 traps. The Sustainability Assessment of 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 Australian Fisheries Management Authority (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 2015 (calendar year), two southern elephant seals (*Mirounga leonina*) became entangled in the longlines and died. One Antarctic fur seal (*Arctocephalus gazella*) died after it was entangled and possibly previously foul hooked. One rockhopper penguin (*Eudyptes chrysolophus*) was also hooked and died. Interactions with three northern giant petrels (*Macronectes halli*) also occurred—two were released alive and one was dead. The deceased bird may have collided with the superstructure of the vessel in a snow storm.

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Chapter 26

Macquarie Island Toothfish Fishery

H Patterson and J Savage

FIGURE 26.1 Area of the Macquarie Island Toothfish Fishery, 2015

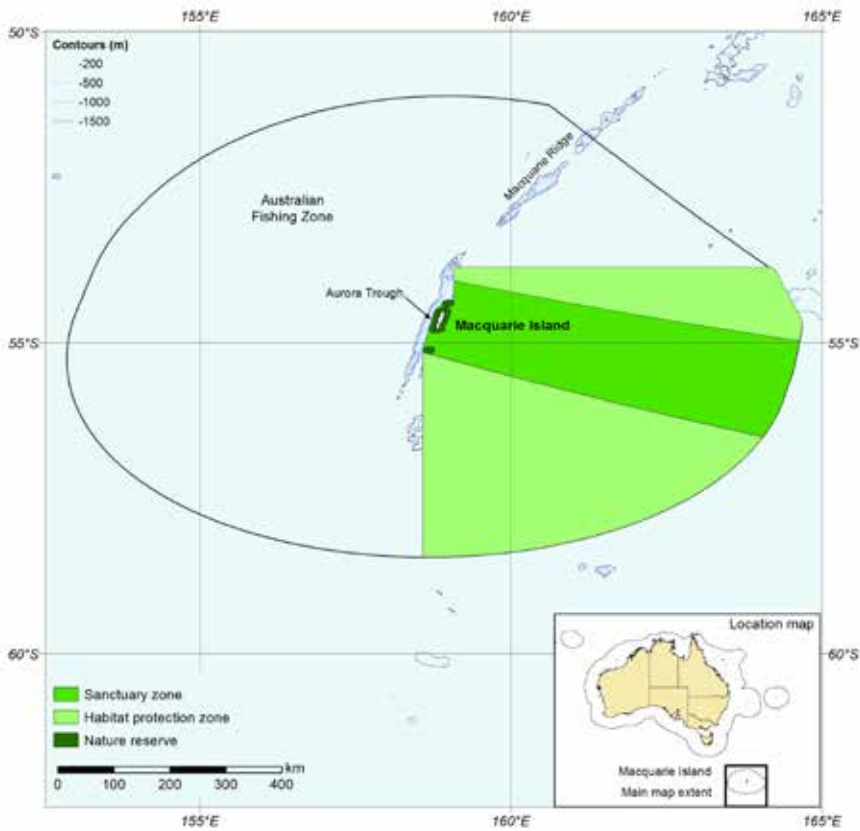


TABLE 26.1 Status of the Macquarie Island Toothfish Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Patagonian toothfish (<i>Dissostichus eleginoides</i>)					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 were most likely positive in 2013–14 and 2014–15 because the TAC for Patagonian toothfish was mostly caught. NER most likely fell in 2015–16 as difficult operating conditions led to lower catch with increased effort, and a substantial level of quota latency emerged.				

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. Byproduct is generally low and is regulated by a 50 t limit for any one species. The byproduct catch, 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 certified as sustainable by the Marine Stewardship Council in May 2012.

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

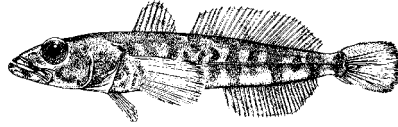
Fishery statistics a	2014–15 fishing season			2015–16 fishing season		
Stock	TAC (t)	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t)	Real value (2014–15)
Patagonian toothfish	410	405	Confidential	460	324	Confidential
Fishery-level statistics						
Effort (longline days)	67			92		
Fishing permits	2 quota 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 2015–16 fishing season was 15 April 2015 to 14 April 2016. 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

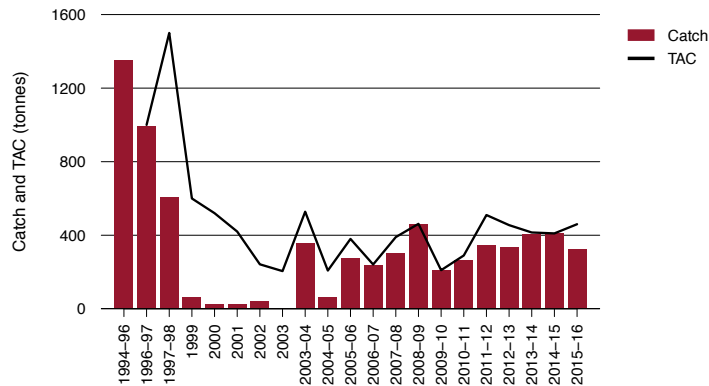
Stock structure

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 programmes (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 TACs. 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 programme 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. As well, fishers balanced their fishing time between the MITF and the Heard Island and McDonald Islands Fishery, where the TAC was substantially increased in 2015.

FIGURE 26.2 Catch and TAC of Patagonian toothfish in the MITF, 1994–95 to 2015–16



Note: TAC Total allowable catch.

Source: Australian Fisheries Management Authority

Stock assessment

In 2015, Stock Synthesis 3 software was used to assess the Patagonian toothfish stock (Day et al. 2015). 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), and recruitment to both areas. Using this assessment, the estimated 2015 female spawning biomass was 69 per cent of the unfished spawning biomass (SB_0). Using the CCAMLR control rule, a single TAC was calculated for the MITF for 2015–16, which was robust to a wide array of catch distributions spread among the different fishing areas.

Stock status determination

The relatively high estimate of current female spawning biomass ($0.69SB_0$) and the robust nature of the assessment result in the stock being classified as **not overfished**. The conservative TAC-setting process, based on 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

Rough sea conditions and operational issues in the 2011–12 and 2012–13 fishing seasons constrained operations in the MITF, resulting in quota latencies of 33 per cent and 27 per cent, respectively. Improved sea operating conditions in the 2013–14 fishing season allowed fishers to catch 98 per cent of the TAC. In the 2014–15 fishing season, the TAC was fully caught with less effort than in the 2013–14 season, suggesting an improvement in net economic returns (NER). 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 and a fall in NER.

The estimated biomass of $0.69SB_0$ in 2015 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 the Macquarie Ridge sector in 2011. The initial demersal longline trial in 2007 found a number of benefits, 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 14 October 2016. 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 scatefish. 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 2011, 2009).

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 2015, no interactions with protected species were recorded in logbooks.

26.5 References

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Patagonian toothfish
Australian Longline

Chapter 27

CCAMLR exploratory toothfish fisheries

H Patterson, S Hansen and J Savage

FIGURE 27.1 CCAMLR Convention area

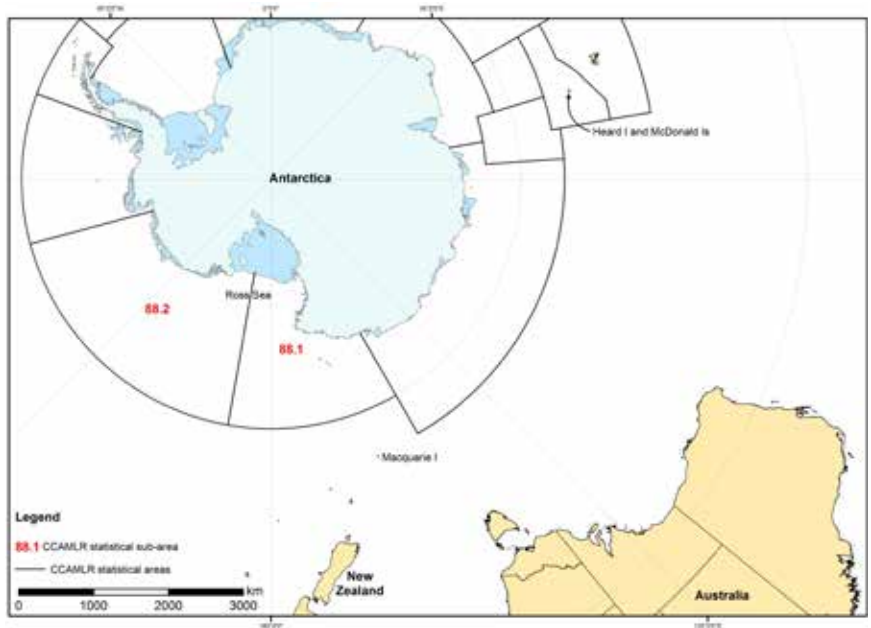


TABLE 27.1 Status of the CCAMLR exploratory toothfish fisheries

Status	2014 a		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Subarea 88.2, toothfish (<i>Dissostichus mawsoni</i> , <i>D. eleginoides</i>)					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 but were most likely positive in 2014–15 because the TAC for toothfish was caught.				

a This stock was not assessed in 2014.

Notes: CCAMLR Commission for the Conservation of Antarctic Living Marine 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 Living Marine 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 such as 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). However, only subarea 88.2 was fished by this vessel, and therefore only that subarea is reported on here.

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 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. In exploratory fisheries, total allowable catches (TACs) are then fished by approved vessels that have nominated to fish specific subareas. Shares of the TAC are not allocated to particular members; however, members may receive allocations to conduct specific research programmes. Fishing is closed when the catch limit for the subarea is reached. Vessels fishing in exploratory fisheries are required to carry scientific observers, and to tag and release toothfish at pre-specified levels as part of the scientific data collection process.

Fishing effort

Australia 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.

TABLE 27.2 Main features and statistics for the CCAMLR exploratory toothfish fisheries

Fishery statistics ^a	2013–14 fishing season			2014–15 fishing season		
	TAC (t)	Catch (t)	Real value (2013–14)	TAC (t)	Catch (t)	Real value (2014–15)
Subarea 88.2						
Antarctic toothfish	–	–	–	619 ^b	213 ^c	Confidential
Total fishery	–	–	–	–	213 ^c	Confidential
Fishery-level statistics						
Effort	–			697 850 hooks		
Fishing permits	–			1		
Active vessels	–			1		
Observer coverage ^d	–			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, not including a 200 t research catch limit. ^c Australian catch only. All catch was Antarctic toothfish. No Patagonian toothfish has ever been reported. ^d All vessels carry two observers on each trip.

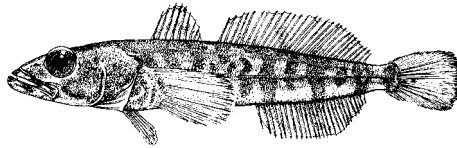
Notes: TAC Total allowable catch. – No Australian vessels participated in the fishery in 2013–14.



Pancake ice
Australian Longline

27.2 Biological status

Toothfish (*Dissostichus mawsoni*, *D. eleginoides*)



Line drawing: FAO

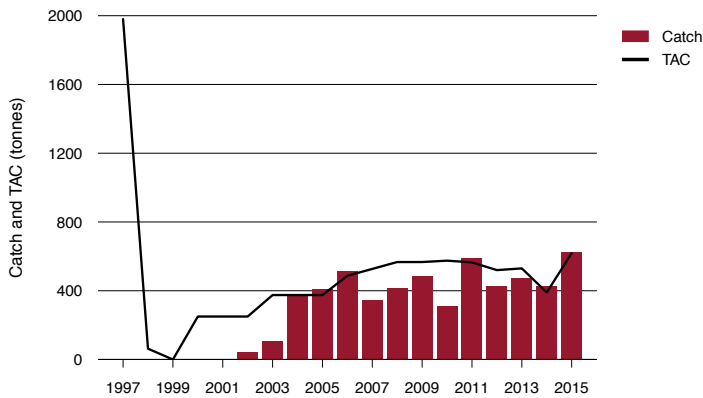
Stock structure

Genetic examination of Antarctic toothfish from widely separated CCAMLR statistical areas (Atlantic Ocean sector, Pacific Ocean sector, Indian Ocean sector) has produced mixed results. Early studies found some weak variation by ocean sector (Kuhn & Gaffney 2008; Smith & Gaffney 2005), whereas 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.

CCAMLR subarea 88.2 is divided into smaller areas known as small-scale research units (SSRUs) labelled A to H. The stock assessment boundaries for the Ross Sea region include subarea 88.1, and SSRUs 88.2 A and B, 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 to 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).

FIGURE 27.2 Total catch and TAC for CCAMLR subarea 88.2, 1997 to 2015

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 was 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 the majority 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 the majority 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. Given this precautionary approach, the limited entry to the fishery and the extensive CCAMLR review process, the stock is classified as **not subject to overfishing**.

27.3 Economic status

Key economic trends

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. Toothfish is a high-value species with well-established markets and supply chains. This further indicates that positive NER are being generated by fishers, even though this is a newly established fishery for Australia.

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. 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 complete catch of the TAC, positive NER are likely to be generated 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. No special recommendations were included in the assessment 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 subareas.

In the 2014–15 fishing season, no logbook or observer reports noted interactions between the Australian vessel and protected species in CCAMLR subarea 88.2.

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Chapter 28

High-seas fisheries for non–highly migratory species

R Noriega, L Georgeson, S Nicol and S Hansen

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. The first SIOFA Scientific Committee meeting was held in March 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 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 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 the Fishery Status Reports.

FIGURE 28.1 South Pacific Regional Fisheries Management Organisation Convention area

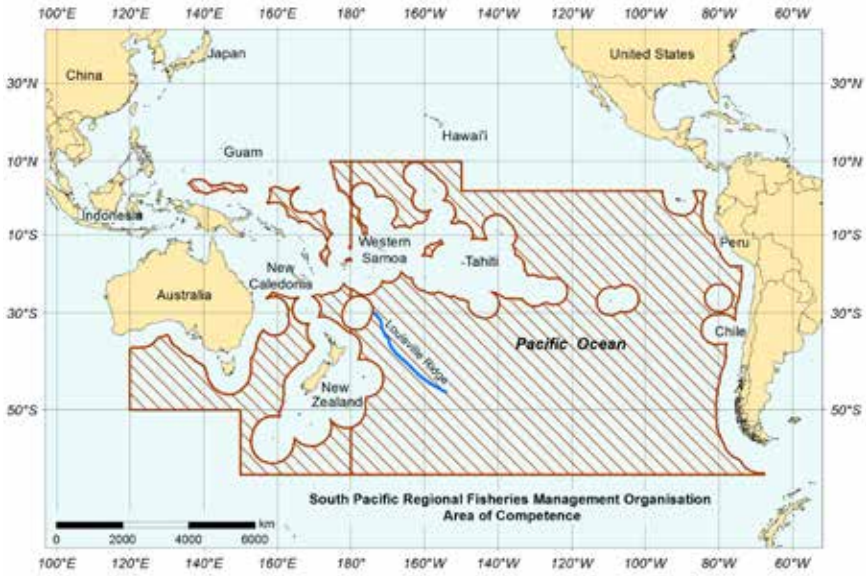


FIGURE 28.2: Southern Indian Ocean Fisheries Agreement area of competence

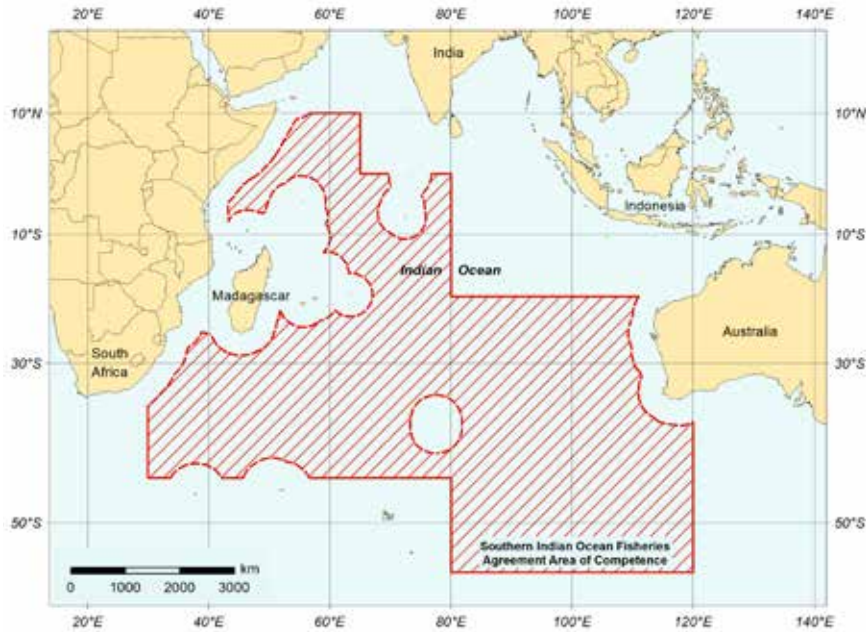
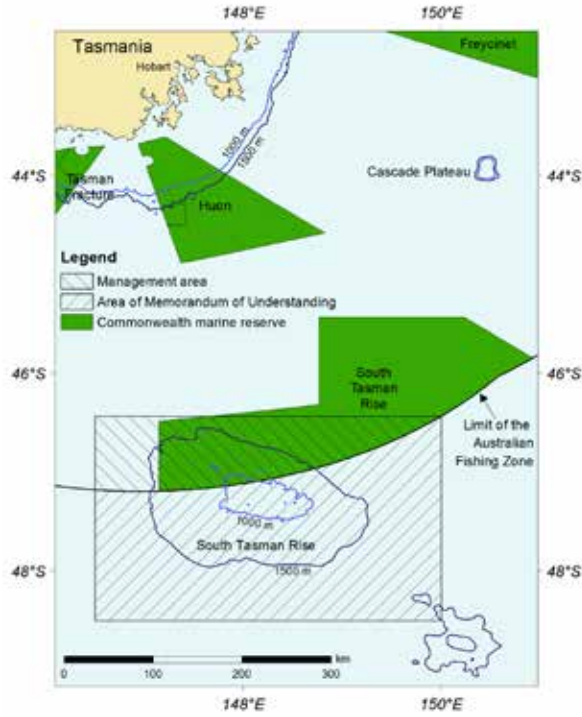


FIGURE 28.3 Area of the South Tasman Rise Trawl Fishery



Orange roughy
AFMA

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 (*Hoplostethus atlanticus*).

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 4.03 and since 2007, has restricted bottom-fishing effort or catch to the average annual level between 2002 and 2006, and ceases bottom-fishing activities within 5 nautical miles of any area for the remainder of the season where fishing activities encounter evidence of a vulnerable marine ecosystem (VME). Upon 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 4.13. Consistent with SPRFMO CMM 4.02 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 STRTF.

Southern Indian Ocean Fisheries Agreement area

SIOFA 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 (Bensch et al. 2009; Clark et al. 2007; Romanov 2003). 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, there was a substantial increase in deep-sea trawling in the area 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 within 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).

At its third Meeting of the Parties in July 2016, SIOFA adopted seven new CMMs (the first measures for this organisation):

- management measures for bottom fishing
- management measures for gillnets
- standards for data collection and reporting
- authorised vessel list
- illegal, unreported and unregulated vessel list
- data confidentiality
- vessels without nationality.

28.2 Catch-and-effort statistics

South Pacific Regional Fisheries Management Organisation Convention area

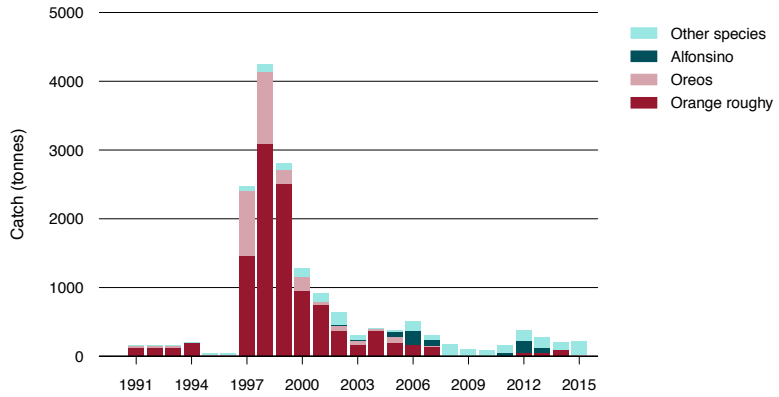
The total reported catch by Australian vessels in the SPRFMO Convention area was 272 t in 2013, 204 t in 2014 and 216 t in 2015 (Figure 28.4). Three Australian vessels were active in the SPRFMO Convention area in 2015: one trawl and two longline vessels.

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, decreasing to 21 t in 2015 from 104 t in 2014 and 139 t in 2013. Orange roughy comprised 81 per cent of the 2015 trawl catch (17 t), alfonsino (*Beryx splendens*; 13 per cent; 3 t) and other species (6 per cent; 1 t) made up the remainder.

Total non-trawl catch by Australian vessels in the SPRFMO Convention area was 195 t in 2015, an increase from 99 t reported in 2014 and 133 t reported in 2013. Bottom longline was the only non-trawl method used in 2015. Jackass morwong (*Nemadactylus macropterus*) accounted for 25 per cent (49 t) of the 2015 non-trawl catch; the remainder comprised yellowtail kingfish (*Seriola lalandi*; 19 per cent; 36 t), flame snapper (*Etelis coruscans*; 11 per cent; 21 t), blue-eye trevalla; 10 per cent; 20 t), redthroat emperor (*Lethrinus miniatus*; 7 per cent; 14 t) and other species (28 per cent; 55 t). Morwong species have constituted the single largest component of the total Australian non-trawl catch in the SPRFMO Convention area since 2008.

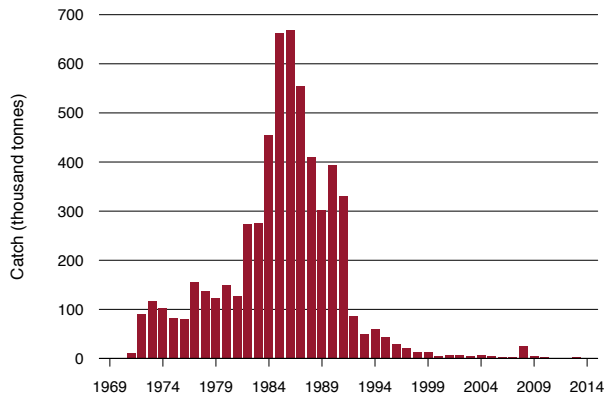
Total reported catch of demersal species by all fleets in the SPRFMO Convention area was 2 001 t in 2013 and 1 743 t in 2014 (Figure 28.5). Most of this catch was reported from the western SPRFMO Convention area, primarily by New Zealand and Australian vessels.

FIGURE 28.4 Australian trawl-and-line catch, by species, in the SPRFMO area of competence, 1990 to 2015



Source: Australian Fisheries Management Authority

FIGURE 28.5 Total SPRFMO catch of demersal species, 1969 to 2014



Source: South Pacific Regional Fisheries Management Organisation

Southern Indian Ocean Fisheries Agreement area

Midwater and demersal trawl have contributed most of Australia’s catch from the SIOFA area of competence. 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 rubyfish (*Plagiogeneion rubiginosum*), ocean blue-eye trevalla, alfonsino, orange roughy and cardinal fish (*Epigonus* spp.) One Australian flagged vessel was active in the SIOFA area in 2015.

South Tasman Rise Trawl Fishery

TABLE 28.1 Status of the South Tasman Rise Trawl Fishery

Status	2014		2015		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Orange roughy (<i>Hoplostethus atlanticus</i>)					Fishery closed under domestic arrangements since 2007 as a result of stock depletion.
Economic status	Fishery closed.				

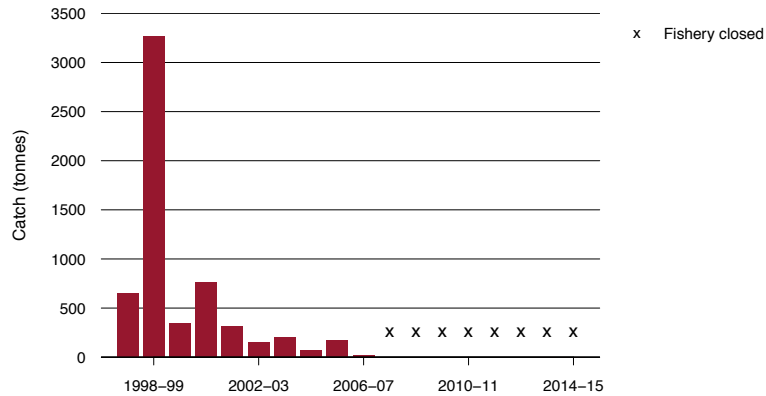
Notes: CCAMLR Commission for the Conservation of Antarctic Living Marine Resources. NER Net economic returns. TAC Total allowable catch.

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 (*Pseudocyttus maculatus*) and spikey oreodory (*Neocyttus rhomboidalis*). No formal stock assessment of oreodories in the STRTF has been undertaken. However, before the fishery was closed, trends in catch and catch rates for these species indicated that stocks had been fished down. If fishing in the STRTF resumes, management arrangements for oreodories should be considered as part of the development of a revised harvest strategy, to ensure that these species are not overexploited.

FIGURE 28.6 Australian orange roughy catch, 1997–98 to 2014–15

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, SIOFA area and 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 within 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 \times 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 overestimate 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 2015 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, and to 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 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 km², 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. In 2010, AFMA provided a submission for high-seas fisheries to be included on the List of Exempt Native Specimens. The Australian Government Department of the Environment advised that the operation of Australia's high-seas fisheries was consistent with the objectives of the wildlife trade provisions under the EPBC Act, and was unlikely to be detrimental to the survival or conservation of any taxon to which the fishery operation relates, or to threaten any relevant ecosystem.

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 2015.

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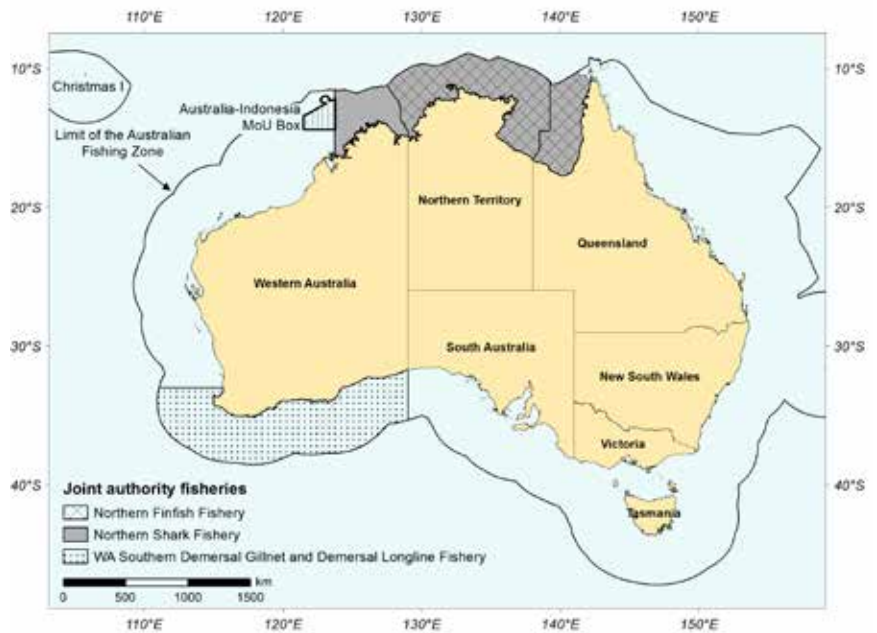
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Chapter 29

Joint authority fisheries

S Hansen

FIGURE 29.1 Geographic extent of the joint authority fisheries



The Australian Government is responsible for 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 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* (Cwth) (see Chapter 15).

29.1 Western Australian Temperate Demersal Gillnet and Demersal Longline Fishery

Currently, two shark fisheries operate off the south and west coasts of Western Australia: the Western Australian JAF and the state-managed West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (WCDF). Collectively, these fisheries are managed as the Temperate Demersal Gillnet and Demersal Longline Fishery. 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 has 57 licences, 20 of which were active in the 2013–14 season (McAuley et al. 2015). The WCDF, which is managed under a complementary management plan, extends north from Cape Bouvard and catches many of the same species; it has 20 licences. 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 McAuley et al. (2015).

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 2013–14 logbook data for the Western Australian JAF and the WCDF indicated a total shark and ray catch of 994 t (an increase from 938 t in 2012–13), comprising mostly gummy shark (445 t), dusky shark (190 t) and whiskery shark (161 t). More than 94 per cent of this combined catch is taken in the Western Australian JAF. Catches of scalefish in both fisheries totaled 191.6 t in 2013–14 (an increase from 133.6 t in 2012–13). The catch included blue groper (*Achoerodus gouldii*), queen snapper (*Nemadactylus valenciennesi*), pink snapper (*Chrysophrys auratus*) and dhufish (*Glaucosoma hebraicum*; McAuley et al. 2015), with the majority taken in the Western Australian JAF.

Status of stocks

The fishery is managed primarily through the setting of maximum fishing effort levels. These are intended to achieve acceptable catches of the species and maintain biomass at greater than 40 per cent of initial unfished levels for the key target species. 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 1998. It indicated that biomass was 43 per cent of the initial unfished level, slightly above the minimum acceptable level of 40 per cent of unfished biomass. Total catch in the Western Australian JAF and the WCDF in 2013–14 was 445 t. Between 2003–04 and 2009–10, catches exceeded the upper limit of the target catch range (350–450 t), but recent (2012–13 and 2013–14) catches have been within this range. Recent catch-per-unit-effort (CPUE) estimates have been higher than at any time since records began. Spawning biomass levels were classified as adequate in 2014 (McAuley et al. 2015).

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 (McAuley et al. 2015).

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 as a result of these poorly quantified sources of fishing mortality. However, higher recent effective CPUE, reduced catch of juvenile sharks and management changes since 2006 suggest that current management is precautionary enough to ensure stock recovery throughout the region (McAuley et al. 2015).

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). Assessments of school shark in the SESSF incorporate catch information from the JAF. Total catch of school shark in the Western Australian JAF and the WCDF in 2013–14 was 1.9 t. There was no reported school shark catch in the Western Australian JAF in 2012–13.

29.2 Northern Shark Fishery

Australian gillnetters began fishing in northern Australian waters in about 1980, although there was significant fishing from foreign vessels before then, and foreign gillnetting continued until 1986. The Northern Shark Fishery was developed during the 1980s and 1990s, and was transferred to the relevant joint authorities in 1995. It includes the Northern Territory Offshore Net and Line Fishery, the Queensland Gulf of Carpentaria Inshore Fin Fish Fishery and the Western Australia Joint Authority Northern Shark Fishery (WANSF). The fishery covers waters off Australia's northern coast, encompassing the Gulf of Carpentaria, the Timor and Arafura seas, Joseph Bonaparte Gulf, and the north-east coast of Western Australia (Figure 29.1).

The primary fishing methods are gillnetting and longlining, and most activity and catch occur in waters off the Northern Territory. Historically, the main commercial species have been blacktip sharks (Australian blacktip—*Carcharhinus tilstoni*, and common blacktip—*C. limbatus*), spot-tail shark (*C. sorrah*) and grey mackerel (*Scomberomorus semifasciatus*). The Australian and common blacktip sharks are difficult to differentiate and so have been treated as a species complex, with the assumption that the majority 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. The status of the fishery was reviewed by the Northern Territory Government in 2015 (Northern Territory Government 2015), and updated figures were provided to ABARES by the Northern Territory Department of Primary Industry and Fisheries in 2016. 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, 10 were active in 2015. A total of 405 boat-days were recorded during 2015, a 32 per cent decrease from effort levels in 2014, and well below the peak of 1 801 boat-days in 2003. This decline in fishing effort is thought to be due to a drop in shark fin prices (Northern Territory Government 2015).

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 421 t in 2015 (a 40 per cent decline from the 2014 catch of 699 t). The decline in catch was related to the decline in fishing effort described above. The 2015 catch included 40 t of blacktip shark and 321 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 September 2016.

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 2016a). 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 of 1 800 m net length. In 2014, 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 86 in the inshore sector. Of these 90 licences, 74 were active. Total shark catch from this fishery peaked in 2003 at 474 t, but has been less than 300 t since 2006. Approximately 219 t of shark catch was reported in 2014 (a decrease from 236 t in 2013; QFish 2016). In 2014, reported catch of blacktip sharks was 123 t (a decrease from 156 t in 2013; QFish 2016).

Queensland considers barramundi and blue threadfin (*Eleutheronema tetradactylum*) to be 'sustainably fished', while other target species are considered to be either 'undefined' or 'uncertain'. 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 fisheries

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 fisheries'. 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 fisheries since 2008–09.

An increase in effort occurred in these fisheries between 1999 and 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 fisheries alone, and 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 were put in place in 2005 in the WASF to prevent targeting of sandbar shark; 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 Fishery, sharks are caught as bycatch and byproduct in other Commonwealth, state and territory fisheries. In Western Australia, the 2012–13 catch of sharks by other state-managed fisheries was less than in previous years (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'. The size and composition of shark catches taken by these traditional fishers are unknown.

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 *bêche-de-mer*. Enforcement measures and collaborative programmes in Indonesia increased in 2005–06 and have been successful, resulting in fewer Indonesian vessels apprehended—7 in 2015–16, compared with 360 in 2005–06 (Scott Clementz [Australian Fisheries Management Authority] 2016, pers. comm., 16 June). However, a substantial number of vessels congregate and fish immediately to the north of the AFZ. 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 fishers included seven high-risk shark species, with these species constituting more than half the total catch (Marshall 2011). A number of the high-risk sharks have recently been listed under the Convention on International Trade in Endangered Species.

Status of stocks

The Northern Territory Government updated a stock assessment of common blacktip shark and Australian blacktip shark in 2013 (Grubert et al. 2013). The assessment indicated that the species have recovered from depletion associated with the historically high catches of the 1970s and 1980s, when foreign-flagged vessels operated in Australian waters. Fishing mortality for both species was estimated to be below the level that produces maximum sustainable yield (MSY; 19 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 is 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 within 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 from time to time since the 1930s. After the declaration of the AFZ, 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 (Northern Territory Department of Resources 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 2015 were provided directly to ABARES from the Northern Territory Department of Primary Industry and Fisheries.

In 2015, 10 vessels were active in the Timor Reef Fishery, recording 804 vessel-days, and 8 vessels were active in the Demersal Fishery, recording 1 025 vessel-days. The Timor Reef Fishery reported a total catch of 806 t in 2015 (an increase from 594 t in 2014), including 305 t of goldband snappers and 251 t of red snappers. The Demersal Fishery reported a total catch of 3 107 t in 2015 (comprising 58 t from trap vessels and 3 049 t from trawl vessels), including 2 298 t of red snappers and 267 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 June 2016.

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 2016b). Three fishing permits are issued for access to the Gulf of Carpentaria Developmental Fin Fish Trawl 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 55 vessel-days in 2015. The total catch in 2015 was 218 t, of which 167 t was red snappers (100 t of crimson snapper and 67 t of saddletail snapper) and 18 t was goldband snappers (QDAF 2016b). Catch and effort in this fishery have declined substantially from 2011, when total catch was reported to be 626 t from 326 vessel-days. The fishery has been granted export approval until November 2016.

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. Data on line-caught red snappers are reported as part of the Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (QDAF 2016b).

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.

Substantial 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.

Significant 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 significantly, 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

Total landings in 2015 from the target fisheries across both jurisdictions (Queensland and the Northern Territory) are estimated at 2 716 t of red snappers and 590 t of goldband snappers. In 2015, the Northern Territory was responsible for 94 per cent of the red snapper catch and 97 per cent of the goldband snapper catch. All fisheries have constraints on gear.

The Northern Territory assesses goldband snappers from the Timor Reef Fishery and the Demersal Fishery as a single stock. The total allowable commercial catch (TACC) in the Demersal Fishery is 400 t for goldband snapper species and 2 500 t for red snapper species. In the Timor Reef Fishery, the TACC has been set at 900 t for goldband snappers and 1 300 t for red snappers. Harvest levels by the Northern Territory fisheries were below these TACCs in 2015 (Thor Saunders, Northern Territory Department of Primary Industry and Fisheries, 2016, pers. comm., 27 June). 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.

The Gulf of Carpentaria Developmental Fin Fish Trawl Fishery operates under a TACC of 450 t for quota species (crimson snapper, saddleback snapper and other tropical snappers; QDAF 2016b). 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 2015, catch was 48 per cent of the quota.

Research suggests that the Northern Territory and Queensland fisheries target a single red snapper stock, whereas the North West Shelf stocks (managed by Western Australia) are separate. Although there is some separation of the stocks in Indonesian and Australian waters, both countries fish the same stock in some areas, particularly in the Arafura Sea (Salini et al. 2006).

In 2004, an Australian–Indonesian ACIAR project undertook a stock assessment for the Arafura Sea (Blaber et al. 2005). Although the Australian catches were comparatively low, the results suggested that the current combined catch from Indonesia and Australia was not likely to be sustainable. The biomass was estimated to have been reduced to between 11 and 31 per cent of unfished levels. However, there are significant uncertainties associated with the data from the Indonesian sector, and the level and impact of illegal fishing.

Detailed specifications for a northern Australian harvest strategy for tropical snappers were developed by O'Neill et al. (2011). The project provided the framework to improve monitoring, management and sustainability of tropical snapper stocks across northern Australia. Implementation of project recommendations, together with future monitoring and a harvest strategy, are likely to provide greater certainty for fisheries managers and industry (O'Neill et al. 2011).

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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 subsequently 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. This 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, the Commission for the Conservation of Southern Bluefin Tuna, and the Indian Ocean Tuna Commission. 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.

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 in excess of 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.

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

		Fishing mortality rate (F)		
		F < F _{TARG} (fishing mortality is below the target)	F _{TARG} < F < F _{LIM} (fishing mortality is between the limit and the target)	F > F _{LIM} (fishing mortality is above the limit)
Biomass (B)	B ≥ 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 ■ Subject to overfishing

Status determination framework

A weight-of-evidence decision-making framework for biological status determination was a key output of the Reducing Uncertainty in Stock Status (RUSS) project, undertaken from 2009 to 2012 (ABARES 2014). 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 a number of the most valuable Commonwealth fisheries. For other fisheries, indicators of fishery revenue and costs are analysed to evaluate likely changes in profitability. Although estimates of a fishery's gross value of production are readily available and provide an indicator of revenue, information on costs is more difficult to obtain. Measures of fishing effort and fuel prices are used for some fisheries to provide an indication of total fishery costs. For data-poor fisheries, the level of unused fishing rights ('latency') can provide an indication of NER. High latency suggests that the fishery is operating at or above a point equivalent to its theoretical open-access equilibrium—at this point, average NER are zero, and all potential resource rents from using the resource are likely to be lost.

Changes in a fishery's NER reflect changes in factors that are both external and internal to the control of fishers and fishery managers. External factors include fish prices and fuel prices, while internal factors include catch and fishing effort. The evaluation of a fishery's economic status primarily focuses on factors that are under the control of fishery managers. However, external factors can be highly variable and complicate the determination of economic status. Therefore, a fishery's NER should be interpreted over time (that is, in terms of its NER trend), and use other fishery information and performance indicators. For example, if a fishery generates positive NER, this does not necessarily mean a positive economic status in the context of maximising NER from the resource. Management arrangements may be impeding the generation of additional NER. Similarly, the catches generating these positive NER may be associated with overfishing. In these cases, economic status could be improved by reducing management constraints or rebuilding stock status.

Economic productivity measures support the interpretation of a fishery's trend in NER and its overall economic status. Productivity measures indicate how effectively a fishery's inputs (such as fuel, labour, capital and the fish stock) are converted into output (catch). At given output prices, an improvement in fishery productivity will be associated with an improvement in NER. Productivity growth in a fishery over time will reflect some combination of improved production decisions by fishers and improvements in fishery management.

Management arrangements

Management arrangements can be a key influence on whether a fishery achieves its full economic potential. The assessment of economic status therefore considers whether a fishery's NER could be improved under alternative arrangements. An informed assessment requires an understanding of a fishery's characteristics, which can vary considerably across fisheries. This allows evaluation of the relative advantages and disadvantages of alternative management arrangements for that fishery.

Management arrangements in Commonwealth fisheries can be categorised as either input controls (for example, effort limits) and 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. 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 (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 take into account the characteristics of the fishery. For example, if a fishery targets a highly variable stock, fluctuations in fishing right 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 result 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 a number of 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 2016* 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 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 take into account 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 2016* 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 Western and Central Pacific Fisheries Commission, the Indian Ocean Tuna Commission 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 actually is. Where necessary, fishing intensity maps have been truncated to limit fishing to within 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 2015 calendar year or the 2014–15 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 km² (the equivalent of one degree of latitude squared) and does not show catch or fishing effort. This conforms with AFMA's information disclosure policy (AFMA 2010).

Fishery management area boundaries are shown for reference, but area closures are not shown except for certain major closures. The 200 m isobath (bathymetric contour) is shown on all maps, where relevant. This approximates the edge of the continental shelf. Place names, including ports, capes, islands and seas, have been included for reference and orientation.

In most cases, the maps are in the geographic coordinate system (that is, without being projected). All maps of domestic fisheries use the geocentric datum for Australia (GDA94).

30.6 References

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Appendix A

Comparison of stock status classifications between the Fishery Status Reports (for Commonwealth fisheries) and the Status of key Australian Fish Stocks Reports (for all states and territories with wild-capture fisheries)

Fishery Status Reports				Status of Key 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 Status of Key Australian Fish Stocks 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 Status of Key Australian Fish Stocks reports rather than ‘transitional–recovering’.

Note: The Status of key Australian fish stocks reports 2014 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
ASAP	Age-Structured Assessment Program
ASPIC	A Stock Production Model Incorporating Covariates
ASPM	Age-Structured Production Model
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
DEPM	daily egg production method
DBSRA	Depletion-based stock reduction analysis
ECDTS	East Coast Deepwater Trawl Sector (of the SESSF)
EEZ	Exclusive Economic Zone
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Cwlth)
ESTF	Eastern Skipjack Tuna Fishery
ETBF	Eastern Tuna and Billfish Fishery

FAO	Food and Agriculture Organization of the United Nations
FM Act	<i>Fisheries Management Act 1991</i>
FRDC	Fisheries Research and Development Corporation
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
QFJA	Queensland Fisheries Joint Authority
RBC	recommended biological catch
RFMO	regional fisheries management organisation
SB	spawning biomass
SBTF	Southern Bluefin Tuna Fishery
SEMAC	South East Management Advisory Committee
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

Acronyms and units

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-western Pacific Ocean
TAC	total allowable catch
TACC	total allowable commercial catch
TAE	total allowable effort
TIB	Traditional Inhabitant Boat (sector)
TRLRAG	Tropical Rock Lobster Resource Assessment Group
TSBDMF	Torres Strait Bêche-de-mer Fishery
TSFF	Torres Strait Finfish Fishery
TSFRLF	Torres Strait Finfish (Reef Line) Fishery
TSPF	Torres Strait Prawn Fishery
TSPZ	Torres Strait Protected Zone
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
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
WSTF	Western Skipjack Tuna Fishery
WTBF	Western Tuna and Billfish Fishery

Units

'	minutes of latitude or longitude (for example, 34°20'S)
°E, °N, °S, °W	degrees east, north, south, west
°C	degree Celsius
cm	centimetre
g	gram
kg	kilogram
km	kilometre
km²	square kilometre
m	metre
mm	millimetre
nm	nautical mile
t	tonne (1 000 kg)

Year ranges

2014–15	financial year or season
2014 or 2015	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 programme 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 the 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* M (natural mortality), 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 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.

H

Handline. Hand-held 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 (c.f. Opportunity cost). The concept of NER is very closely related to economic efficiency, a necessary condition for NER to be maximised.

Non-detriment finding. Relating to a species listed in an appendix of the Convention on International Trade in Endangered Species (CITES), a conclusion by a scientific authority that the export of specimens of the species will not negatively affect the survival of that species in the wild. A non-detriment finding is required before an export or import permit, or a certificate for an introduction from the sea may be granted for a specimen of an Appendix-I species, and before an export permit or a certificate for an introduction from the sea may be granted for a specimen of an Appendix-II species.

Non-target species. Species that is unintentionally taken by a fishery or not routinely assessed for fisheries management. *See also* Bycatch, Byproduct.

Not overfished. *See* Overfished.

O

Oceanic. Open-ocean waters beyond the edge of the continental shelf.

Offshore Constitutional Settlement (OCS). The 1982 package of uniform national, state and territory laws that forms the basis for Australian governments at those levels to enter into agreements for specified fisheries to be managed by a 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 approach, 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 indexes, 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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