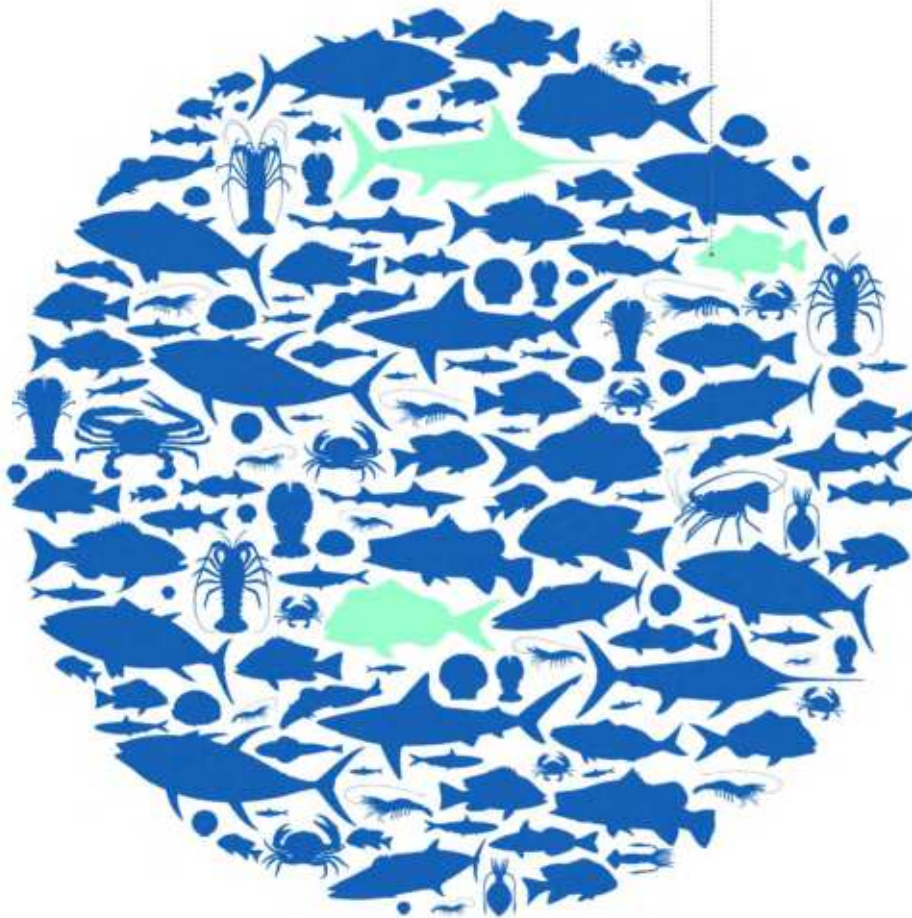




FRDC
FISHERIES RESEARCH &
DEVELOPMENT CORPORATION

Status of
Key Australian
Fish Stocks Reports
2014



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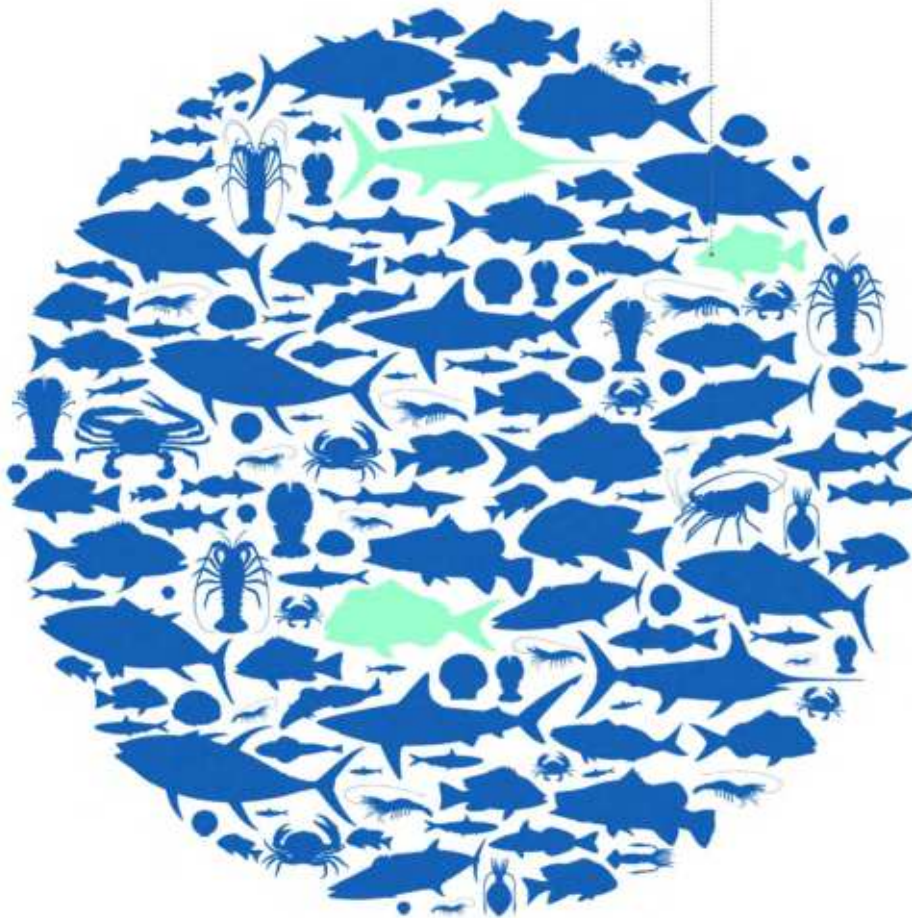
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Contributors



Foreword

Australia's fisheries are truly diverse, running from freshwater rivers to estuaries and bays and out to the continental shelf and oceanic waters on the high seas.

It is our responsibility as stewards of these resources, to manage and utilise them for the benefit of all Australians, both present and future generations, to the best of our abilities and based on the best science available.

The Food and Agriculture Organization (FAO) reports that marine and inland fisheries, together with aquaculture, provide food, nutrition and a source of income to around 820 million people around the world from harvesting, processing, marketing and distribution. This important industry forms part of the traditional cultural identity for many communities.

As a regional leader Australia plays a critical role in ensuring that we contribute to global food security through utilising our fisheries resources to their optimal levels, and by sharing our knowledge and expertise with the world.

The Australian community is interested in knowing the food they buy is sustainably produced and harvested. Governments and producers are investing significant resources into research and development to ensure that the management and industry practices are in line with, or exceed, the world's best standards. We are meeting this target and our fisheries are among the best managed in the world.

The researchers involved in the *Status of key Australian fish stocks reports* Advisory Group and the Fisheries Research and Development Corporation have improved and added to the second edition of the *Status of key Australian fish stocks reports*. The reports were prepared by the Australian Bureau of Agricultural and Resource Economics and Sciences, in collaboration with all government fishery research agencies across Australia. In total, more than 100 researchers contributed to the preparation of the reports.

The reports cover sixty eight key species or species groups that underpin Australia's wild-catch fisheries. They focus on the ongoing sustainability of the harvest from the fish stocks of these species, providing scientific assessments of the status of the stocks. A total of nineteen new species have been added and the reports now cover a majority of both value and quantity of Australia's wild-catch fisheries production.

The *Status of key Australian fish stocks reports* provide a scientifically robust and simple tool to inform fishers, seafood consumers, managers, policy makers and the broader community about the status of the key wild-caught fish stocks around Australia.

Australians should take comfort that our fisheries are sustainably managed and our fish stocks remain healthy.



Senator the Hon. Richard Colbeck

Parliamentary Secretary to the Minister for Agriculture

December 2014

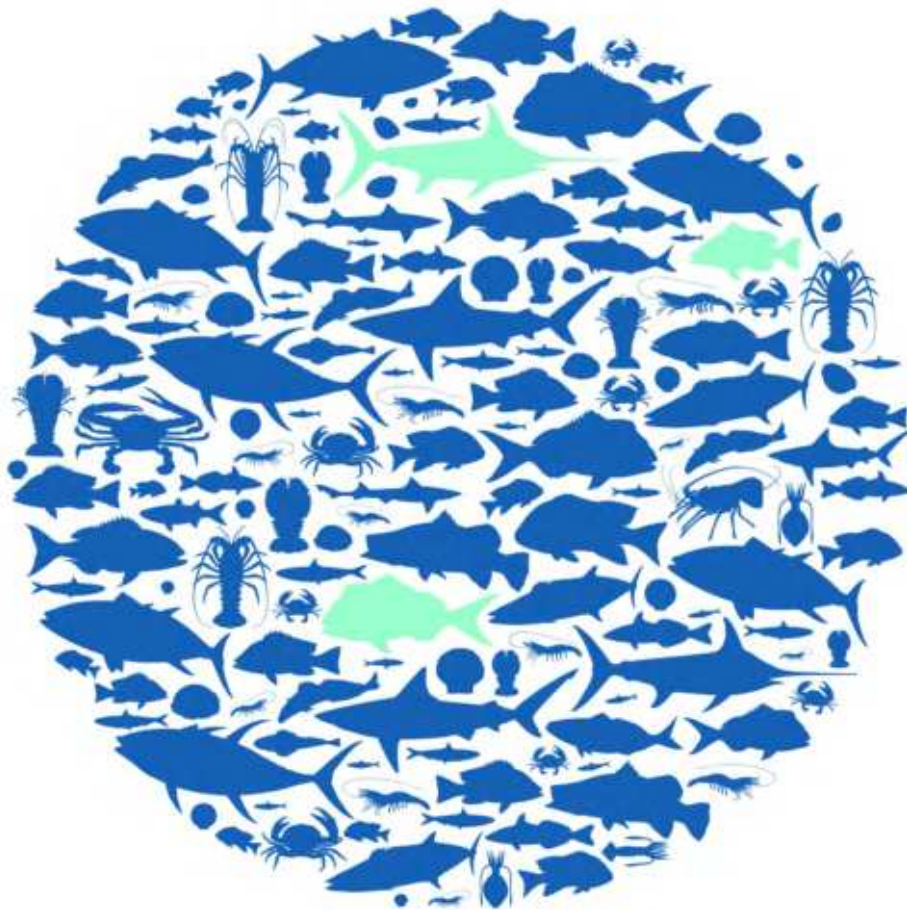
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Summary



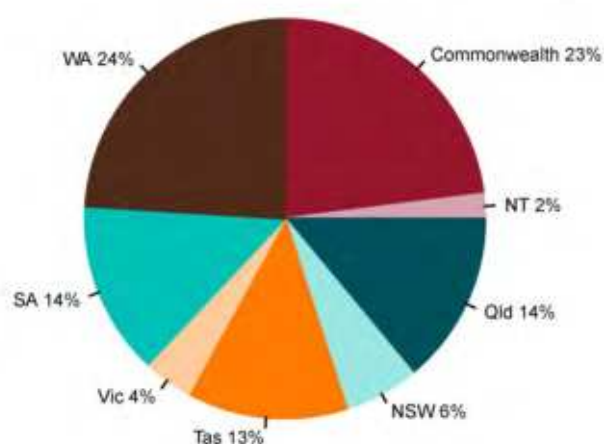
Summary

The *Status of key Australian fish stocks reports 2014* assess the biological sustainability of the key wild-caught fish¹ stocks against a nationally agreed framework. The reports examine whether the abundance (biomass) of fish and the level of harvest from the stock are sustainable. National reporting on fish stock sustainability is the first step towards national fishery-wide reporting that will consider other aspects of ecologically sustainable development, such as the effects of fishing on the marine environment, economic and social performance and governance. Although these issues are not considered in the stock status classifications, the reports comment on the effects of fishing on the marine environment and the effects of the environment on the stocks.

Australia has one of the largest marine domains in the world, covering an area larger than the Australian mainland. Australia also has a long history of Indigenous, commercial and recreational fishing (including charter fishing) in its waters. Over the past decade, Australia's wild capture fisheries and aquaculture production has generated, on average, \$2.5 billion a year. In the 2012–13 financial year, wild-capture fisheries contributed 58 per cent (\$1.4 billion) of the total value of Australia's fisheries production and produced more than 150 000 tonnes (t) of seafood, for local, domestic and export markets.

Australian seafood is diverse; it includes scallops, prawns, crabs, squid, coastal fish such as whiting and flathead, reef fish such as Coral Trout, and oceanic tuna and billfish. The fisheries that supply our seafood operate in estuaries and bays, across the continental shelf to oceanic waters and, in some cases, on the high seas. The fisheries and the wild fish stocks on which they are based are managed by eight jurisdictions (Figure 1). In general, the states and the Northern Territory manage fisheries that extend from the coast to a distance of 3 nautical miles, and the Commonwealth manages fisheries that extend from 3 nautical miles to the 200 nautical mile limit of the Australian Fishing Zone.

Figure 1: Contribution to gross value of wild-capture fisheries production by jurisdiction, 2012–13



The productivity and sustainability of wild-capture fisheries depend on the wild fish stocks and marine ecosystems that support the fish. Fish species tend to form relatively discrete populations in different geographical areas, which are referred to as biological stocks. Because separate biological stocks have limited interbreeding, fishing one biological stock may not directly affect others. The size and distribution of individual biological stocks vary greatly between species. For example, Southern Bluefin Tuna comprise a single biological stock that spans much of the world's southern oceans, whereas hundreds to many thousands of separate biological stocks of Blacklip Abalone are thought to exist in Australia. A key aim of fisheries management is to

¹ The term 'fish' is used to cover the animals caught by wild-capture fisheries; it includes crustaceans (such as crabs, lobsters and prawns), shellfish (such as scallops and abalone), squid and octopus, finfish and sharks.

ensure that biological stocks are maintained at sustainable levels. Although state/territory and Commonwealth jurisdictional boundaries may be appropriate from a governance perspective, many biological stocks straddle these boundaries, spanning the waters of more than one jurisdiction. The same fish species may be caught in several jurisdictions, in several fisheries and, in some cases, also outside Australian waters. The catch in the different jurisdictions may be from separate biological stocks of the species, which have little interaction, or from a single biological stock. Therefore, a national approach to assessing and reporting on the status of fish stocks is critical to understanding the state of wild-caught fish stocks and Australian fisheries management.

The stock status classifications presented in the *Status of key Australian fish stocks reports* are at the biological stock level wherever possible, even where a biological stock spans the waters of more than one Australian jurisdiction—that is, a shared stock. This recognises the biological boundaries of fish stocks rather than administrative boundaries of management units (for example, for individual fisheries, a group of fisheries or a region defined by management) or jurisdictions (i.e. the borders of the waters of the Commonwealth, the states or the Northern Territory). Where insufficient information is available to determine biological stock structure (that is, where it is not known exactly where one stock finishes and the next begins), or where large numbers of small biological stocks make biological stock-based assessments impractical, stock status assessments are made at the level of management or jurisdiction. In the reports, the term ‘stock status’ is applied generically to the status of biological stocks, management units and populations assessed at the jurisdictional level.

The *Status of key Australian fish stocks reports 2014* are national reports on the status of Australian wild-caught fish stocks. In the inaugural 2012 edition, 49 wild-caught species (or, in some cases, species complexes) were considered. Many of the species included comprise multiple stocks, in total 150 stocks were assessed across the 49 species in 2012. In the 2014 edition, the number of wild-caught species has increased to 68, comprised of 238 separate stocks. These species and their stocks contributed around 85 per cent of the annual catch and 90 per cent of the value of Australian wild-capture fisheries in 2012–13.

Traditionally, fishery status reporting has been undertaken separately within each Australian jurisdiction for commercial wild-capture fisheries. In developing the *Status of key Australian fish stocks reports*, several jurisdictions have reviewed their status determination processes and are modifying their jurisdictional reports to follow the framework applied in the national reports, where possible. As future editions of the *Status of key Australian fish stocks reports* are produced, increased coverage—including more species and reporting on fishery-level issues—may lead to a reduced requirement for separate jurisdictional reports.

National framework for stock status reporting

The national reporting framework used in the *Status of key Australian fish stocks reports 2014* was developed collaboratively by fisheries scientists from around Australia. This framework uses standardised terminology and reference points for stock status classifications. Following release of the *Status of key Australian fish stocks reports 2012*, a review was undertaken to document the lessons learned. Feedback from stakeholders suggested that national reporting on the status of key Australian fish stocks should continue, and that effort should be made to incorporate reporting on fishery-level environmental, economic, governance and social aspects.

The national framework for these reports considers both the abundance (number or biomass [weight]) of fish in a stock and the level of fishing pressure (rate of fishing) applied to a stock. The status classifications assess whether the current abundance of fish in a stock is adequate—that is, whether there is a large enough proportion of the original adult stock remaining that the production of juveniles is not significantly reduced. They also assess whether the amount of fish currently being removed through fishing is adequately controlled to ensure that stock abundance is not reduced to a point at which production of juveniles is significantly reduced. The framework makes these assessments against the biomass reference point of ‘recruitment overfished’, which is the point at which the spawning stock biomass has been reduced by fishing so that average recruitment (that is, the production of juveniles) is significantly reduced. There are five classification categories (refer to Introduction for full descriptions):

- *Sustainable stock*—indicates that biomass (or biomass proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (that is, the stock is not recruitment overfished) and that fishing pressure is adequately controlled to avoid the stock becoming recruitment overfished.
- *Transitional–recovering stock*—indicates that biomass is recruitment overfished, but management measures are in place to promote stock recovery, and recovery is occurring.

- *Transitional–depleting stock*—indicates that biomass is not yet recruitment overfished, but fishing pressure is too high and moving the stock in the direction of becoming recruitment overfished.
- *Overfished stock*—indicates that spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced (that is, the stock is recruitment overfished). Current management is not adequate to recover the stock; or adequate management measures have been put in place but have not yet resulted in measurable improvements.
- *Environmentally limited*—indicates that spawning stock biomass has been reduced to the point where average recruitment levels are significantly reduced, primarily as a result of substantial environmental changes or disease outbreaks (that is, the stock is not recruitment overfished). Fisheries management has responded appropriately to the environmental change in productivity.
- *Undefined stock*—indicates that insufficient information exists to determine stock status.

What has changed since the *Status of key Australian fish stocks reports 2012*?

The *Status of key Australian fish stocks reports 2014* builds on the 2012 reports, with minor alterations to the national stock status classification framework and species chapters, and the addition of 19 new species. The additional species were nominated by the states and the Northern Territory as either iconic species that are likely to be seen in fish shops or historically overfished species. The additional species bring the total count to 68 species/species complexes in this 2014 edition.

The main update to the national stock status classification framework is the inclusion of the new environmentally limited category, noted above. The *Status of key Australian fish stocks reports* Advisory Group included this additional category to describe stocks depleted below the limit reference point by environmental factors rather than fishing.

In the 2014 reports, negligible catch stocks are also excluded, if appropriate, from species chapters. These are stocks that have had historically low to negligible catch, are generally not targeted and do not form part of a cross jurisdictional biological stock. No stock status determination was undertaken for these stocks but an estimated level of catch is provided. The catch graphs and fishing footprint maps do not include catch from these stocks and the stocks are not included in Table 1.

In each species chapter the main features and statistics section for Australian fisheries is now presented as a comprehensive table, including information on fishing methods, management methods, active vessels, catch and markets; by jurisdiction and individual fisheries.

Between 2012 and 2014 there have been a number of changes to both stock structure for some species and stock status. In both cases the changes are based on the most recent and reliable information available.

Key results

In total, 238 stock status assessments were undertaken across the 68 species chapters, with assessments undertaken at the biological stock level, wherever possible.

A stock status classification could be determined for 170 of the stocks assessed. The remaining 68 stocks were classified as undefined stocks. The undefined stock classification does not necessarily mean that the stock is at increased risk; it means that there is limited or conflicting information available to undertake the assessment.

Of the 170 stock status classifications that could be assigned, 129 stocks were assessed as being sustainable stocks, 7 transitional–recovering stocks, 19 transitional–depleting stocks, 4 environmentally limited stocks and 11 overfished stocks (Tables 1 and 2). The 11 stocks classified as overfished are the Blacklip Abalone Victorian Western Zone and Victorian Central Zone management units, the Greenlip Abalone Victorian Western Zone and Victorian Central Zone management units, Black Jewfish in the Northern Territory, Eastern Gemfish biological stock, Mulloway in New South Wales, the School Shark Southern Australian biological stock, Golden Snapper in the Northern Territory, Bigeye Tuna in the Pacific Ocean biological stock and the Southern Bluefin Tuna biological stock.

The total volume of commercial catch reported in the *Status of key Australian fish stocks reports 2014* from Australian-managed fisheries is 139 722 t². This total does not include international catches (that is, catch taken outside Australian waters by countries other than Australia) of the tuna and billfish species that are reported in the *Status of key Australian fish stocks reports 2014*. The Australian catch of these species, with the exception of Southern Bluefin Tuna, is small compared with the international catch.

Of the Australian catch reported in the *Status of key Australian fish stocks reports 2014*, 87.5 per cent is from sustainable stocks, 0.9 per cent is from transitional–recovering stocks, 2.1 per cent is from transitional–depleting stocks, 4.9 per cent is from overfished stocks, 0 percent from environmentally limited stocks and 4.6 per cent is from undefined stocks (Table 2).

There were 102 stock status assessments at the biological stock level. Of these, 68 biological stocks were considered sustainable stocks, 4 transitional–recovering stocks, 5 transitional–depleting stocks, 4 overfished stocks and 21 undefined stocks (Tables 1 and 2).

Stock status assessments at the biological stock level could not be done for 136 stocks. Of these, 89 stock status assessments are presented at the management unit level, and 47 at the jurisdiction level.

Of the 89 stock status assessments carried out at the management unit level, 48 management units were considered to be sustainable stocks, 3 transitional–recovering stocks, 13 transitional–depleting stocks, 4 environmentally limited stocks, 4 overfished stocks and 17 undefined stocks (Tables 1 and 2).

Of the 47 jurisdiction-based stock status assessments, 13 assessments were considered sustainable stocks, 1 a transitional–depleting stock, 3 overfished stocks and 30 undefined stocks (Tables 1 and 2). None were considered to be transitional–recovering stocks or environmentally limited stocks.

In future, it is intended that most species currently assessed in the *Status of key Australian fish stocks reports 2014* at the level of management unit or jurisdiction will be assessed at the biological stock level, where research has revealed the biological stock boundaries.

In addition to assessing the status of the species, the *Status of key Australian fish stocks reports 2014* provides key statistics and the main features of the fisheries that target each species, and discusses the effects of fishing on the marine environment and effects of the environment on fish stocks.

² For some species in the *Status of key Australian fish stocks reports 2014* Western Australian data were not provided at the level of the individual stocks that were reported on in the species chapters. Where this is the case the combined catch is not included in the total commercial catch figure provided here. Also note, the reporting period varies among stocks presented in the *Status of key Australian fish stocks reports 2014*, so this total represents a combination of calendar year, financial year and fishing season data.

Table 1: Stock status classification summary of the stocks in the *Status of key Australian fish stocks reports 2014*, and the proportion of the catch of all species considered in the reports

	Number of stocks				Catch (’000 t)	% of the total catch of species considered
	Biological stock	Management unit	Jurisdiction	Total stocks		
Sustainable stock	68	48	13	129	122.3	87.5
Transitional–recovering stock ↑	4	3	0	7	1.2	0.9
Transitional–depleting stock ↓	5	13	1	19	3.0	2.1
Overfished stock	4	4	3	11	6.9	4.9
Environmentally limited stock	0	4	0	4	0	0
Undefined stock	21	17	30	68	6.4	4.6
Total	102	89	47	238	139.7^{a,b}	100

a The total does not include international catches (that is, catch taken outside Australian waters by countries other than Australia) of the four tuna and billfish species.

b For some species in the *Status of key Australian fish stocks reports 2014* Western Australian data were not provided at the level of the individual stocks that were reported on in the species chapters. Where this is the case the combined catch is not included in the total commercial catch figure provided here. Also note, the reporting period varies among stocks presented in the *Status of key Australian fish stocks reports 2014*, so this total represents a combination of calendar year, financial year and fishing season data.

Table 2: Status assessment summary for all species and species complexes

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Molluscs			
Abalones			
Blacklip Abalone	South Australian Western Zone Fishery (M)	South Australia	Transitional–depleting
	South Australian Central Zone Fishery (M)	South Australia	Transitional–depleting
	South Australian Southern Zone Fishery (M)	South Australia	Sustainable
	Victorian Western Zone Fishery (M)	Victoria	Overfished
	Victorian Central Zone Fishery (M)	Victoria	Overfished
	Victorian Eastern Zone Fishery (M)	Victoria	Transitional–depleting
	Tasmanian Western Zone Fishery (M)	Tasmania	Transitional–depleting
	Tasmanian Central-western Zone Fishery (M)	Tasmania	Transitional–depleting
	Tasmanian Northern Zone Fishery (M)	Tasmania	Transitional–depleting
	Tasmanian Bass Strait Zone Fishery (M)	Tasmania	Sustainable
	Tasmanian Eastern Zone Fishery (M)	Tasmania	Transitional–recovering
	New South Wales (M)	New South Wales	Transitional–recovering
Greenlip Abalone	South Australian Western Zone Fishery (M)	South Australia	Sustainable
	South Australian Central Zone Fishery (M)	South Australia	Transitional–depleting
	Tasmanian Greenlip Abalone Fishery (M)	Tasmania	Undefined
	Victorian Western Zone Fishery (M)	Victoria	Overfished
	Victorian Central Zone Fishery (M)	Victoria	Overfished
	Western Australia Area 2 Fishery (M)	Western Australia	Sustainable
	Western Australia Area 3 Fishery (M)	Western Australia	Sustainable

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Pipis			
Pipi	South Australia (J)	South Australia	Sustainable
	Victoria (J)	Victoria	Undefined
	New South Wales (J)	New South Wales	Undefined
Scallops			
Commercial Scallop	Commonwealth (J)	Commonwealth	Undefined
	Tasmania (J)	Tasmania	Undefined
	Victoria (J)	Victoria	Undefined
Saucer Scallop	Shark Bay Scallop Managed Fishery (M)	Western Australia	Environmentally limited
	Abrolhos Islands and Mid-West Trawl Managed Fishery (M)	Western Australia	Environmentally limited
	South West Trawl Managed Fishery (M)	Western Australia	Sustainable
	South Coast Trawl Fishery (M)	Western Australia	Sustainable
	East Coast Otter Trawl Fishery (M)	Queensland	Sustainable
Octopus			
Pale Octopus	Tasmania (J)	Tasmania	Transitional–depleting
	Victoria (J)	Victoria	Undefined
Squids			
Gould's Squid	Southern Australian (B)	Commonwealth, Tasmania	Sustainable
Southern Calamari	South Australia (J)	South Australia	Sustainable
	Tasmania (J)	Tasmania	Undefined
	Victoria (J)	Victoria	Sustainable
	New South Wales (J)	New South Wales	Undefined
	Commonwealth (J)	Commonwealth	Undefined

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Crustaceans			
Crabs			
Blue Swimmer Crab	Shark Bay (M)	Western Australia	Environmentally limited
	Cockburn Sound (Crab) Managed Fishery (M)	Western Australia	Environmentally limited
	Peel–Harvey Estuary Crab Fishery (M)	Western Australia	Sustainable
	Western Australian north coast (M)	Western Australia	Sustainable
	Western Australian south-west coast (M)	Western Australia	Sustainable
	North-eastern Australian (B)	Queensland	Sustainable
	Spencer Gulf (B)	South Australia	Sustainable
	Gulf St Vincent (B)	South Australia	Transitional–recovering
	West coast (B)	South Australia	Undefined
	South-eastern Australian (B)	New South Wales	Undefined
Giant Crab	Southern Australian (B)	Tasmania, Victoria, South Australia, Western Australia	Transitional–depleting
Mud Crab	Northern Australian (B)	Northern Territory, Queensland, Western Australia	Sustainable
	East coast (B)	Queensland, New South Wales	Sustainable
Spanner Crab	East coast (B)	Queensland, New South Wales	Sustainable

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Bugs			
Balmain Bug	East coast (B)	Queensland, New South Wales	Sustainable
Moreton Bay Bug	East Coast Otter Trawl Fishery (M)	Queensland	Sustainable
	Western Australia (J)	Western Australia	Undefined
	Northern Prawn Fishery (M)	Commonwealth	Sustainable
	Torres Strait Prawn Fishery (M)	Commonwealth	Sustainable
Lobsters			
Eastern Rock Lobster	New South Wales Rock Lobster Fishery (B)	New South Wales	Sustainable
Southern Rock Lobster	Southern Australian (B)	Tasmania, Victoria, South Australia, Western Australia	Sustainable
Tropical Rock Lobster	North-eastern Australian (B)	Commonwealth, Queensland	Sustainable
Western Rock Lobster	West Coast Rocklobster Managed Fishery (B)	Western Australia	Sustainable
Prawns			
Eastern King Prawn	Eastern Australian (B)	Queensland, New South Wales	Sustainable

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Endeavour Prawns	Northern Prawn Fishery (Blue Endeavour Prawn) (M)	Commonwealth	Sustainable
	Northern Prawn Fishery (Red Endeavour Prawn) (M)	Commonwealth	Undefined
	Torres Strait Prawn Fishery (Blue Endeavour Prawn) (M)	Commonwealth	Sustainable
	East Coast Otter Trawl Fishery (Red and Blue Endeavour Prawn) (M)	Queensland	Sustainable
	Exmouth Gulf Prawn Managed Fishery (Blue Endeavour Prawn) (M)	Western Australia	Sustainable
	Shark Bay Prawn Managed Fishery (Blue Endeavour Prawn) (M)	Western Australia	Undefined
	North Coast Prawn Managed Fisheries (Blue Endeavour Prawn) (M)	Western Australia	Undefined
School Prawn	New South Wales (J)	New South Wales	Sustainable
	Victoria (J)	Victoria	Undefined
	Queensland (J)	Queensland	Undefined
Tiger Prawns	Northern Prawn Fishery (Brown Tiger Prawn) (M)	Commonwealth	Sustainable
	Northern Prawn Fishery (Grooved Tiger Prawn) (M)	Commonwealth	Sustainable
	Torres Strait Prawn Fishery (Brown Tiger Prawn) (M)	Commonwealth	Sustainable
	East Coast Otter Trawl Fishery (Brown and Grooved Tiger Prawn) (M)	Queensland	Sustainable
	Shark Bay Prawn Managed Fishery (Brown Tiger Prawn) (M)	Western Australia	Sustainable
	Exmouth Gulf Prawn Managed Fishery (Brown Tiger Prawn) (M)	Western Australia	Sustainable
	North Coast Prawn Managed Fisheries (Brown Tiger Prawn) (M)	Western Australia	Sustainable

*STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY*

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Western King Prawn	Shark Bay Prawn Managed Fishery (M)	Western Australia	Sustainable
	Exmouth Gulf Prawn Managed Fishery (M)	Western Australia	Sustainable
	North Coast Prawn Managed Fisheries (M)	Western Australia	Sustainable
	South West Trawl Managed Fishery (M)	Western Australia	Sustainable
	East Coast Otter Trawl Fishery (M)	Queensland	Sustainable
	Spencer Gulf Prawn Fishery (M)	South Australia	Sustainable
	Gulf St Vincent Prawn Fishery (M)	South Australia	Transitional–depleting
	West Coast Prawn Fishery (M)	South Australia	Sustainable
White Banana Prawn	Northern Prawn Fishery (M)	Commonwealth	Sustainable
	East coast (M)	Queensland	Sustainable
	Exmouth Gulf Prawn Managed Fishery (M)	Western Australia	Sustainable
	Nickol Bay Prawn Managed Fishery (M)	Western Australia	Sustainable
	Kimberley Prawn Managed Fishery (M)	Western Australia	Sustainable
Sharks			
Blacktip Shark	East coast (B)	Queensland, New South Wales	Undefined
	Gulf of Carpentaria (B)	Northern Territory, Queensland	Undefined
	North and west coast (B)	Northern Territory, Western Australia	Sustainable
Dusky Shark	Western Australian (B)	Commonwealth, South Australia, Western Australia	Transitional–recovering
	Eastern Australian (B)	Commonwealth, New South Wales	Undefined

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Gummy Shark	Southern Australian (B)	Commonwealth, New South Wales, Tasmania, Victoria, South Australia, Western Australia	Sustainable
	Eastern Australian (B)	New South Wales	Undefined
Sandbar Shark	Western Australian (B)	Northern Territory, Western Australia	Transitional–recovering
	Eastern Australian (B)	Queensland, New South Wales	Undefined
School Shark	Southern Australian (B)	Commonwealth, New South Wales, Tasmania, Victoria, South Australia, Western Australia	Overfished
Finfish			
Australian Salmon	Eastern Australian Salmon (B)	New South Wales, Tasmania, Victoria	Sustainable
	Western Australian Salmon (B)	Victoria, South Australia, Western Australia	Sustainable
Australian Sardine	Eastern Australian (B)	Commonwealth, New South Wales, Victoria	Sustainable
	Southern Australian (B)	Victoria, South Australia	Sustainable
	Western Australia west coast (B)	Western Australia	Sustainable
	Western Australia south coast (B)	Western Australia	Sustainable
Banded Morwong	Tasmanian Banded Morwong Fishery (M)	Tasmania	Transitional–depleting
	Victorian Banded Morwong Fishery (M)	Victoria	Undefined

*STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY*

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Barramundi	Barramundi Fishery (M)	Northern Territory	Sustainable
	Kimberly Gillnet and Barramundi Managed Fishery (M)	Western Australia	Sustainable
	Southern Gulf of Carpentaria (B)	Queensland	Sustainable
	Northern Gulf of Carpentaria (B)	Queensland	Sustainable
	Princess Charlotte Bay (B)	Queensland	Sustainable
	North-east coast (B)	Queensland	Sustainable
	Mackay (B)	Queensland	Sustainable
	Central east coast (B)	Queensland	Sustainable
Black Jewfish	Northern Territory (J)	Northern Territory	Overfished
	Gulf of Carpentaria (M)	Queensland	Undefined
	Queensland east coast (M)	Queensland	Undefined
	Western Australia (J)	Western Australia	Undefined
Blue Grenadier	Commonwealth Trawl Sector (B)	Commonwealth	Sustainable
	Great Australian Bight Trawl Sector (B)	Commonwealth	Sustainable
Coral Trout	Torres Strait Finfish Fishery (M)	Commonwealth	Sustainable
	Northern Territory (J)	Northern Territory	Undefined
	Coral Reef Finfish Fishery (M)	Queensland	Sustainable
	Gulf of Carpentaria (M)	Queensland	Undefined
	Western Australia (J)	Western Australia	Undefined
Gemfish	Eastern (B)	Commonwealth, New South Wales	Overfished
	Western (B)	Commonwealth	Sustainable

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Mulloway	Western Australia (J)	Western Australia	Undefined
	Lakes and Coorong Fishery (M)	South Australia	Sustainable
	Marine Scalefish Fishery (M)	South Australia	Undefined
	Victoria (J)	Victoria	Undefined
	New South Wales (J)	New South Wales	Overfished
	Queensland (J)	Queensland	Undefined
Murray Cod	South Australia (J)	South Australia	Undefined
	Victoria (J)	Victoria	Undefined
	New South Wales (J)	New South Wales	Undefined
	Australian Capital Territory (J)	Australian Capital Territory	Undefined
	Queensland (J)	Queensland	Undefined
Pink Ling	Western (B)	Commonwealth, New South Wales	Sustainable
	Eastern (B)	Commonwealth, New South Wales	Undefined

*STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY*

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Southern Garfish	West coast (B)	South Australia	Undefined
	Southern Spencer Gulf (B)	South Australia	Undefined
	Northern Spencer Gulf (B)	South Australia	Transitional–depleting
	Southern Gulf St Vincent (B)	South Australia	Undefined
	Northern Gulf St Vincent (B)	South Australia	Transitional–depleting
	South-east (B)	South Australia	Undefined
	West coast (B)	Western Australia	Undefined
	South coast (B)	Western Australia	Undefined
	Victoria (J)	Victoria	Sustainable
	Scalefish Fishery (B)	Tasmania	Undefined
Tailor	Eastern Australian (B)	Queensland, New South Wales, Victoria	Sustainable
	Western Australian (B)	Western Australia	Sustainable
Yellowtail Kingfish	Eastern Australian (B)	Commonwealth, Queensland, New South Wales	Undefined
	Western Australian (B)	Western Australia	Undefined
Flathead			
Deepwater Flathead	Great Australian Bight (B)	Commonwealth	Sustainable
Dusky Flathead	Queensland (J)	Queensland	Sustainable
	New South Wales (J)	New South Wales	Sustainable
	Victoria (J)	Victoria	Sustainable
Southern Sand Flathead	Victoria (J)	Victoria	Undefined
	Tasmania (J)	Tasmania	Undefined

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Tiger Flathead	Southern Australian (B)	Commonwealth, New South Wales, Tasmania, Victoria	Sustainable
Mackerel			
Common Jack Mackerel	Eastern (B)	Commonwealth, New South Wales, Tasmania	Sustainable
	Western (B)	Commonwealth, Tasmania	Sustainable
Grey Mackerel	Central east Queensland (B)	Queensland	Sustainable
	North-east Queensland (B)	Queensland	Sustainable
	Gulf of Carpentaria (B)	Northern Territory, Queensland	Sustainable
	North-west Northern Territory (B)	Northern Territory	Sustainable
	Western Australian (B)	Western Australia	Sustainable
Spanish Mackerel	Torres Strait (B)	Commonwealth	Sustainable
	East coast (B)	Queensland	Sustainable
	Gulf of Carpentaria (M)	Queensland	Sustainable
	Northern Territory (J)	Northern Territory	Sustainable
	Mackerel Managed Fishery (M)	Western Australia	Sustainable
Mullet			
Sea Mullet	Eastern Australian (B)	Queensland, New South Wales	Sustainable
	Western Australian (B)	Western Australia	Sustainable
Yelloweye Mullet	Western Australia (J)	Western Australia	Undefined
	Lakes and Coorong Fishery (M)	South Australia	Sustainable
	Marine Scalefish Fishery (M)	South Australia	Sustainable
	Victoria (J)	Victoria	Undefined
	Tasmania (J)	Tasmania	Undefined

*STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY*

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Temperate Snapper and Bream			
Snapper	East coast (B)	Queensland, New South Wales, Victoria	Undefined
	Western Victorian (B)	Victoria	Sustainable
	South East Fishery (M)	South Australia	Transitional–depleting
	Southern Gulf St Vincent Fishery (M)	South Australia	Transitional–depleting
	Northern Gulf St Vincent Fishery (M)	South Australia	Sustainable
	Southern Spencer Gulf Fishery (M)	South Australia	Transitional–depleting
	Northern Spencer Gulf Fishery (M)	South Australia	Transitional–depleting
	West Coast Fishery (M)	South Australia	Undefined
	South coast (M)	Western Australia	Undefined
	Shark Bay oceanic (M)	Western Australia	Sustainable
	Shark Bay inshore—eastern gulf (B)	Western Australia	Sustainable
	Shark Bay inshore—Denham Sound (B)	Western Australia	Sustainable
	Shark Bay inshore—Freycinet Estuary (B)	Western Australia	Transitional–recovering
	West coast (M)	Western Australia)	Transitional–recovering
Yellowfin Bream	Eastern Australian (B)	Queensland, New South Wales, Victoria	Sustainable
Tropical Snappers and Emperors			
Crimson Snapper	Northern Australian (B)	Northern Territory, Queensland	Sustainable
	East coast Queensland (B)	Queensland	Undefined
	North West Shelf (B)	Western Australia	Sustainable

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Goldband Snapper	Northern Australian (B)	Northern Territory, Queensland	Sustainable
	East coast (M)	Queensland	Undefined
	Kimberley (B)	Western Australia	Sustainable
	Pilbara (B)	Western Australia	Sustainable
	Gascoyne (B)	Western Australia	Sustainable
Golden Snapper	Northern Territory (J)	Northern Territory	Overfished
	Western Australia (J)	Western Australia	Undefined
	Gulf of Carpentaria (M)	Queensland	Undefined
	East coast (M)	Queensland	Undefined
Red Emperor	Gascoyne (B)	Western Australia	Sustainable
	Pilbara (B)	Western Australia	Sustainable
	Kimberley (B)	Western Australia	Sustainable
	Northern Territory (J)	Northern Territory	Undefined
	Gulf of Carpentaria (M)	Queensland	Undefined
	East coast Queensland (M)	Queensland	Undefined
Redthroat Emperor	East coast Queensland (B)	Queensland	Sustainable
	Western Australian (B)	Western Australia	Undefined
Saddletail Snapper	Northern Australian (B)	Northern Territory, Queensland	Sustainable
	East coast Queensland (B)	Queensland	Undefined
	North West Shelf (B)	Western Australia	Sustainable

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SUMMARY

Species	Stock (status assessment unit: biological stock [B], management unit [M], jurisdiction [J])	Jurisdiction(s)	Stock status
Tuna			
Bigeye Tuna	Indian Ocean (B)	Commonwealth	Sustainable
	Pacific Ocean (B)	Commonwealth	Overfished
Southern Bluefin Tuna	Global (B)	Commonwealth	Overfished
Yellowfin Tuna	Indian Ocean (B)	Commonwealth	Sustainable
	Western and Central Pacific Ocean (B)	Commonwealth	Sustainable
Billfish			
Swordfish	Indian Ocean (B)	Commonwealth	Sustainable
	South-west Pacific Ocean (M)	Commonwealth	Undefined
Whiting			
Eastern School Whiting	South-eastern Australian (B)	Commonwealth, New South Wales, Tasmania, Victoria	Sustainable
King George Whiting	Gulf St Vincent (B)	South Australia	Transitional–depleting
	Spencer Gulf (B)	South Australia	Transitional–depleting
	West coast—Eyre Peninsula (B)	South Australia	Sustainable
	Western Australia (J)	Western Australia	Sustainable
	Victoria (J)	Victoria	Sustainable
Sand Whiting	Queensland (J)	Queensland	Sustainable
	New South Wales (J)	New South Wales	Sustainable
Stout Whiting	Eastern Australian (B)	Queensland, New South Wales	Sustainable

If you have feedback you would like to provide on the *Status of key Australian fish stocks reports 2014*, please send it to:

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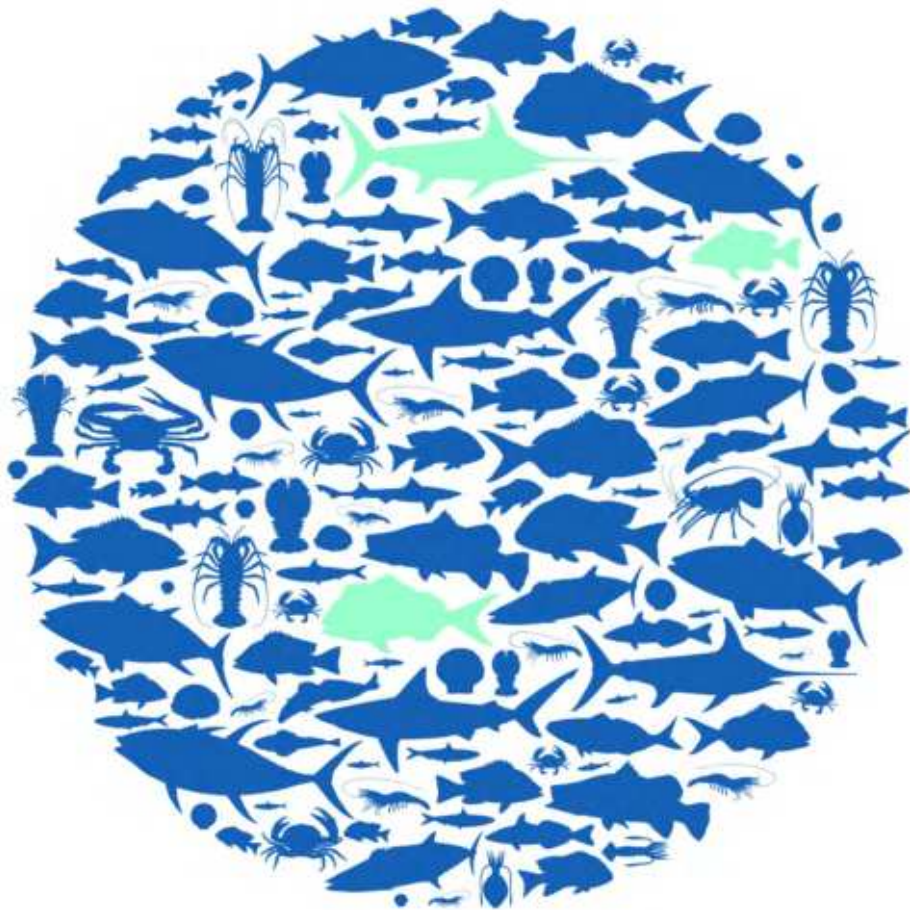
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Introduction



Introduction

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Australian fisheries

Australia's marine domain, our Exclusive Economic Zone (EEZ), is one of the largest in the world, covering around 10 million square kilometres¹. This is larger than mainland Australia (7.69 million square kilometres). Australia has a long history of Indigenous, commercial and recreational fishing (including charter fishing) in our waters. Over the past decade, Australia's fisheries production, both wild capture and aquaculture, has generated, on average, \$2.5 billion a year (real value 2012–13 dollars) (Figure 1). In 2012–13, wild-capture fisheries contributed 58 per cent (\$1.4 billion) of the total value of Australia's fisheries production and produced 152 689 tonnes (t) of seafood² (Figure 2).

Our commercial fisheries are diverse, operating from estuaries and bays, across the continental shelf to oceanic waters and, in some cases, on to the high seas. The seafood caught is also diverse, including scallops, prawns and squid, coastal fish such as whiting and flathead, reef fish such as Coral Trout, and oceanic tuna and billfish. Australian fisheries supply fresh seafood for local and domestic markets, as well as exporting high-value products.

Figure 1: Real value of Australian fisheries production, by sector, 2001–02 to 2012–13²

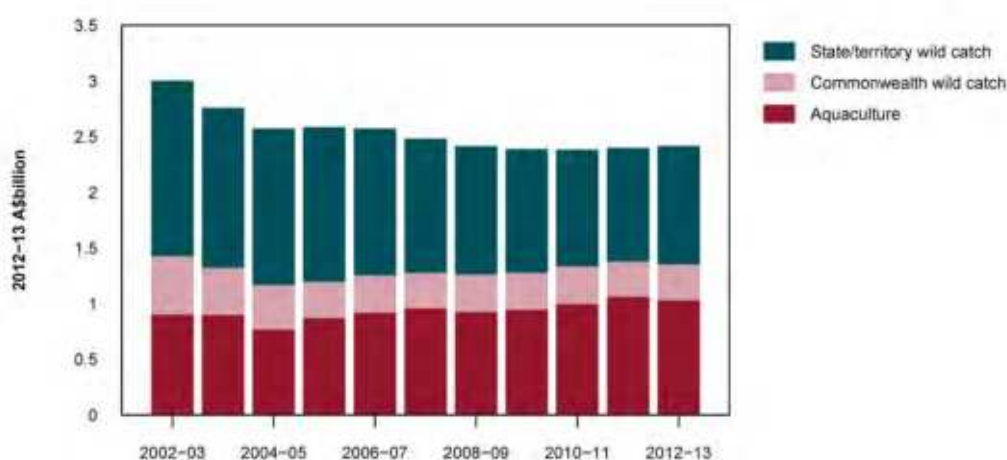
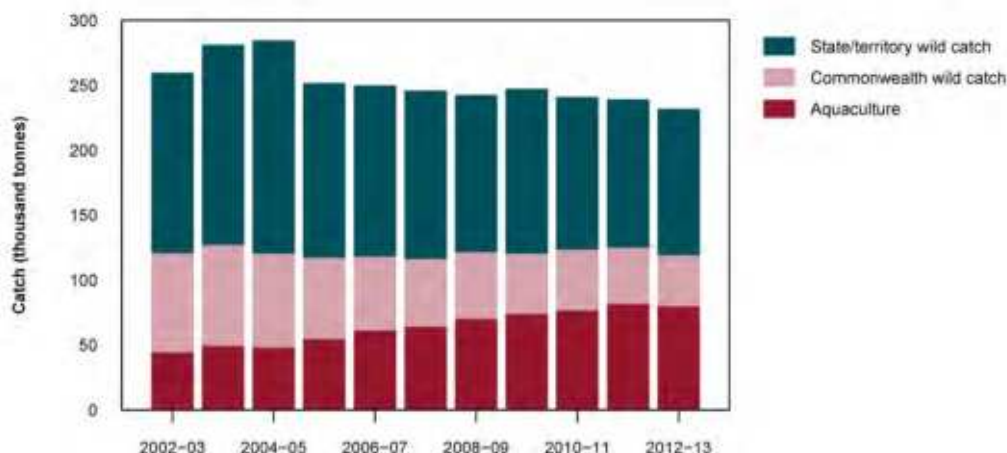


Figure 2: Volume of Australian fisheries production, by sector, 2002–03 to 2012–13²

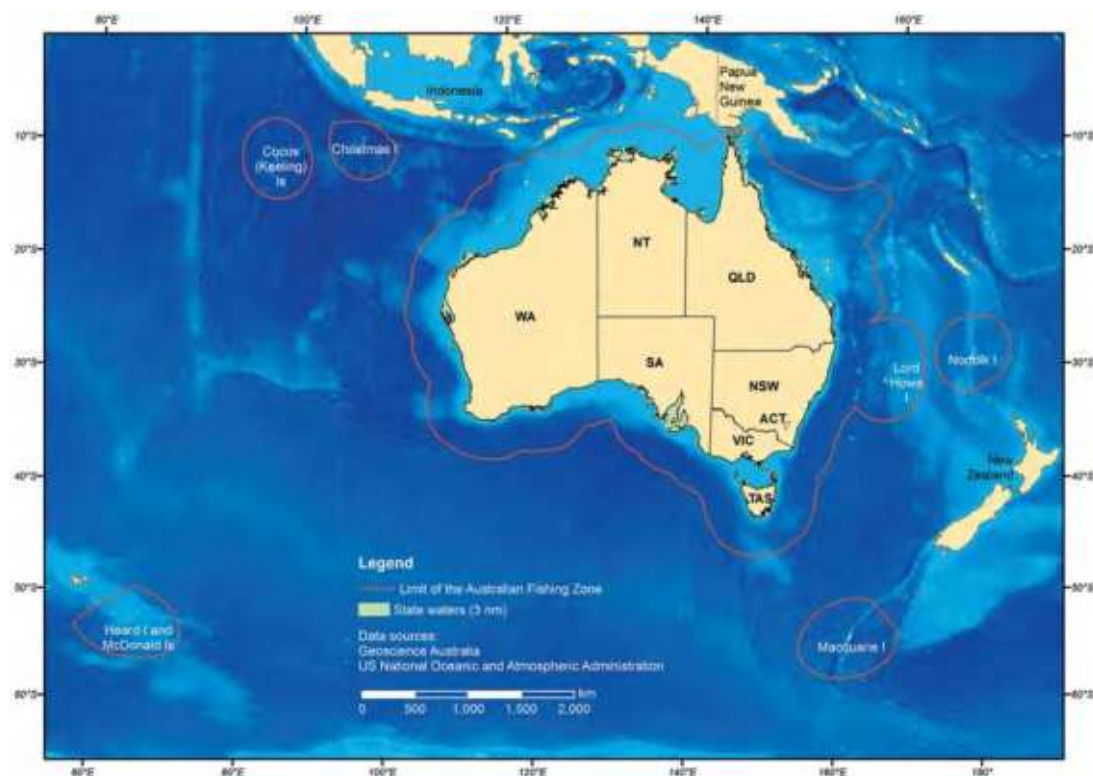


The fisheries and the wild fish³ stocks on which they are based are managed by eight jurisdictions within the Australian EEZ. In general, state and territory fisheries extend from the coast to a distance of 3 nautical miles from the coast, and the Commonwealth manages fisheries that extend from 3 nautical miles to the 200 nautical mile EEZ limit—that is, the Australian Fishing Zone (Figure 3). The Commonwealth also manages Australian vessels fishing on the high seas. The jurisdictional boundaries are set out under the 1982 Offshore Constitutional Settlement, a package of uniform national, state and territory laws outlining responsibilities for offshore fisheries, mining, shipping and navigation^{3–5}. In some situations where fisheries or fish stocks fall within more than one jurisdiction, the default jurisdictional boundaries may not allow sensible fisheries management. In these cases, the Australian, state and Northern Territory governments have developed arrangements to assign management responsibility to one jurisdiction.

Recreational and Indigenous fishers also depend on wild fish stocks. In many cases, less information is available for recreational and Indigenous fishing than for commercial fisheries, and different management approaches are used. The *Status of key Australian fish stocks reports 2014* focuses on the commercial fisheries for key stocks. However, information on recreational and Indigenous fisheries is included if it is available.

³ The term ‘fish’ is used to cover the animals caught by wild-capture fisheries; it includes crustaceans (such as crabs, lobsters and prawns), shellfish (such as scallops and abalone), squid and octopus, finfish and sharks.

Figure 3: Limit of the Australian Fishing Zone



Note: The Australian Fishing Zone extends from the 3 nautical mile limit (limit of state waters) to the limit of the Exclusive Economic Zone (EEZ) around the mainland of Australia and Macquarie Island, and, in the case of the external territories (for example, Norfolk Island), from the coastline to the limit of the EEZ.

What are the Status of key Australian fish stocks reports 2014?

The productivity of Australia's wild-capture commercial fisheries depends on the state of the wild fish stocks. In some cases, these fish stocks also support recreational and Indigenous fisheries. They are also part of the broader marine ecosystems and environment. One of the key aims of fisheries management is to ensure that fish stocks are maintained at sustainable levels. This is reflected in international, Commonwealth, state and territory legislation. The *Status of key Australian fish stocks reports 2014* assesses the biological sustainability of the key wild-caught fish stocks against a nationally agreed framework. In short, for the key fish stocks, the reports examine whether the abundance of fish (or biomass) and the level of harvest from the stock are sustainable.

Fisheries management also considers other aspects of ecologically sustainable development, such as the effects of fishing on the marine environment, economic performance and governance. Although these issues are not considered in the stock status classification, the reports provide comments on the effects of fishing on the marine environment and environmental effects on the stocks. There is increasing interest in the state of fish stocks, the sustainability of fisheries and the marine environment, from fishers, seafood consumers, policy makers and the broader community.

Hundreds of species are caught and sold from Australia's wild-capture fisheries. The *Status of key Australian fish stocks reports 2014* covers 68 key species or species complexes. The species included represent around 85 per cent of the annual catch and 90 per cent of the value of Australian wild-capture fisheries in 2012–13. They also reflect the wide diversity of species found in Australian fisheries and markets, including shellfish, crustaceans (such as prawns and crabs), squid, finfish and sharks. They cover species from the tropical waters of northern Australia to the temperate waters of the south, and species caught on the high seas.

Traditionally 'fishery status reports' have been produced by most jurisdictions, assessing the key fish stocks they manage, and reporting on the effectiveness of their fisheries management. However, the format and type of stock status assessments have historically varied, as has the terminology used to describe the status of stocks^{6–12}. This, at least in part, reflects the different regulatory requirements in different jurisdictions with marine fisheries. However, it has made understanding stock status at a national level challenging. Also, some

biological stocks of fish span more than one jurisdiction—in these cases, it has often been difficult to understand the overall status of the shared biological stocks.

The inaugural *Status of key Australian fish stocks reports 2012* provided the first national, scientifically robust stock status assessments of key Australian fish stocks. The reports in 2012, and the current updated version in 2014, were developed with the involvement of fisheries research agencies in all jurisdictions. They provide a key information source for fishers, seafood consumers, policy makers and the broader community. They will also inform the broader international community about Australia's fisheries management performance.

At present, separate jurisdictional reports, such as *Fishery status reports*, which is produced for Commonwealth fisheries by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), will continue to be produced to meet legislative and policy requirements specific to each jurisdiction. Typically, jurisdictional reporting is undertaken at a fishery level; reports may include information on the history of catch and fishing activity in the fishery, management conditions, stock status, any bycatch or ecological impacts of the fishery on the environment, and the extent of recreational interest in a stock or species. Jurisdictional reports may also include the legislative and policy objectives for a fishery, and any economic conditions affecting performance. They tend to be annual, so that there is regular feedback on management performance. For Commonwealth fish stocks, the *Status of key Australian fish stocks reports 2014* considers equivalent biological information to that presented in the *Fishery status reports 2013–14*⁷ but presents classifications based on the nationally agreed *Status of key Australian fish stocks reports 2014* classification framework. In developing the *Status of key Australian fish stocks reports*, several jurisdictions have reviewed their status determination processes and are modifying their jurisdictional reports to follow the framework applied in the national reports, where possible. Over time, the *Status of key Australian fish stocks reports* may reduce the requirement for separate jurisdictional reports.

Fish stocks

The *Status of key Australian fish stocks reports 2014* focuses on the status of biological fish stocks wherever possible; hence, it is important to distinguish between biological stocks and fisheries. Biological stocks are relatively discrete populations of a fish species, usually in a given geographical area and with limited interbreeding with other biological stocks of the same species. Although one fish species may exist in many geographical locations around Australia (or worldwide), fish caught in different areas may come from separate biological stocks. Individual biological stocks may be found in a single jurisdiction or may be shared across two or more jurisdictions. In some cases, individual biological stocks may also extend into the high seas. The size and distribution of individual biological stocks vary greatly between species. For example, Southern Bluefin Tuna comprises a single biological stock that spans much of the world's southern oceans. In comparison, hundreds to many thousands of separate biological stocks of Blacklip Abalone are thought to exist in Australia. Because separate biological stocks have limited connectivity, fishing one may not directly affect others. Hence, it is important to assess each biological stock separately, where possible.

Biological stocks are natural resources, and different biological stocks may have different natural abundance, growth rates and mortality rates. Different biological stocks may also be influenced by different environmental factors, depending on where they occur. As a result, the amount of catch that can be sustainably removed may vary from one biological stock to another, even within a species.

In contrast, fisheries are management units engaged in harvesting fish. Fisheries are typically defined in terms of the people involved, the species caught, the area of water or seabed fished, fishing methods and the types of boats used¹³. A single biological stock may be caught by one or a number of fisheries. Similarly, a single fishery may catch one or a number of different species, from one or more different biological stocks. Some of the species and biological stocks fished by Australian fisheries are migratory, and are taken in both the Australian EEZ and the high seas or the EEZ of other countries.

A key measure of fisheries management performance is the status of the fish stocks—the natural resource on which the fisheries depend. Therefore, the *Status of key Australian fish stocks reports 2014* provides status classification for fish stocks. Where possible, this takes into account the impacts of all fisheries at the level of individual biological stocks. Where the stock delineation is not known (that is, it is not known exactly where one biological stock finishes and the next begins) or the numbers of biological stocks for a species are very high (for example, Blacklip Abalone), reporting has been undertaken at the level of either the jurisdiction or the management unit. The level of reporting (biological stock, management unit or jurisdiction) for each species is presented at the beginning of each chapter, along with the rationale for this choice. In these reports, the term

‘stock’ is used generically to refer to all three levels of stock status assessment—biological stocks, management units and populations assessed at the jurisdictional level. In future, most species currently assessed at the management unit or jurisdictional level will be assessed at the biological stock level, wherever research has revealed the biological boundaries of the stocks for the species.

Fisheries management

In general, fisheries are managed to ensure the ongoing sustainability of harvest from the fish stocks in that fishery. Management of fisheries also aims to optimise resource allocation (balancing social and economic considerations) and to minimise adverse impacts of fishing on the environment. Australian fisheries are managed in line with the United Nations Convention on the Law of the Sea (UNCLOS), which is reflected in the legislation and policy of the Commonwealth, states and territories. The United Nations Food and Agriculture Organization (FAO) *Code of Conduct for Responsible Fisheries* provides guidelines for the implementation of UNCLOS, with the high-level requirement that:

States should prevent overfishing and excess fishing capacity and should implement management measures to ensure that fishing effort is commensurate with the productive capacity of the fishery resources and their sustainable utilization. States should take measures to rehabilitate populations as far as possible and when appropriate¹⁴.

Generally, fisheries managers set limits on either the amount of fishing effort (including when, where and with what gear catches can be taken—referred to as input controls) or the level of catch that can be taken from a stock (referred to as output controls). These decisions are usually based on the best available science at the time of the decision, but may also take into account other factors, such as economics. Fisheries management is generally an adaptive process, because fish stocks can be influenced not only by the fishery’s harvest but also by environmental effects and natural variation. Fisheries also change in response to changes in market demands, fuel prices and other factors.

One of the key factors that managers and fishers need to respond to is the state of fish stocks and how this can change over time, in response to fishing, environmental effects and potentially other factors (such as other human impacts, climate change or extreme natural events). These reports focus on this key element: the state of fish stocks.

In the context of ecologically sustainable development, fisheries management performance can also be assessed against economic, social and broader ecological or environmental aspects of a fishery. The effectiveness and efficiency of the governance system itself can also be considered. The jurisdictional fishery status reports cover these broader elements of fisheries management to varying extents^{6–12}. The *Status of key Australian fish stocks reports 2014* focuses on fish stock status; future companion reports are envisaged to provide broader assessments of Australian fisheries. Although the broader ecological effects of fishing, such as bycatch (the incidental catch of noncommercial species), are not formally assessed here, they are discussed briefly for each species. The broader ecological effects tend to be at the fishery scale, rather than the fish stock scale.

Stock status classification system

In general, stock status classifications assess whether the current abundance (number or biomass [weight]) of fish in a stock is at an adequate level and whether the level of fishing pressure (the amount of fish being removed through fishing) is adequately controlled through management. The terminology, criteria and reference points used for stock status classification can vary among jurisdictional status reports.

The abundance of a wild fish stock is usually compared with the abundance of that same stock before any fishing had taken place. Abundance is considered to be adequate if there is a large enough proportion of the original adult stock remaining that production of juveniles (recruitment) is not significantly reduced. That is, the abundance of adults has not been reduced to the point where there is increased risk of recruitment failure. This level of adult abundance will vary between different species of fish.

In terms of fishing pressure, stock status considers whether the current level of fishing pressure is adequately controlled to ensure that the stock abundance is not reduced to a point where production of juveniles is significantly reduced. Where information is available, level of fishing pressure includes consideration of Indigenous and recreational (including charter) fishing as well as commercial fishing.

The classification system agreed on by the *Status of key Australian fish stocks reports* Advisory Group combines information on both the current stock size and the level of catch into a single classification for each stock (Table 1; Figure 4). To classify stocks into one of these categories, the current abundance and level of fishing pressure are compared with defined biological reference points (see 'Reference points', below). Each stock is then classified as a sustainable stock, transitional–recovering stock, transitional–depleting stock, overfished stock or environmentally limited stock.

The environmentally limited classification is a new addition to the 2014 edition of the *Status of key Australian fish stocks reports*. Stocks are classified as environmentally limited if the spawning stock biomass has been reduced to the point where average recruitment levels are significantly reduced, primarily as a result of substantial environmental changes/impacts or disease outbreaks (that is, the stock is not recruitment overfished). Fisheries management must have also responded appropriately to the environmental change in productivity.

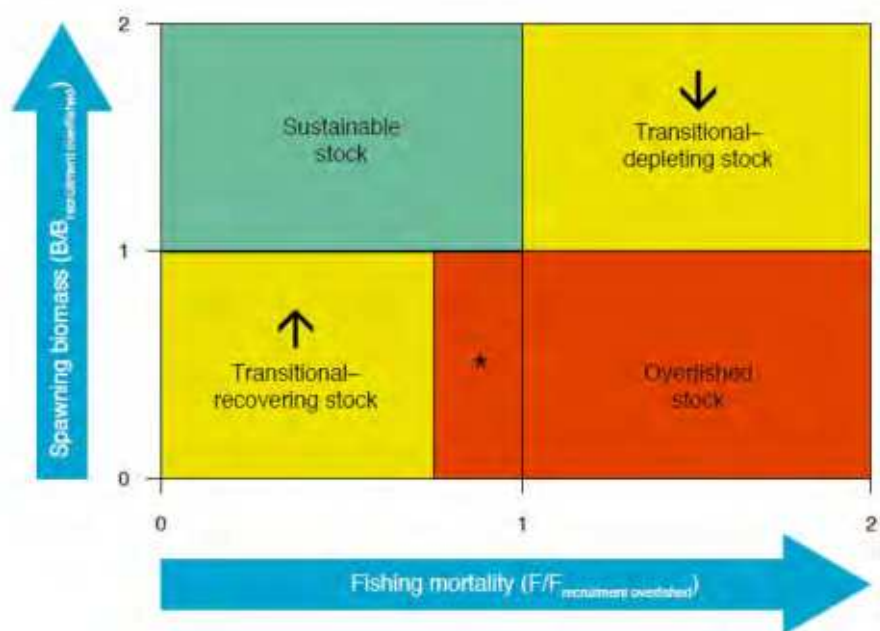
For ease of interpretation, the classifications are also depicted by a colour-coding system. An 'overfished stock' classification (red) indicates that a management response is required, to ensure the sustainability of the stock in question.

The term 'sustainable stock' in the *Status of key Australian fish stocks reports 2014* refers specifically to the biological status of fish stocks, and does not take into account broader ecological or economic considerations. A sustainable stock classification is given to stocks that are above the biological limit reference point of 'recruitment overfished' (see below) and for which the level of current fishing mortality is considered unlikely to cause the stock to become recruitment overfished. Given the focus of the *Status of key Australian fish stocks reports 2014* on stock status, the term does not have the broader meaning of terms such as 'ecologically sustainable' or 'ecologically viable', which consider the sustainability of the entire ecosystem and the role of specific stocks in the function of the ecosystem¹⁵ (see glossary for full definitions). As outlined above, it is envisaged that broader ecological considerations will be considered in future in companion reports.

Table 1: Stock status terminology for the *Status of key Australian fish stocks reports*

	Stock status	Description	Potential implications for management of the stock
	Sustainable	Stock for which biomass (or biomass proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (i.e. not recruitment overfished) and for which fishing pressure is adequately controlled to avoid the stock becoming recruitment overfished	Appropriate management is in place
↑	Transitional–recovering	Recovering stock—biomass is recruitment overfished, but management measures are in place to promote stock recovery, and recovery is occurring	Appropriate management is in place, and the stock biomass is recovering
↓	Transitional–depleting	Deteriorating stock—biomass is not yet recruitment overfished, but fishing pressure is too high and moving the stock in the direction of becoming recruitment overfished	Management is needed to reduce fishing pressure and ensure that the biomass does not deplete to an overfished state
	Overfished	Spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced (i.e. recruitment overfished). Current management is not adequate to recover the stock, or adequate management measures have been put in place but have not yet resulted in measurable improvements	Management is needed to recover this stock; if adequate management measures are already in place, more time may be required for them to take effect
	Environmentally limited	Spawning stock biomass has been reduced to the point where average recruitment levels are significantly reduced, primarily as a result of substantial environmental changes/impacts, or disease outbreaks (i.e. the stock is not recruitment overfished). Fisheries management has responded appropriately to the environmental change in productivity	Appropriate management is in place
	Undefined	Not enough information exists to determine stock status	Data required to assess stock status are needed

Figure 4: Diagrammatic representation of stock status classification system, with relative fishing mortality (the ratio of current fishing mortality to the fishing mortality that would cause the stock to become recruitment overfished) on the x axis and relative spawning biomass (the ratio of current spawning biomass to the recruitment overfished spawning biomass limit) on the y axis



* Note that part of the transitional-recovering block has been marked as 'overfished'. This represents stocks for which adequate management measures have been put in place, but these have not yet resulted in measurable improvements. Since environmentally limited stocks are not below the limit reference point as a result of fishing pressure, they are not included in this diagram.

Reference points

Biological reference points provide guidance on determining whether stock abundance is too low or fishing pressure is too high. Formal reference points in a fishery generally include targets to indicate where we would like to be, and limits to show what to avoid. Stock assessments usually produce estimates of abundance and fishing pressure over time, which can be assessed against biological reference points. The use of reference points to guide management decisions is consistent with the *FAO Code of conduct for responsible fisheries*¹⁴.

Limit reference points

The limit reference points used to determine stock status for management response have historically varied across the Australian jurisdictions. For example, Commonwealth fish stocks with a biomass below 20 per cent of the unfished abundance (biomass) level are generally classified as overfished, whereas, in New South Wales, stocks are generally considered overfished when they are below 30 per cent of the unfished abundance (biomass). The reference points for Commonwealth fisheries are specified in the Commonwealth Fisheries Harvest Strategy Policy (which underwent a review from March 2012 to March 2013)¹⁶, and Commonwealth fisheries are assessed against these reference points. Most other Australian jurisdictions have similar policies or legislative frameworks.

For assessing fish stock status nationally, ‘recruitment overfished’ was agreed as the biological limit reference point for determining whether or not a fish stock is overfished. ‘Recruitment overfished’ is defined as follows:

The point at which a stock is considered to be recruitment overfished is the point where the spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced.

The percentage of the unfished abundance that is considered to represent a recruitment overfished state varies to some extent across species and stocks, based on differences in biology. The recruitment overfished limit reference point for abundance in the *Status of key Australian fish stocks reports* is different from the limit reference points defined in some jurisdictions, which may include economic considerations or a precautionary buffer against measurement uncertainty. Reference points that include economic considerations or precautionary buffers can be very useful in particular decision-making contexts. However, it is intended that the national reporting be based solely on biological considerations, and these other considerations and buffers are therefore not included in the biological limit reference point used in the *Status of key Australian fish stocks reports*.

With respect to fishing pressure, for a stock to be classified as a sustainable stock in the *Status of key Australian fish stocks reports*, the current level of fishing pressure must be at a level considered to be unlikely to cause the stock to become recruitment overfished—that is, recruitment overfishing should not be occurring (see glossary for a more detailed explanation of recruitment overfishing).

Target reference points

Target reference points correspond to levels of biomass and fishing pressure that are considered to be ideal. Generally, fisheries management aims to ensure that stocks are maintained at these levels and away from limit levels. Target reference points commonly incorporate management objectives, such as maximising the sustainable yield or economic returns. For example, the Commonwealth Fisheries Harvest Strategy Policy seeks to maintain fish stocks, on average, at a target biomass equal to the biomass that would produce maximum economic yield¹⁶. As with limit reference points, a range of target reference points is currently used in the different fisheries and jurisdictions across Australia.

There is no single agreed national target level, so it is not yet possible to include quantitative information based on targets in stock status determinations. Although the stock status determinations provided in these reports rely on limit reference points, it is envisaged that, in the future, stock status classification will consider stock status in relation to targets as well as limits.

Defining stock status—weight-of-evidence approach

Assessing the status of fish stocks can be a difficult task. The methods used to monitor and assess stock status vary, ranging from simple catch levels to complex stock assessments. Smaller-volume and lower-value stocks and fisheries often have fewer data available or limited resources to undertake quantitative stock assessments. If targeted catch from a stock is very low, or a species is only taken in small numbers as byproduct, it may not be cost effective to invest in the development of resource-intensive quantitative stock

assessment models. However, robust stock status assessments can be made without having quantitative stock assessments.

In the *Status of key Australian fish stocks reports*, a weight-of-evidence approach has been used to establish an evidentiary base to support stock status determination. This is achieved by systematically considering a range of biological and fisheries information. The approach provides a structured, scientific process for assembly and review of indicators of biomass status and levels of fishing mortality. For most fish stocks, particularly in the smaller fisheries, only a subset of the types of evidence is available and/or useful. Expert judgment plays an important role in stock status determination, with an emphasis on documenting the key evidence and rationale for the decision. The decision-making process is undertaken separately for abundance and fishing pressure.

Lines of evidence used in the weight-of-evidence approach include:

- empirical indicators, including catch, effort, catch rate, size- or age-based indicators, and spatial and temporal distribution of the fishery
- risk assessments
- fishery-independent surveys
- quantitative stock assessment models
- harvest strategies.

It is intended that all stocks considered in the *Status of key Australian fish stocks reports 2014* be classified by the same standards, regardless of the evidence base used.

Stock assessments

Stock assessments are one of the main sources of information for determining stock status. Stock assessments are mathematical and statistical models that are used to predict the stock abundance and response to fishing. They typically incorporate information on growth, natural mortality, the stock–recruitment relationship and carrying capacity, and data from fishery-dependent sources (for example, catch and fishing effort) and fishery-independent sources (for example, surveys). The outputs of these assessments generally include an indication of the unfished stock abundance (that is, how big the stock was before fishing started), an indication of the current stock abundance, and an indication of current fishing pressure. In combination with biological reference points, the information from a stock assessment can be used to determine the stock status classification.

Abundance: Stock assessments of different species use different ways of measuring current stock size because of differences in biology and management systems. Measurements include spawning stock biomass, total biomass, and egg or pup production. In the *Status of key Australian fish stocks reports 2014*, each of these terms is used. However, regardless of the measure of biomass, the basic premise is that, for the stock to be classified as a sustainable stock, the level of abundance (biomass) must be above the level that results in the stock being recruitment overfished. This means that the abundance of adults will not have been reduced to the point where there is increased risk of recruitment failure.

Fishing pressure: In some cases in the *Status of key Australian fish stocks reports 2014*, estimates of fishing mortality are explicitly stated for a stock, where they are available. In these cases, the actual fishing mortality can be compared with fishing mortality limits set by management rules to determine whether current fishing pressure is likely to cause the stock to become recruitment overfished. In other cases, stock assessment models are used to determine total allowable catches (TACs), which are designed to ensure that the stock remains at (or will return to) an adequate size—often defined by target reference points. In these cases, it is meaningful to compare the catch from a stock with that recommended by the TAC. If the catch is below or equal to a biologically meaningful TAC, the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

Effects of fishing on the marine environment

The stock status classification provided for each stock does not take into account the effects of fishing on the marine environment. As discussed previously, these elements of the broader concept of ecologically sustainable development tend to be considered at the fishery level, rather than the stock level. It is envisaged that future companion reports will provide broader assessments of Australian fisheries that will include formal classification of fisheries based on the effects of fishing on the marine environment. Although no formal classification has been given, the effects of fishing on the marine environment are briefly explored in each chapter, and measures that have been put in place to mitigate detrimental effects are described.

Assessments of Australian fisheries under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth)

The environmental performance of Commonwealth-managed fisheries, and state and Northern Territory fisheries that have an export component and/or operate in Commonwealth waters, is assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act).

The Australian Government Department of the Environment assesses a fishery's management arrangements for consistency with the EPBC Act using criteria listed in the *Guidelines for the ecologically sustainable management of fisheries* (2nd edition)¹⁶. The guidelines outline specific principles and objectives to ensure a strategic and transparent way of evaluating the ecological sustainability of fishery management arrangements. The guidelines include the principles that:

- a fishery must be conducted in a manner that does not lead to overfishing; for those stocks that are overfished, the fishery must be conducted such that there is a high degree of probability that the stock(s) will recover, and
- fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of ecosystems¹⁷.

An assessment is undertaken if:

- product from the fishery is to be exported
- the fishery is to operate in Commonwealth waters, and/or
- the fishery is to be managed by the Commonwealth.

Part 13A—export. An Australian native wildlife specimen can only be exported for commercial purposes if it is approved for export from a program such as an approved wildlife trade operation, or is included in the list of exempt native specimens.

Part 13—species and communities. Under part 13 of the EPBC Act, it is an offence to harm listed threatened species (except a conservation-dependent species) in Commonwealth waters unless a fisher has obtained a permit or the management arrangements for the fishery are accredited under the Act. Management arrangements can be accredited under part 13 if the Environment Minister is satisfied that:

- the management arrangements require individual fishers to take all reasonable steps to avoid killing or injuring a member of a species protected under the EPBC Act (that is, a threatened species, a listed migratory species, a listed marine species or cetacean)
- the fishery does not, or is not likely to, adversely affect the conservation status of protected species, or affect the survival and recovery of listed threatened species¹⁷.

Part 10—strategic assessment of Commonwealth managed fisheries. The EPBC Act also requires that Commonwealth-managed fisheries undergo strategic assessment of their impacts on matters of national environmental significance, including the Commonwealth marine area. The outcomes of a strategic assessment inform other decisions under the EPBC Act for Commonwealth-managed fisheries.

EPBC Act assessments focus on the operation of a fishery as a whole, rather than specifically on individual species within a fishery. Hence, the details of EPBC Act assessments are not provided in all of the species chapters of the *Status of key Australian fish stocks reports 2014*.

However, details for all fisheries assessed are available on the Department of the Environment website (www.environment.gov.au/coasts/fisheries/index.html#fisheries).

Environmental effects on stocks

Many fish stocks vary naturally as a result of the effects of the environment, even in the absence of fishing. For example, recruitment of prawns can be affected by rainfall^{18,19}. Weather events, ocean currents, changes in climate and disease can all affect fish abundance. Where links have been established between environmental factors and stock abundance for a given species, these are outlined in the species chapters.

Non-fishing factors that affect the sustainability of fish stocks

Along with fishing pressure and natural environmental factors, human activities that are unrelated to fishing can have a substantial impact on the sustainability of fish stocks—for example, the clearing of mangroves for coastal development. Although the impacts of human activities are not discussed on a species-by-species basis

in the *Status of key Australian fish stocks reports 2014*, these factors may, in some cases, have a greater impact on fish stocks than fishing.

What to expect in each species report

The *Status of key Australian fish stocks reports 2014* contains 68 stock status assessment chapters that cover the status of 68 species or species complexes. Each chapter describes the distribution of stocks around Australia, providing stock status classifications for each. In cases where biological stock delineation is known and biological stock numbers are not too high, information is presented at the level of biological stocks. In other cases, information is presented at the management unit or jurisdictional level. Each chapter also includes information on the main fishing methods, the management measures, the number of vessels that catch the species, and the amount of catch from commercial, recreational and Indigenous fisheries. As discussed above, the effects of fishing on the marine environment are described, along with mitigation measures, and an indication is also given of environmental factors that can affect the stocks.

Reporting period

This second edition of the *Status of key Australian fish stocks reports* presents data up to 2013—the most recent data and assessments available at the time of publishing across all Australian jurisdictions with marine fisheries. In general, data are presented on the basis of calendar years, unless otherwise indicated (that is, where financial years or fishing seasons are used instead).

Process for production of the *Status of key Australian fish stocks reports*

The national *Status of key Australian fish stocks reports 2014* rely on a consistent reporting framework. The framework has been designed and agreed on by the *Status of key Australian fish stocks reports* Advisory Group, comprising heads of fisheries research agencies in all Australian jurisdictions. The Advisory Group agreed on the process for identifying the species to be included, developed the species chapter template, and agreed on a common set of terminology and reference points against which stocks were to be assessed. The agreed approach for producing the *Status of key Australian fish stocks reports* was endorsed by the Australian Fisheries Management Forum. The species chapter template and classification framework were reviewed following the production of the first edition of the *Status of key Australian fish stocks reports* in 2012. Apart from the addition of the ‘environmentally limited’ classification (described above), the species chapter template and classification framework are very similar to those used in 2012.

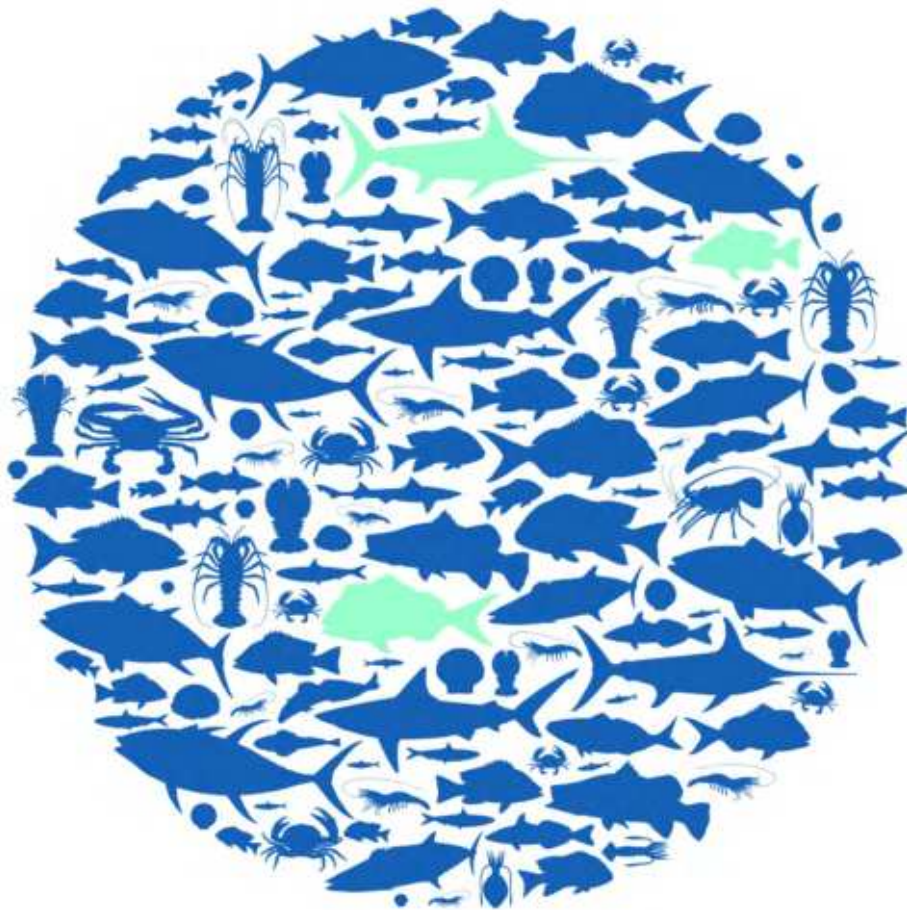
For each of the 68 species or species complexes chosen for inclusion in the reports, the Advisory Group identified ‘lead’ and ‘support’ jurisdictions for drafting species chapters. Stock status determination was undertaken in a collaborative manner, involving the relevant experts and team members in the jurisdictions in which the stocks are managed. This process meant that the researchers engaged in studying and assessing these species were responsible for the status assessment. For stocks that are shared by multiple jurisdictions, the lead jurisdiction was responsible for facilitating a process and discussion to determine the overall status of the stocks.

The individual species chapters have been reviewed by ABARES and the *Status of key Australian fish stocks reports* Advisory Group. In addition, the Fisheries Research and Development Corporation facilitated anonymous technical peer reviews of each of the 68 species or species complex chapters. The reports were provided to the relevant fisheries management agency in each Australian jurisdiction for comment.

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Fishing methods



Fishing methods

Fishing gear and methods are designed to take into account the particular characteristics and behaviour of the species being sought, including their feeding, spawning, shoaling and migratory behaviour, their ecology or relationship with their habitat, and their herding behaviour. The catchability of each species depends on the action of the gear, and the composition of the catch from a particular fishing area may therefore depend on the type of gear used.

The information presented here is extracted from the 1993 authoritative *Australian fisheries resources*¹, and updated to reflect changes in fishing techniques and management over the past 20 years. It is not intended to be a comprehensive review of all fishing gear used in Australia. However, it covers the main fishing methods used to catch species that are included in the *Status of key Australian fish stocks reports*. This chapter thus contains information on nets, hook and line, traps and enclosures, and other miscellaneous methods. More detail on minor fishing methods can be obtained from *Australian fisheries resources*¹.

The length of commercial fishing craft in Australia varies from 1.5 m to 87 m. The smaller craft, such as punts, dinghies and 'runabouts', are primarily used in inshore waters by net, trap or hand-line fishers; dories and skiffs are often employed in inshore or open-water fisheries in conjunction with larger vessels—for example, in purse-seine operations. Many craft designs are categorised by the fishing gear used on them—for example, 'trawlers' and 'longliners'. Other boats in Australian commercial fishing fleets are multipurpose and can be rigged with different gear to operate in a number of fisheries; a line fishing boat may also set traps or pots.

Nets

Fishing nets are responsible for the largest share of Australia's fish catches, and are used in a wide variety of configurations and designs, depending on the species being targeted. The four main types of fishing gear that use netting are gillnets and entanglement nets, surrounding nets, seine nets, and trawls. The main components of a common net are described below.

The netting or mesh is the panel of net that fish will encounter and be retained in. Modern nets are typically constructed from synthetic fibres, such as monofilament nylon for gillnets, and multiple twisted or braided polymer filaments for seine and trawl nets.

The top edge of the net is attached to a rope called the headline, floatline or corkline. Floats are attached to the headline to provide buoyancy.

The bottom edge of the net is attached by hanging twine to a rope called the footrope or leadline. Weights or sinkers made of lead or other materials are attached to the footrope and spread the net vertically in the water. The type and number of floats and weights used depend on whether the net is to be positively or negatively buoyant (see below).

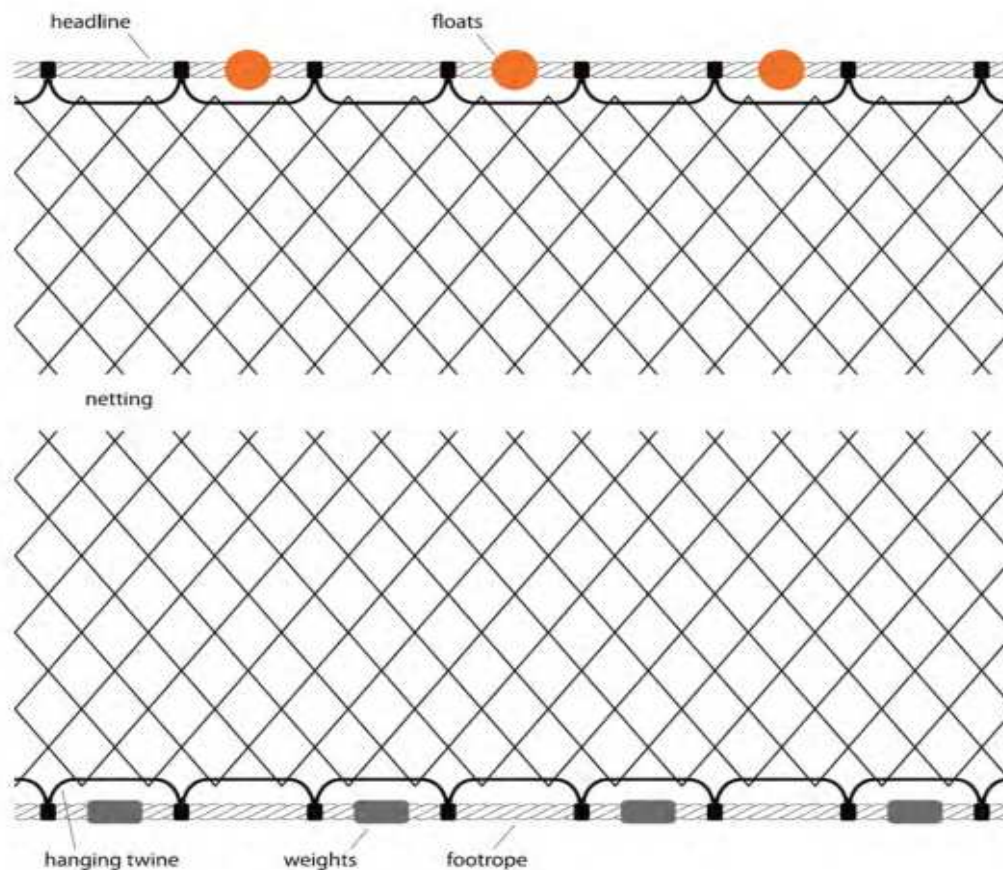
Gillnets and entanglement nets

Gillnets and entanglement nets consist of a panel (or panels) of net held vertically in the water column, either in contact with the seabed or suspended from the sea surface. The size of the mesh in the net determines the size range of the species caught, since smaller fish are able to swim through the mesh. The legal net length and mesh size are set by individual jurisdictions. Gillnets and entanglement nets are used in offshore and inshore waters, and in rivers and estuaries.

Fish are caught in gillnets or entanglement nets in one of three ways:

- gilled—the fish tries to swim through one or more meshes; if it cannot pass through, it becomes caught behind its gill covers as it tries to back out of the net
- wedged—the fish is tightly held in the net around the body by one or more meshes
- tangled—the fish is caught in the net by some part of its body, such as protruding fins or spines.

Pelagic gillnets (also known as drifting gillnets) are used in Commonwealth, Queensland and Northern Territory waters to target tropical sharks and mackerels. Pelagic gillnets are made up of individual net panels tied together, allowing easy removal or replacement of damaged sections. They are set in open water and can be set with the headline on the sea surface (*positively buoyant*) or suspended below the surface (*negatively buoyant*), with one end of the net remaining attached to the vessel.

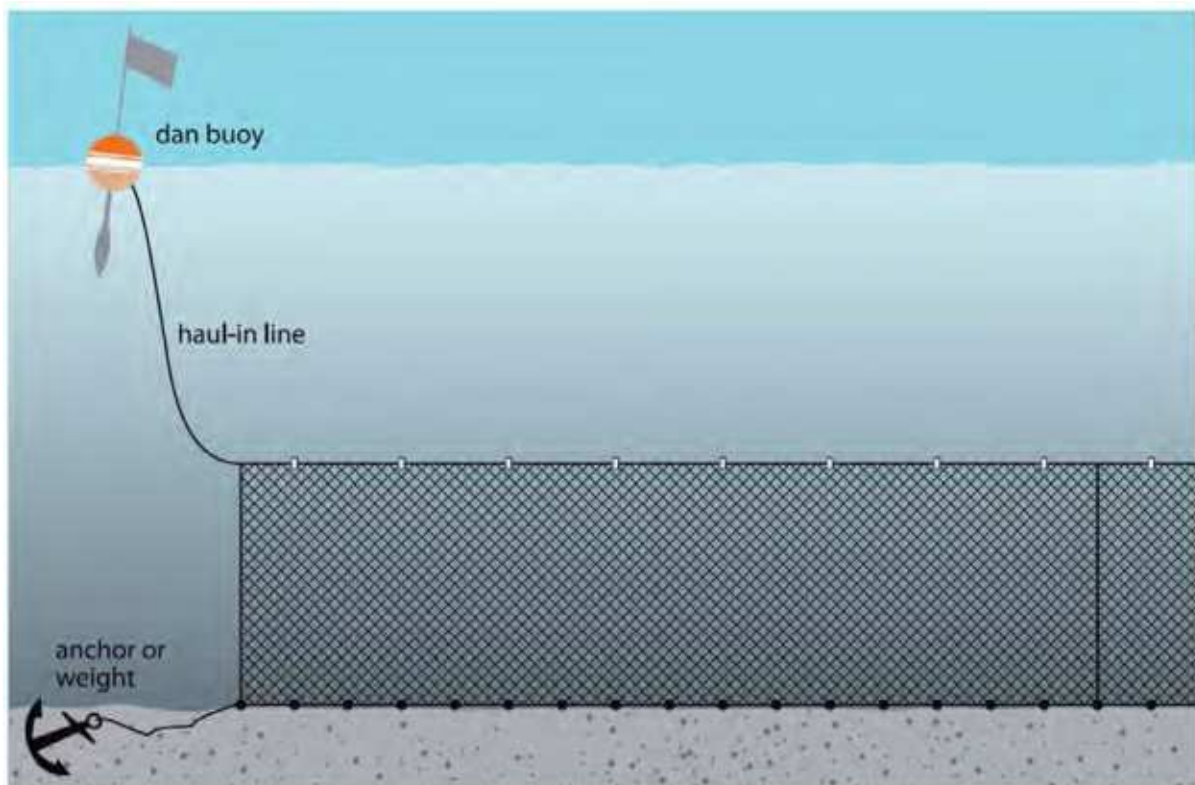


A common net



A pelagic gillnet

Demersal gillnets (also called bottom-set gillnets, shark nets, graball nets or mesh nets) are used to target Gummy Shark, in the Commonwealth-managed Gillnet, Hook and Trap Sector of the Southern and Eastern Scalefish and Shark Fishery. State-managed fisheries also use demersal gillnets to target finfish species. Demersal gillnets are similar to pelagic gillnets but are negatively buoyant and fish on the ocean floor. The boat does not remain attached to the gear, but usually remains within a short distance of it.

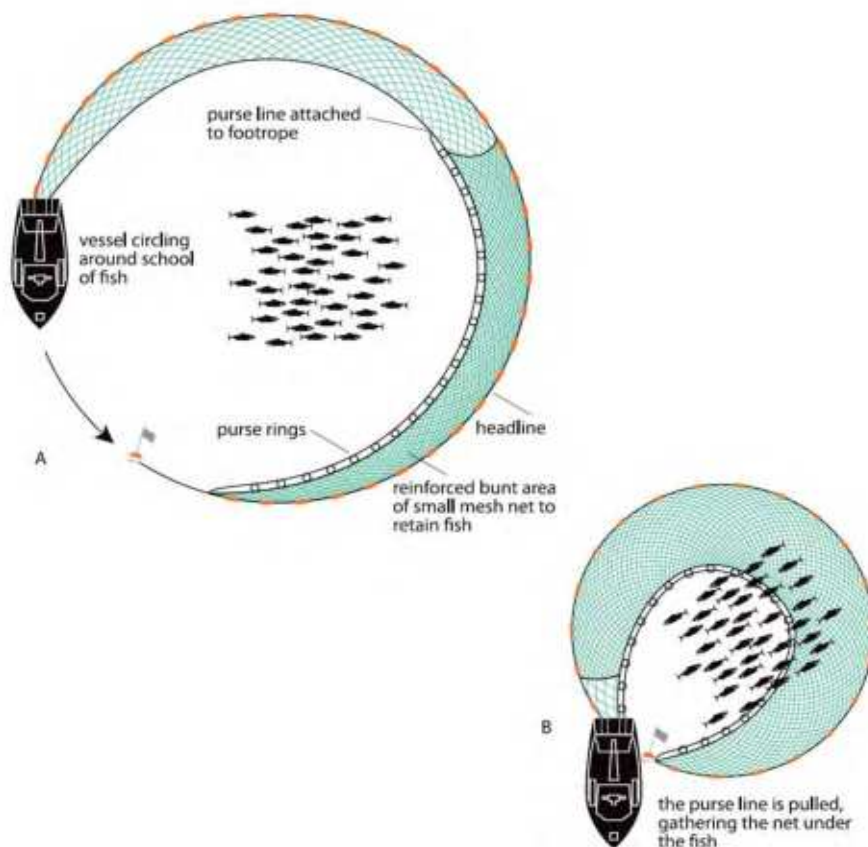


A demersal gillnet

Coastal-, estuary- and river-set gillnets (also called swinger nets, mesh nets, running nets or offshore-set gillnets) are set in estuaries and adjacent to the coast. They are used throughout Australia, with the main target species in southern waters being mullet, bream, trevally, Luderick, Banded Morwong, warehou, flathead, Mulloway and King George Whiting. In Queensland, the Northern Territory and north-west Western Australia, Barramundi and Threadfin are the main target species. Estuary-set gillnets are set using small dinghies. The headline is tied to a tree or otherwise secured on the shore above the high-water mark. The dinghy is used to set the net across the river in a range of directions, depending on the tide and the species being targeted. Coastal-set and offshore-set gillnets are used throughout Australia. Offshore-set gillnets are set in at least 2 m of water, but coastal-set gillnets are usually anchored on the shoreline and may even be exposed at low tide, only catching fish as the tide rises.

Running nets are used for prawns. They are set in shallow water with a slight run-out current, between the boat and a channel. The prawns are worked along the net to the boat anchored on the end of the net, where they are collected in scoop nets. Swinger nets are used in South Australia to catch Mulloway around river mouths. They are set from the shore. One end of the net is placed in the water and allowed to drift out through the surf with the aid of the offshore 'rip' current, while the other end is held on the bank. The net swings around with the tide and is then hauled back onto the bank.

Ring nets (also called encircling gillnets, bull ringing, bunting nets, ring shots, power hauling, drain-off shots or round haul nets) are used in many parts of Australia to target species such as mullet, garfish, Australian Herring and whiting. They generally consist of a straight panel of netting (a pocket section may be incorporated) that is set around a school of fish sighted on the surface.

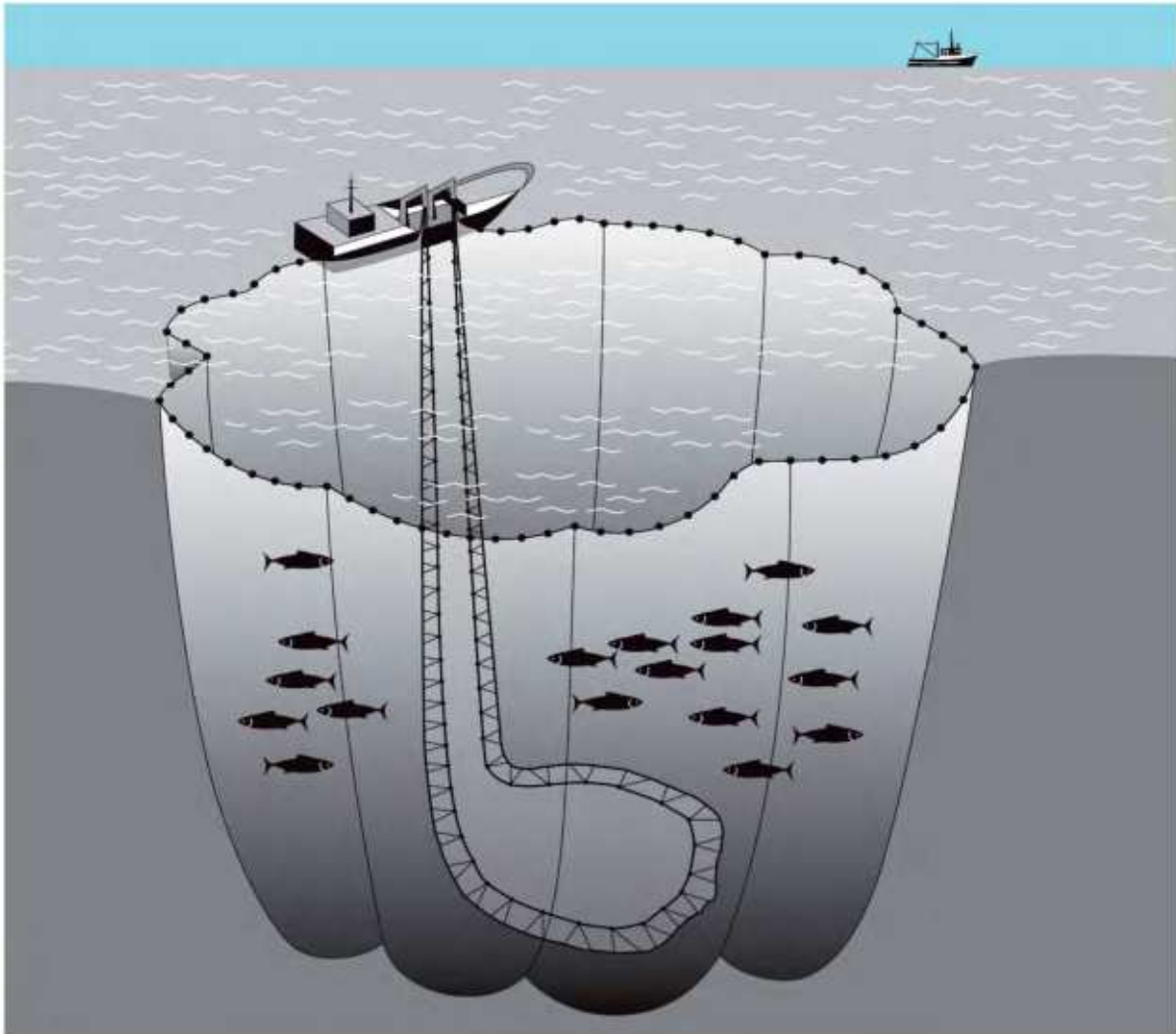


Typical ring net configuration

Surrounding nets

Surrounding nets take advantage of the shoaling behaviour of pelagic fish. The nets work by enclosing schools of fish within walls of netting that prevent the fish from escaping both outwards and downwards.

Purse-seine nets are used in the southern states of Australia to target schooling pelagic fish species, such as Australian Sardine, Jack Mackerel and Southern Bluefin Tuna. They are positively buoyant, with sufficient flotation to support the expected catch. The end of the net that is set first (the bunt) is heavily reinforced, as this is where the fish will be concentrated when the net is hauled. The footrope of the net has purse rings attached at regular intervals by rope or chain. A purse line runs through the rings; when the line is pulled, it effectively closes the bottom of the net.



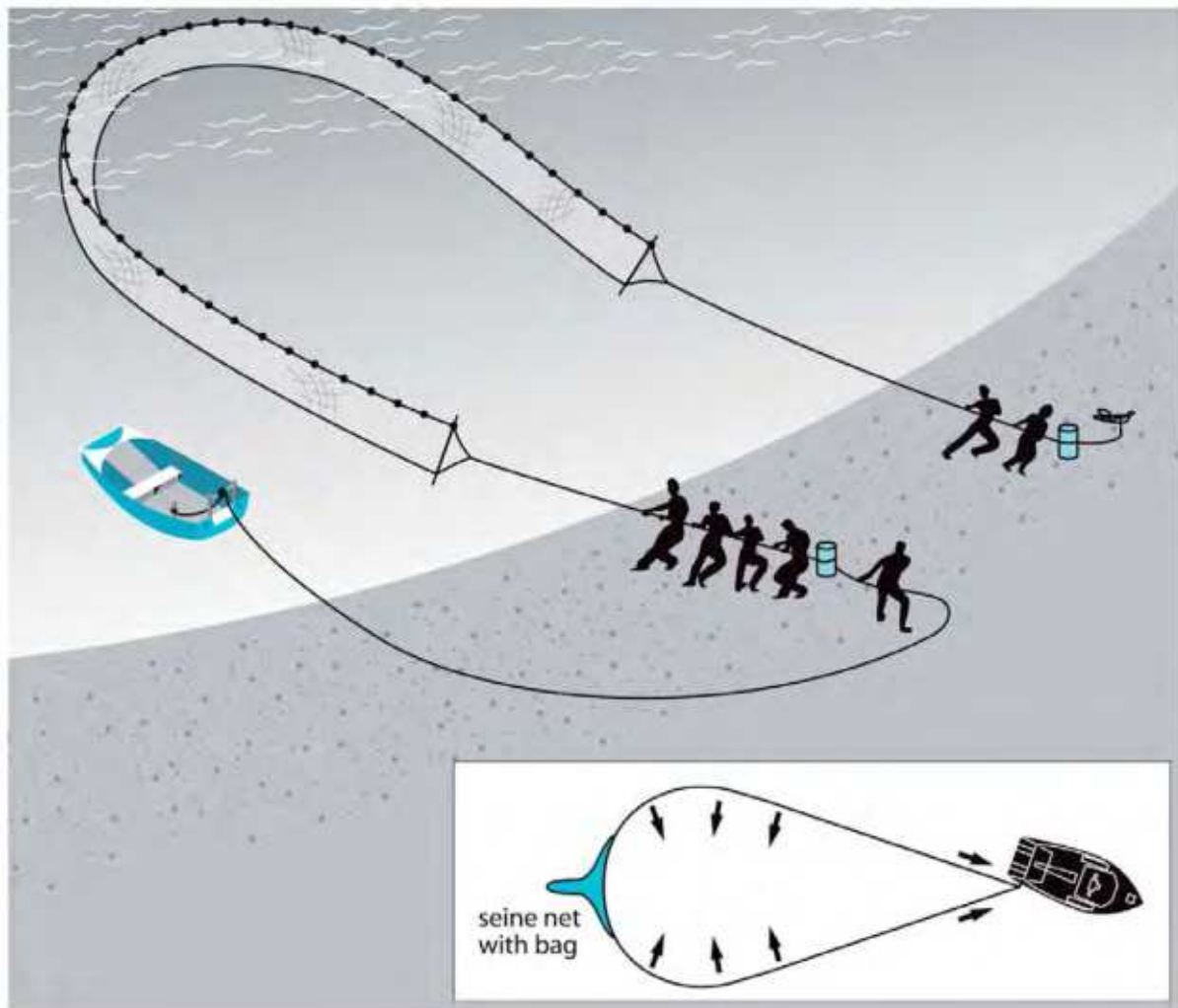
A purse-seine net

Schools of fish are located by visual sighting, spotter aircraft or sonar. The fishing vessel travels around the school, setting the net, and the headline is then winched in so that both ends of the net are beside the vessel. The purse line is winched in from both ends, closing off the bottom of the net. The net is then pulled in towards the boat, and the catch is either pumped or lifted out in landing nets; alternatively, the entire net is lifted aboard. In the case of Southern Bluefin Tuna, the fish are transferred to towing cages and towed to sheltered waters closer to shore (for example, Port Lincoln in South Australia) over a period of days or weeks, after which they are transferred to aquaculture grow-out cages.

Seine nets

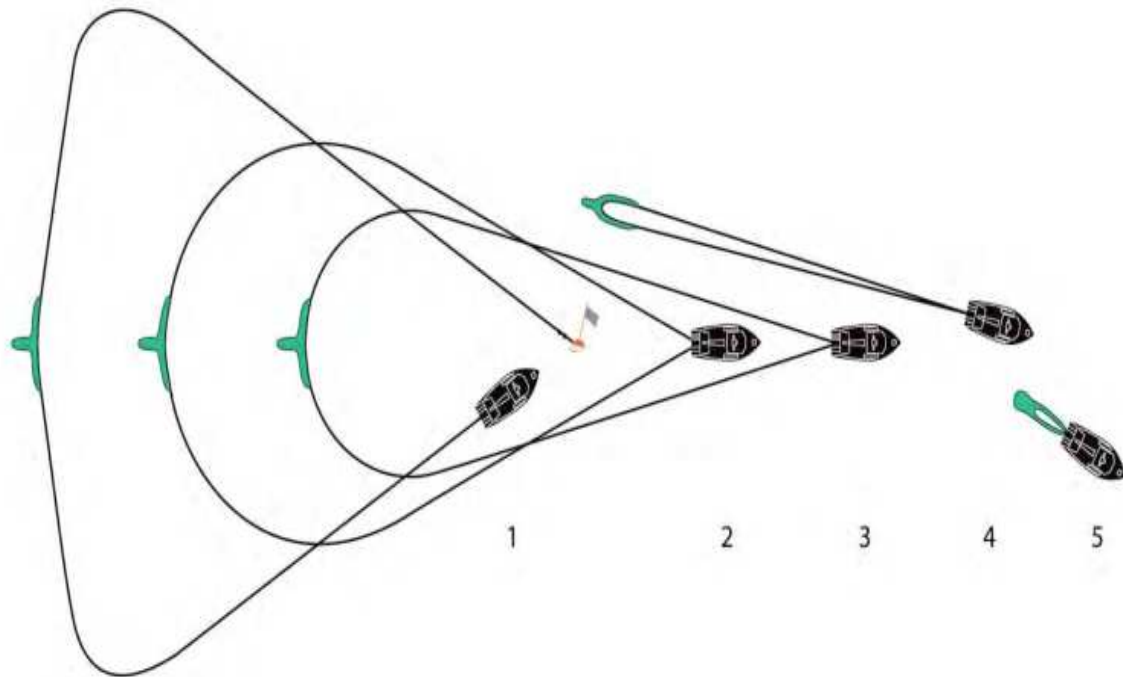
Seine nets usually have two long wings and a section that concentrates and retains the catch. Lengths of rope are added to the end of each of the wings. These ropes are negatively buoyant and extend the working area of the net while adding minimum drag to the hauling operation. The nets function on the principle that fish are reluctant to swim over a moving object in the water and instead try to swim in front of it. The fish are thus herded by the ropes and wing ends into the net.

Beach-seine nets (also called haul seines, pocket seines, baitfish seines, garfish seines, snapper seines, hauling seines, seines or estuary seines) are used Australia-wide to catch many species, including mullet, whiting, Australian Salmon, garfish, Tailor and bream. The net may have a loose section of netting acting as the bunt area for retaining fish, or may have a bag at one end of the net or in the centre. Beach-seine nets can be set around a sighted school of fish, or in an area where fish are known to congregate. The net is set from a dinghy or can be walked out in shallow water, with the first length of rope being set perpendicular to the shore, the net set parallel to the shore, and the second rope set back to the shore. The ropes are then hauled onto the beach evenly, by hand, four-wheel drive vehicle or tractor, herding the fish into the net. Hauling continues until the net and fish are dragged onto the shore, or the fish are concentrated in the bag.



A beach-seine net

Danish-seining is the main form of boat seine used in Australia. It is used in New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia to target a variety of species, including emperor, flathead, whiting and Redfish.



A Danish-seine net

Danish-seining gear is similar to a beach seine but is used on the continental shelf in depths up to 150 m to fish along the sea floor. The nets are negatively buoyant, and the lengths of rope used off each wing can be more than 40 times the length of the actual net. The principle of setting and hauling a Danish-seine is similar to that used for beach seining, but the process is undertaken from a boat rather than from the shore. The gear is set in a pear shape, with the net at the base of the pear and the ropes making up the sides. Retrieval of the net uses a combination of the forward movement of the vessel to close the net and hauling on the ropes using a powered winch.

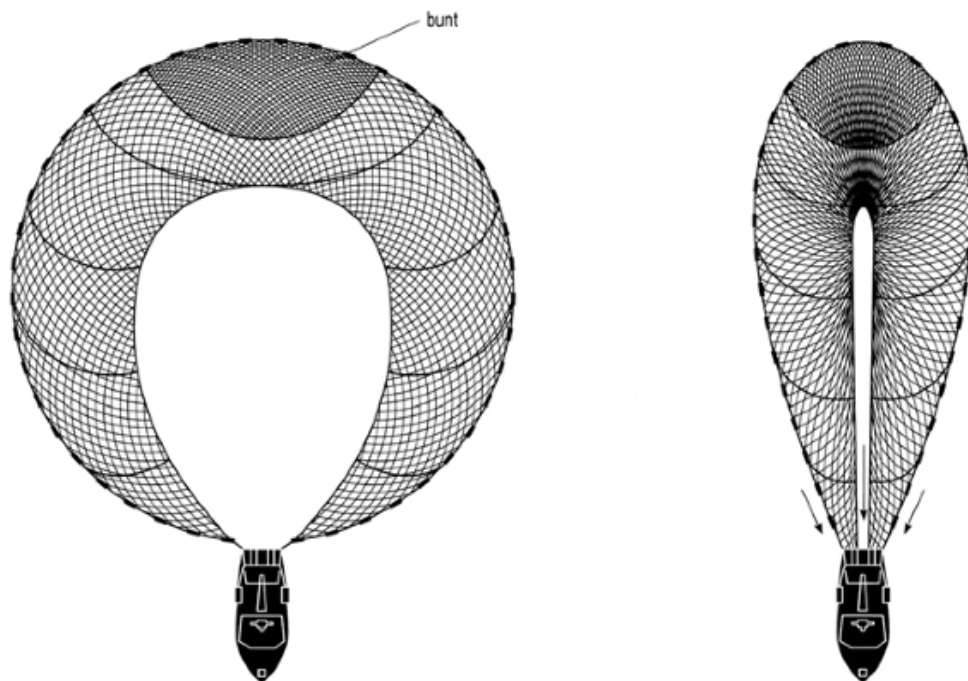
Haul nets are used in South Australia, Tasmania and Victoria to catch Snapper, garfish, King George Whiting, Southern Calamari and bream. They are similar to a Danish-seine, with the net being positively or negatively buoyant, depending on the target species. The gear is deployed from small vessels in shallow water and is set in the same manner as a Danish-seine. The nets are predominantly deployed in waters shallower than 5 m, but may be deployed in waters deeper than 20 m when targeting Snapper. The ropes are short, and hauled either by hand or using mechanised winches while the vessel is stationary. Modified haul seines (ringing seines) are used predominantly in Corner Inlet, Victoria, where large tidal ranges ensure that the nets are usually hauled from within the boat. The nets have only one wing, and there are rings on the footrope through which a line is passed to purse up the catch.

River prawn seines (also called snigging seines) are used in New South Wales bays and estuaries to catch bay prawns and school prawns from small vessels. They are also similar to Danish-seine, except that the net has a smaller mesh and the ropes are quite short. They are set and hauled in the same manner as a Danish-seine.



A river haul net

Lampara nets (also called ocean garfish haul nets) are used occasionally in Australia to catch pilchards (for example, Australian Sardines), Australian Anchovy and garfish. They are a more specialised type of surrounding net with wings (long, tapered panels of net added to each side of the bunt), giving the net a characteristic scoop shape. Lampara nets are mostly used at night with lights. The net is towed during the hauling process.



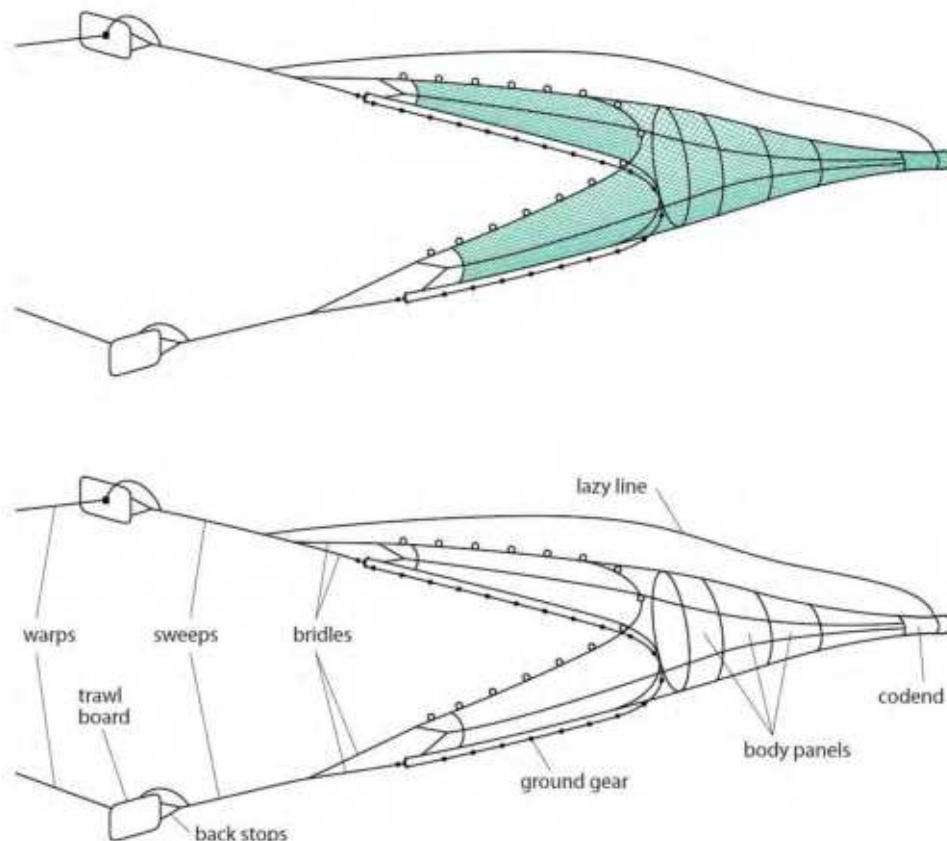
A lampara net

Trawl

Trawl is one of the most widely used commercial fishing methods in Australia. Trawling is performed in many ways, in depths of water ranging from just a few metres to 1000 m. The design of trawl nets is more complex than the basic nets discussed above. Trawls are made up of components that perform specialised functions, as described below:

- *Warps* are wire ropes connecting the trawl boards to the vessel. They are stored on *winch drums* for ease of operation.
- *Trawl boards* (also called otter boards or trawl doors) keep the net open horizontally by acting as hydrodynamic kites. They also provide weight, which is required to keep the trawl at the desired depth of operation.
- *Backstops* are short lengths of wire or chain that connect the trawl boards to the sweeps. *Sweeps* are used on demersal otter trawls to connect the backstop to the bridle on each side of the net. *Bridles* connect the sweep on each side of the net to the headline and footrope on the wing ends of the net.
- *Ground gear* is a wire or chain that is attached to the footrope by short *chain droppers*. The ground gear has several rubber or steel *bobbins* and *spacers* threaded along its length. The purpose of the ground gear is to reduce damage from snagging by lifting the footrope and net clear of the seabed.
- *Body panels* are the panels of net that make up the body of the trawl; they comprise upper and lower sections.
- The *codend* or bag is the last section of the net, where fish are collected and held during trawling operations. This area has the smallest mesh size, which determines the size of fish that the trawl will retain. The end of the codend is tied with a quick-release knot so that the fish can be easily emptied from the net.

The *lazy line* is sometimes used to pull the codend on board so that it can be emptied.

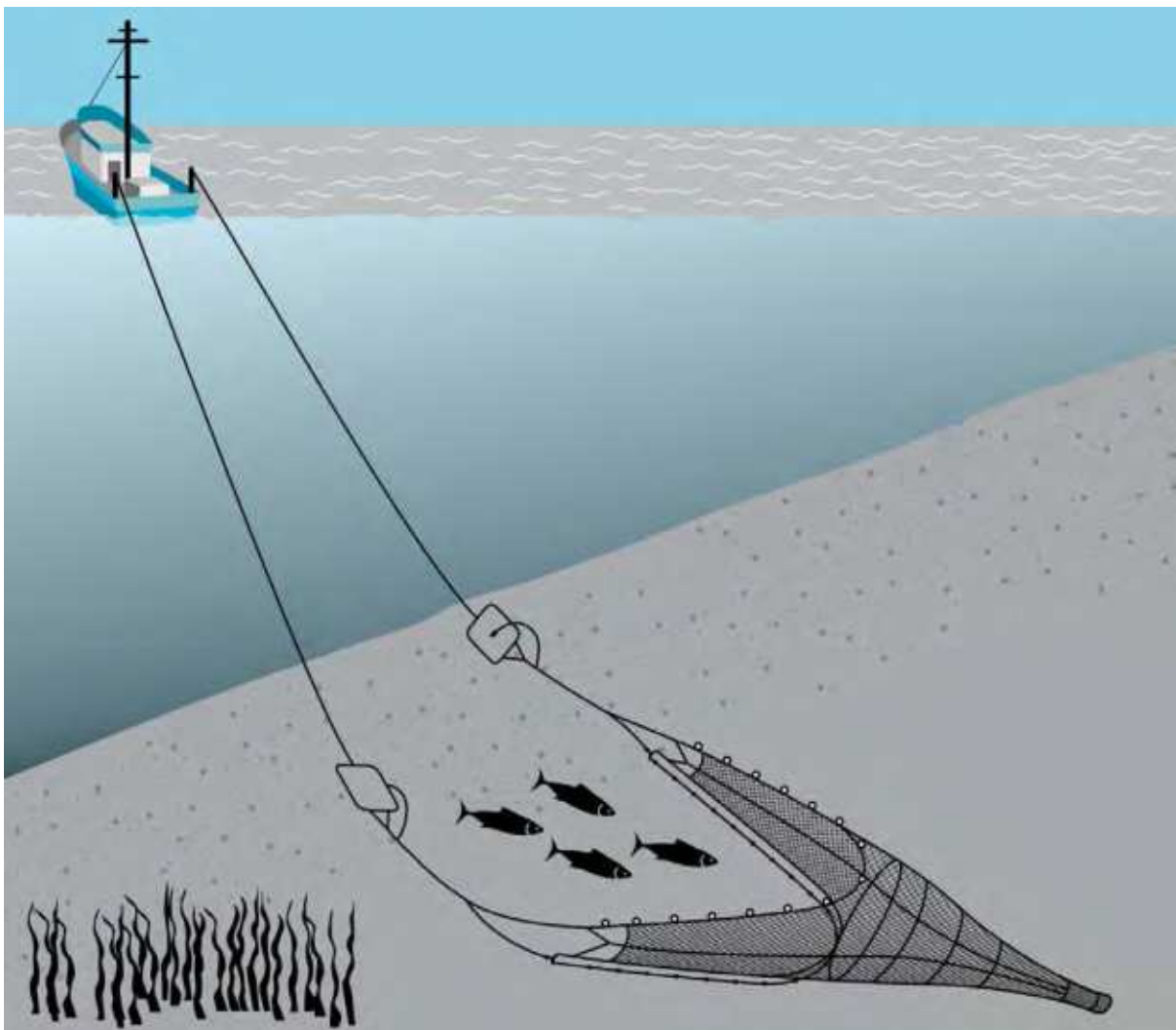


Trawl net configuration

Beam trawls (also called dredge nets, beam tide nets or push nets) are used in Queensland to catch school prawns and bay prawns. In northern Queensland and the Northern Territory, a beam trawl is sometimes used to sample the catch in demersal otter trawl prawn fisheries, both before the larger demersal otter trawl gear is set and during the trawl itself, to make sure the area being fished is still productive.

A beam trawl is simple in construction and can be used by small vessels, especially in restricted areas such as lakes and estuaries. It is constructed with two curved, steel end plates; the height of the end plates determines the vertical opening of the net. A straight steel bar that connects the tops of the end plates acts as a solid 'headline' and also determines the horizontal net opening. The top of the netting is attached to the beam, while the footrope is attached to the back of the end plates.

Demersal otter trawling for fish (also called stern trawling, bottom trawling, otter trawling or trawling) operates in south-eastern Australia, the south of Western Australia and the North West Shelf. A modified version (see semipelagic otter trawl, below) is used in some areas of the Northern Territory and Queensland. Australian trawl vessels also operate in Antarctic waters and on the high seas. Species taken in the southern fisheries include Blue Grenadier, Pink Ling, Silver Warehou, flathead and Redfish. In northern Australia, species taken include Snapper, emperor, rock cod and squid.



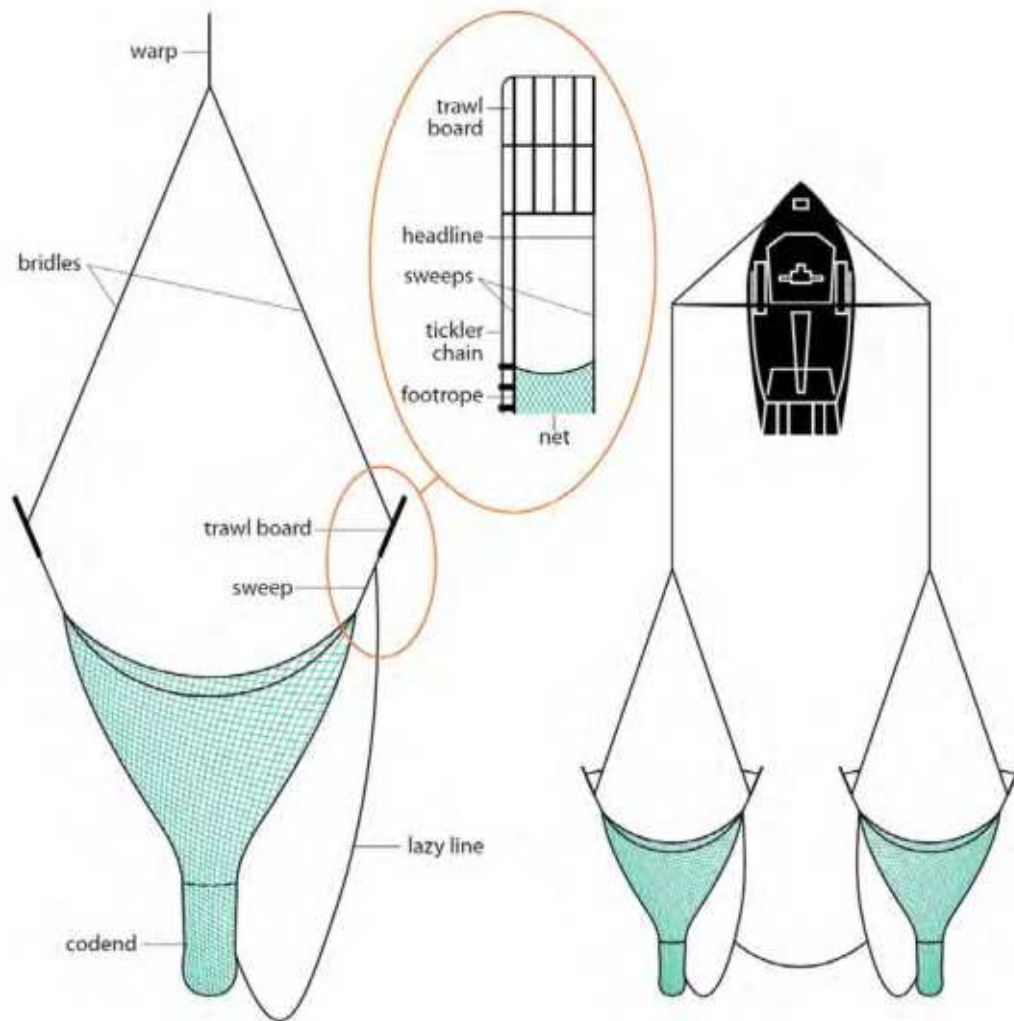
Demersal otter trawl gear



The trawl boards, sweeps, lower bridle and ground gear of demersal otter trawls are in contact with the seabed during fishing. The net is held open horizontally by trawl boards being dragged along the seabed, spreading the sweeps, bridles and net wings. These herd the fish towards the net, where they are retained in the codend.

Demersal otter trawling for prawns (also called prawn trawling or trawling) takes place in all Australian states except Victoria and Tasmania. Tiger Prawns, Banana Prawns, King Prawns and Endeavour Prawns are the main species caught. Demersal otter trawls for prawns resemble a fish trawl, except that they do not employ groundgear, long sweeps, backstrops or long wing ends. They also generally have a smaller size mesh in the codend and body panels.

Prawns generally burrow into, or live on, the ocean floor and do not have the same escape capabilities as finfish. To compensate for this, a ground chain is used. This hangs below the footrope to disturb the prawns, causing them to jump up into the path of the oncoming net. In some fisheries, a tickler chain is also used, which is set in front of the ground chain. Similar trawl nets are used to target Saucer Scallops in Queensland and Western Australia, and Scampi in the Commonwealth North West Slope Trawl Fishery.

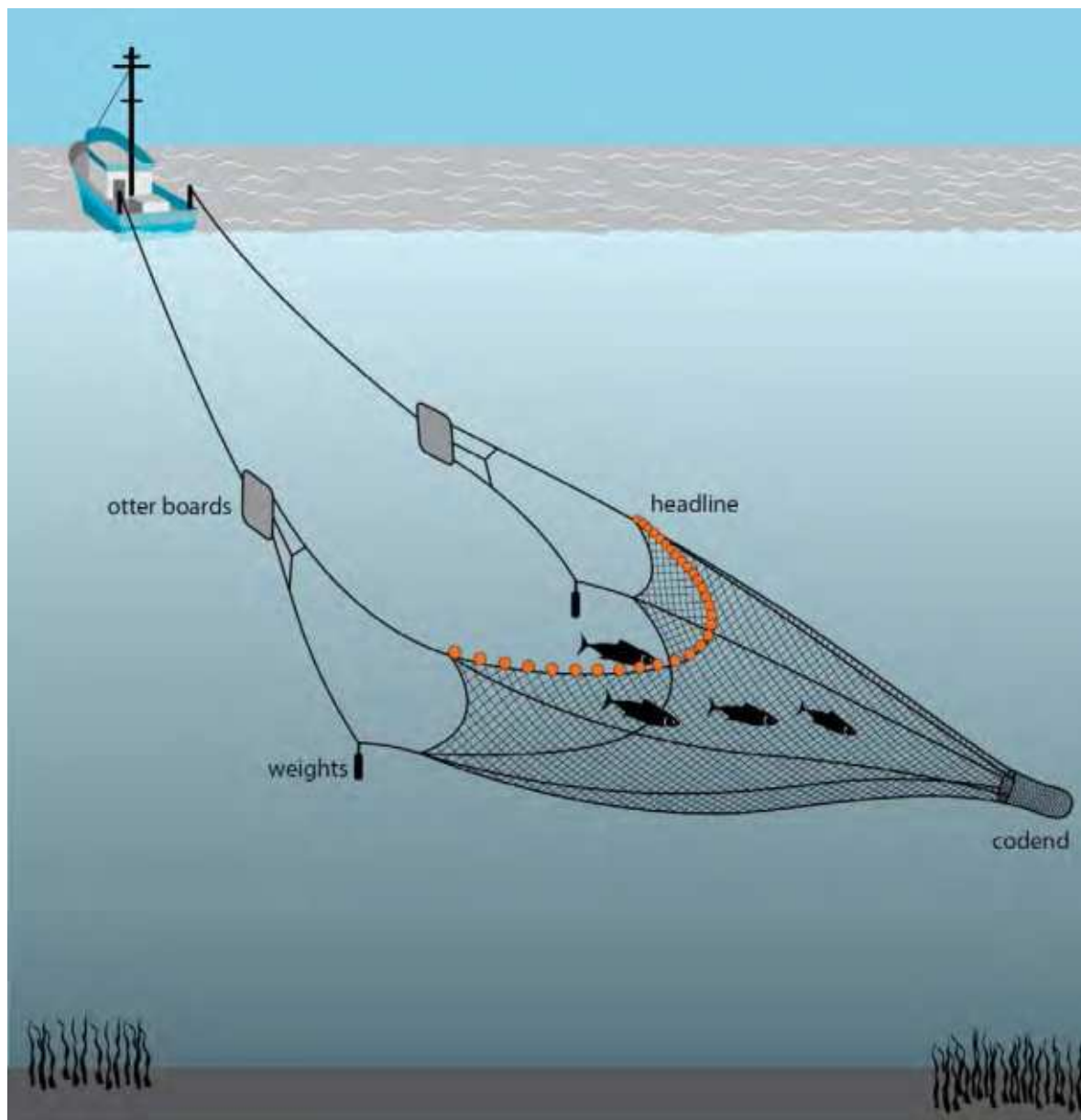


Demersal otter prawn trawl gear (left) and double rig configuration (right)

Long booms extending out from each side of the boat allow *multiple* rigs to be used. These rigs can be in a double, triple or quad net arrangement. The gear and rig configuration used often depends on the fisher's preference and the regulations imposed in a particular fishing area.

Semipelagic otter trawl (also called high-aspect semipelagic trawl or semidemersal trawl) fishes close to the seabed, with only the trawl boards, wing end weights and chain droppers coming in contact with the seabed. This type of trawl net is commonly used to target finfish in the Northern Territory.

Midwater trawling (also called pelagic trawling) is used to target pelagic finfish such as Redbait, Jack Mackerel and Blue Mackerel in the Commonwealth Small Pelagic Fishery, and spawning Blue Grenadier in the Commonwealth Trawl Sector.



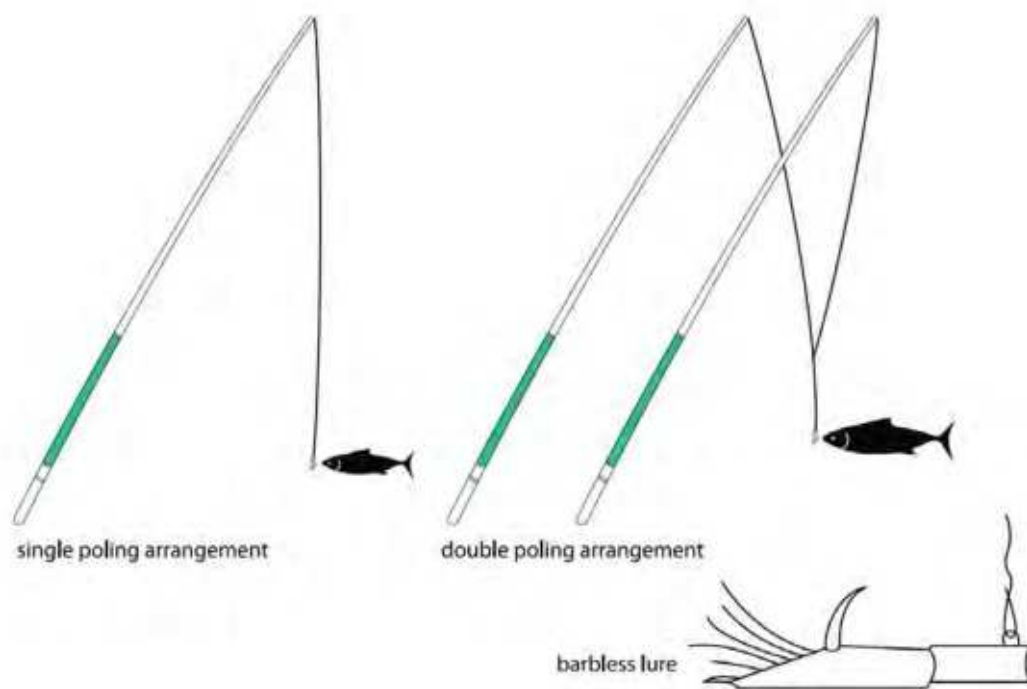
Midwater trawling

Midwater trawl nets resemble demersal trawl nets for fish, except that they have a much larger mouth with short or no wings. The trawl boards are connected to the net via a long bridle and help to give the net its horizontal opening. Vertical opening of the net is achieved by flotation on the headline and weight on the footrope, as well as an additional weight on each lower bridle, close to where it connects to the footrope. The position of the net in the water column is controlled by the length of the warp and by varying the speed of the vessel.

Hook and line

Hand lines, hand reels and powered reels (also called rod-and-line fishing or deepwater line fishing) are used commercially in all jurisdictions to target finfish. Hand lines are the simplest form of fishing; they consist of one or more baited hooks attached to a line, which is retrieved by hand. They may be used singly or several at a time. Hand reels can be mounted on the side of a vessel or attached to a rod (rod and line). Rod and line is the predominant method used by recreational fishers in Australia. Reels are used to deploy and retrieve the line and are usually fitted with a drag system (a 'brake' system, which is designed to create resistance in the reel as the fish takes out line). To reduce the time and effort involved in setting and hauling the line, electric or hydraulic motors are fitted to some larger reels (powered reels).

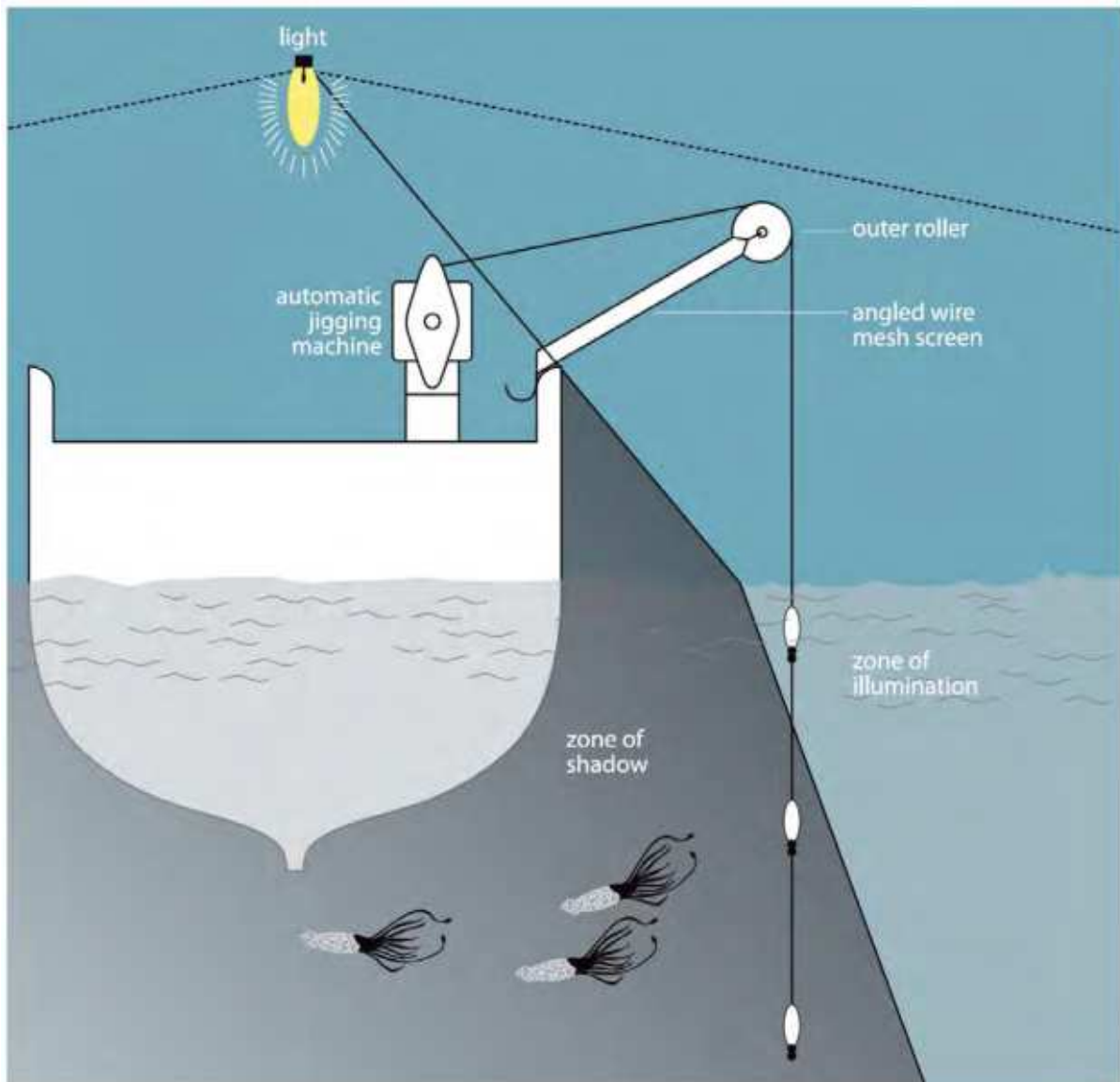
Pole and line (also called poling) consists of a fibreglass pole and a short line with a barbless lure attached. This method of fishing typically targets pelagic species such as tuna. It is not commonly used any more in Australia. The fish are attracted to the boat by throwing bait into the water and by disturbing the surface of the water, mimicking the behaviour of baitfish. As fish are hooked on the lure, they are hauled over the fisher's shoulder onto the deck. Larger fish are taken using a double poling arrangement, operated by two fishers.



Pole and line

Squid jigs

Squid jigging is carried out in south-eastern Australia to catch Gould's Squid and occasionally Southern Calamari. Jigging is a night fishing method that exploits the squids' strong attraction to light. Powerful lights are positioned along the vessel to attract the squid. The squid congregate next to the vessel in the shadowed area and dart into the lit area to feed. A line with several barbless lures is used off an elliptical spool, which is either automatic or hand operated. The rotation of the spool as the line is wound creates the jigging action. Squid caught on the lures are hauled over a roller, fall onto a wire mesh screen at the side of the vessel and slide onto the deck. Automatic machines continually wind up and down, and need little attention. Modern squid jigging machines can be controlled by a computer located in the vessel's wheelhouse, which can vary the fishing speed and pattern between machines.

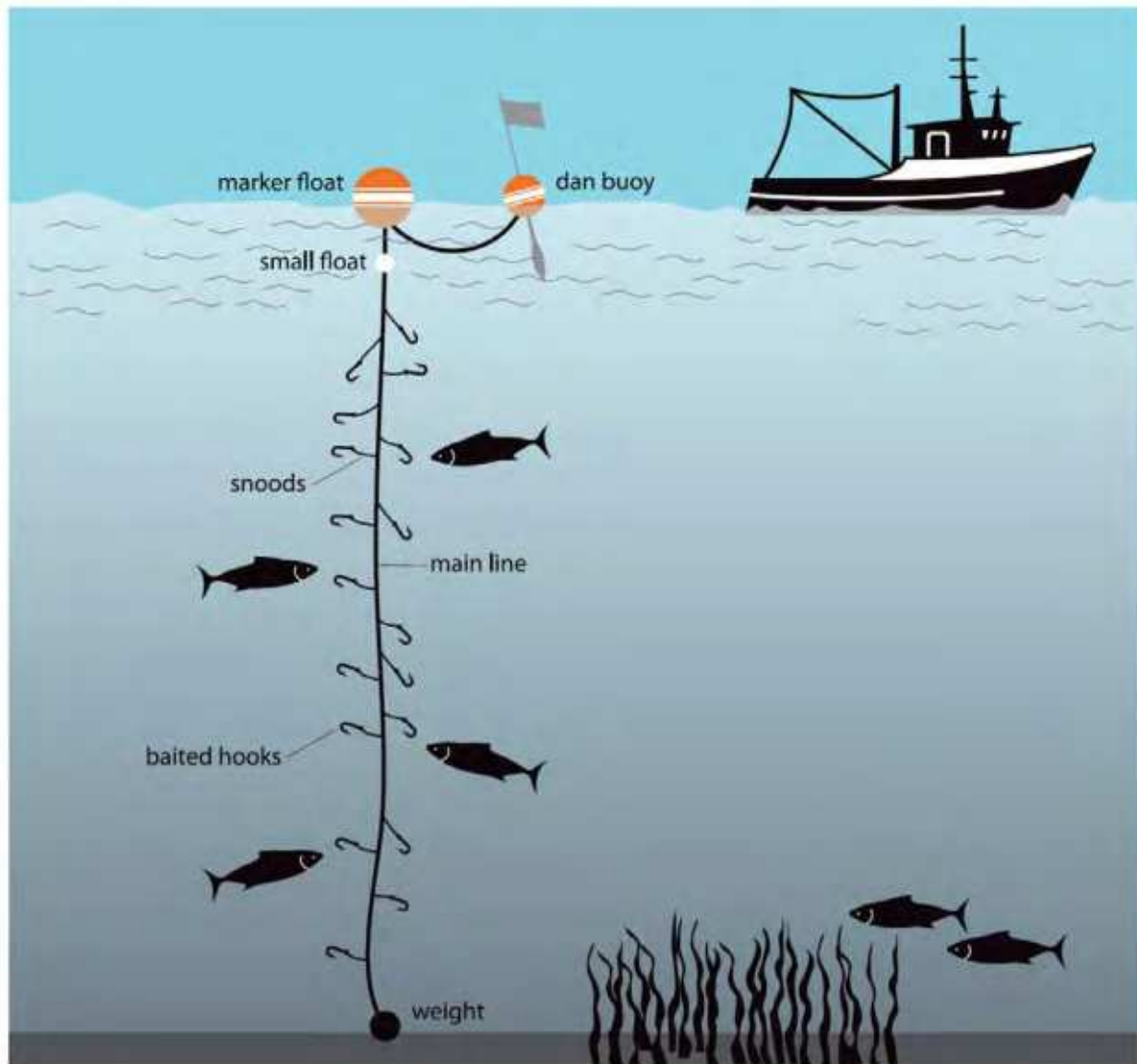


Squid jigging gear

Anchored longlines

Anchored longlines can be set vertically in the water column (dropline), horizontally along the seabed (bottom-set longline) or horizontally suspended off the seabed (trotline).

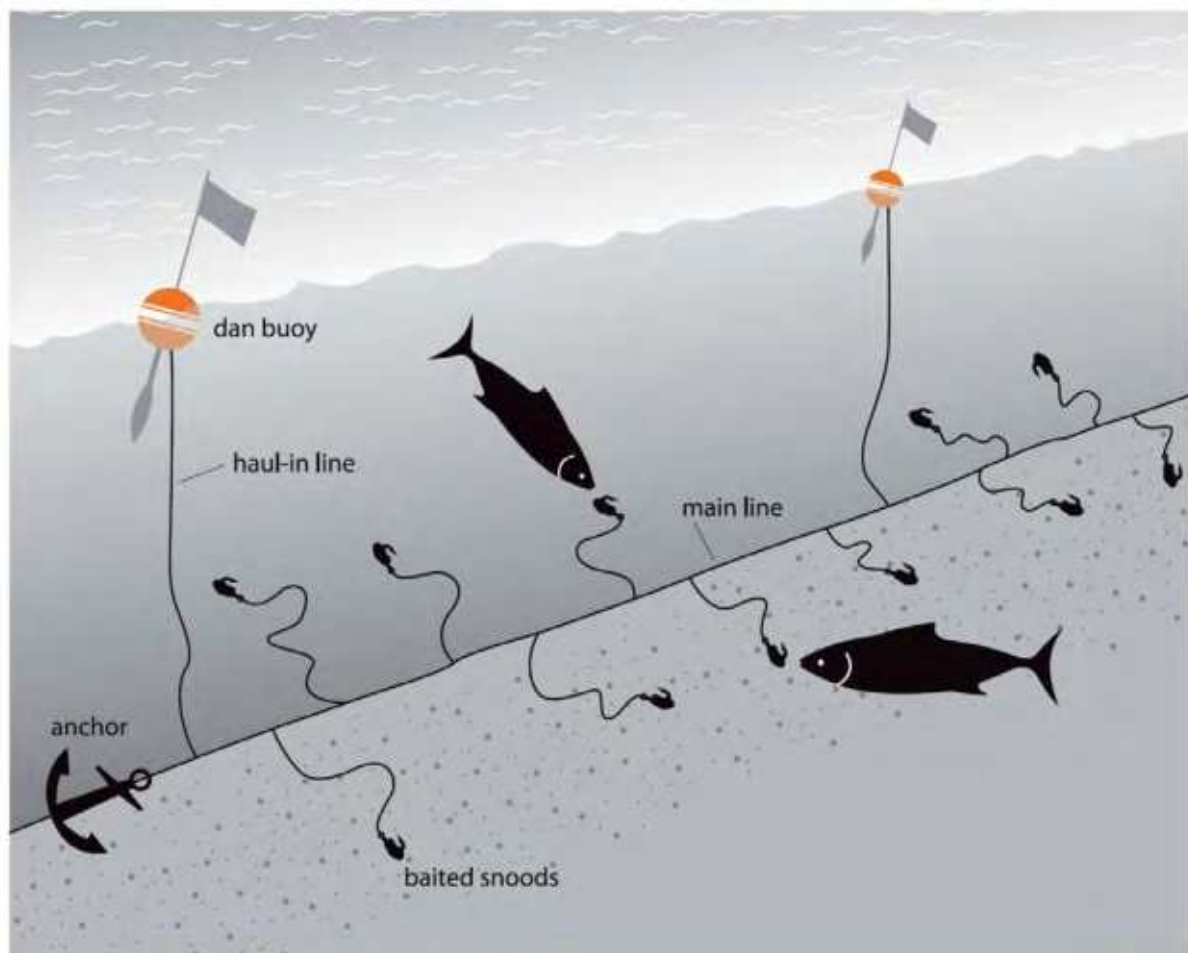
Droplines are used mainly on the continental slope off south-eastern Australia to target Blue-Eye Trevalla, Striped Trumpeter and Hapuku, although Gemfish, sharks and Pink Ling are also taken. Off southern Western Australia, droplines are used on the continental shelf to target Snapper and shark species. In the Northern Territory, tropical snappers and emperors are targeted by droplining in waters more than 80 m deep.



A dropline

Droplines consist of a *mainline* of rope, wire or nylon that is anchored vertically in the water with a weight on the bottom and floats attached at the surface. Short lengths of twine or nylon called *snoods* or *traces* have a clip attached to one end and a hook on the other. When being set for fishing, the desired number of prebaited snoods (usually between 10 and 100) is clipped at regular intervals along the lower section of mainline as it is fed out. Alternatively, the snoods may be permanently attached to the mainline, and are baited and lined up in order along individual shooting rails while the vessel is heading for the fishing grounds. When the weight is dropped overboard, they are pulled off the rails in turn as the line is set.

Demersal longlines (also called bottom-set longlines) are used on the continental shelf and slope all around Australia to catch a variety of species, including Blacktip Shark, Gummy Shark, emperors and Pink Ling. In Victoria, they are primarily used to target Snapper. This line differs from a dropline in that the mainline with the baited snoods attached is set along the seabed. One end of the haul-in line has a weight attached to anchor the end of the mainline, and the other has a dan buoy (a small buoy, with a flag, used to temporarily mark a position at sea) and float. The line is left to fish for up to 6 hours. Setting and hauling of longlines can be mechanised by hydraulic line setters and haulers, with snoods stored in magazines, and a baiting machine that attaches bait to the hooks as the line feeds over the vessel's stern. Such auto-longlines are used in the Commonwealth Gillnet, Hook and Trap Sector to target deepwater finfish such as Blue-eye Trevalla and Pink Ling.



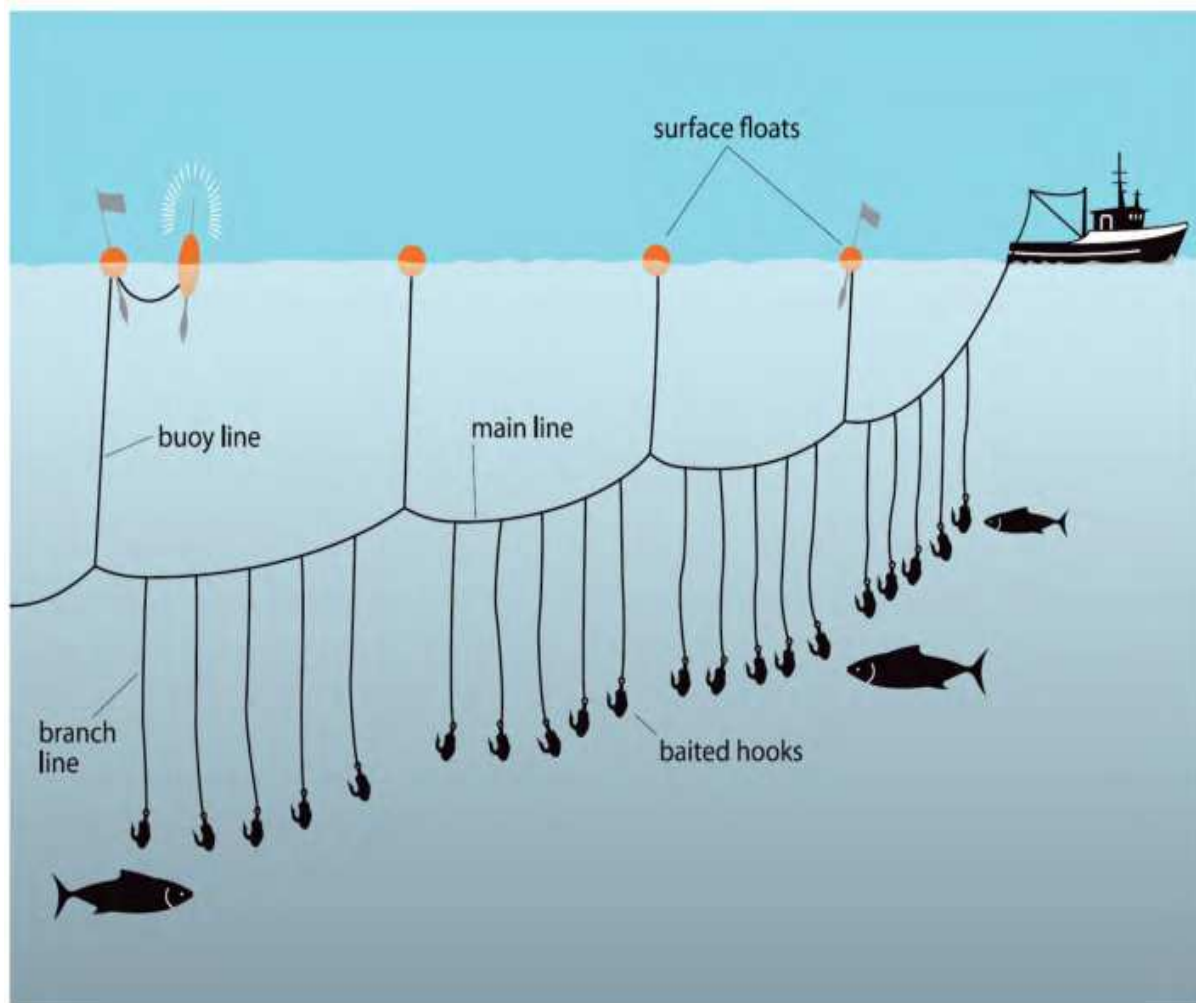
Demersal longline configuration

Trotlines are used to target Blue-eye Trevalla and Hapuku on or beyond the continental shelf off south-eastern Australia. The gear is designed to fish over rough substrates. The mainline is set horizontally, with small floats to suspend it off the seabed so that it does not snag. At set intervals along the mainline's length, weighted short droppers or trots are attached, each containing up to 20 baited hooks. The droppers are set vertically in the water and act like a series of joined short droplines.

Drifting longlines

Drifting longlines (or pelagic longlines) are used off all states of Australia, but not the Northern Territory. Species taken include Yellowfin, Bigeye and Southern Bluefin Tuna; Striped Marlin; and Swordfish.

Drifting longlines have the mainline suspended horizontally in the water at a predetermined depth by *buoy lines*, with floats spaced regularly every 200–400 m along their length. *Branch lines* 25–50 m long are attached at regular intervals along the mainline. Each branch line has a baited hook and fishes at a different depth, depending on its position and the curve of the mainline between floats.

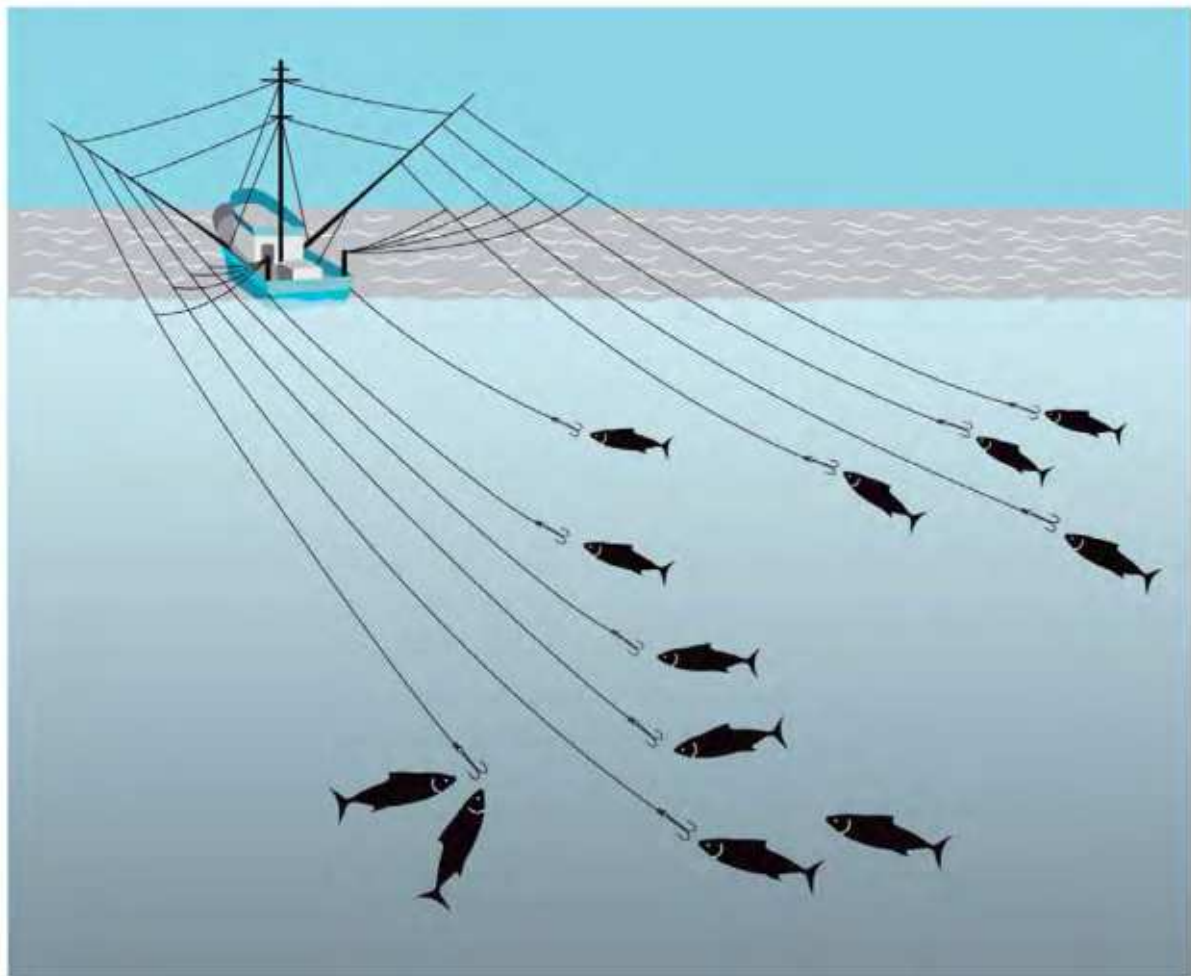


Drifting longline configuration

Drifting longlines are set while the vessel is moving ahead. The buoys and branch lines are attached as the mainline feeds out. Mainlines can range from 10 km to 100 km in length, and can carry from 200 to 2000 hooks. The mainline takes 2–6 hours to set, while hauling takes approximately 4–12 hours.

Trolling

Trolling is used Australia-wide to target species such as Spanish Mackerel, Yellowtail Kingfish and several tuna species. Trolling is a simple method of fishing in which lines with baits or lures are dragged behind a vessel as it moves along at a speed of 2–10 knots. Most commercial operations use lines rigidly mounted to the stern of the vessel or off outriggers or booms, and troll 3–18 lines at once. A variety of lines, rig designs, and lures or baits are used for trolling. In New South Wales, *leadlines* (lines with lead weights attached every 30 cm) are used to troll deeply for Yellowtail Kingfish. *Bowden cable* (galvanised cable of 1–1.5 mm diameter) is used to troll for Spanish Mackerel in Queensland.



Trolling

Traps and pots

Traps and pots are enclosures or devices that fish, crustaceans or molluscs enter voluntarily, or are entangled in, but from which they are prevented from escaping in some way. Animals are enticed into the enclosure either by bait or because the apparatus appears to provide a refuge.

Most traps and pots are set on the seabed or riverbed with a haul-in line, surface float or dan buoy to mark their position. They can have one or more entrances or openings on the top or sides, depending on the target species. A line hauler is often used to pull traps and pots for checking and rebaiting.

Fish traps

Fish traps can be set in water depths ranging from 2 m to hundreds of metres. They are made in a variety of shapes and sizes, depending on the target species. Most baited traps are set on the seabed, with at least one entrance facing down-current. The traps are left to fish for around 20 minutes to 24 hours.

Rectangular traps with a frame covered in light wire mesh are used in New South Wales to target Snapper, bream and morwong. In South Australia, rectangular traps with a steel frame covered in wire mesh are used to target Ocean Jacket. Both trap designs may have one or more tapered oval entrances located on the side, towards the top. Rectangular metal traps with tapered entrances on their sides (towards the base) are used in the Northern Territory to target demersal snappers. The weight of these traps ensures that they fish on the seabed. Fish traps in Western Australia are used to target tropical demersal reef fish such as snappers, emperors and groupers. They are either square or rectangular, with one side of the trap leading into a funnel-shaped, tapered, vertical slit entrance.

Rock lobster and crayfish traps and pots

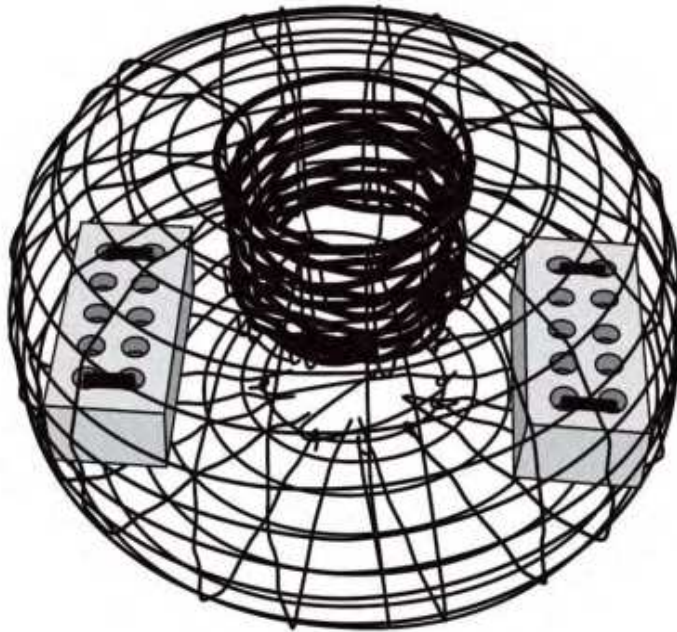
Rock lobster pots are set in rocky or weedy areas for periods of 6 hours to several days. The methods of rigging, setting and hauling are similar to those used for fish traps. Rock lobster pots are generally smaller than fish traps and have one of several designs.

Batten pots are used mainly for Western Rock Lobster. The pots are rectangular, with tapered sides and a single entrance at the top. They are constructed with a steel base with wooden slats (battens) on the sides and top. The traps are baited. Undersized rock lobsters that enter the trap can escape through the escape gaps near the base of the pot.



Batten pots

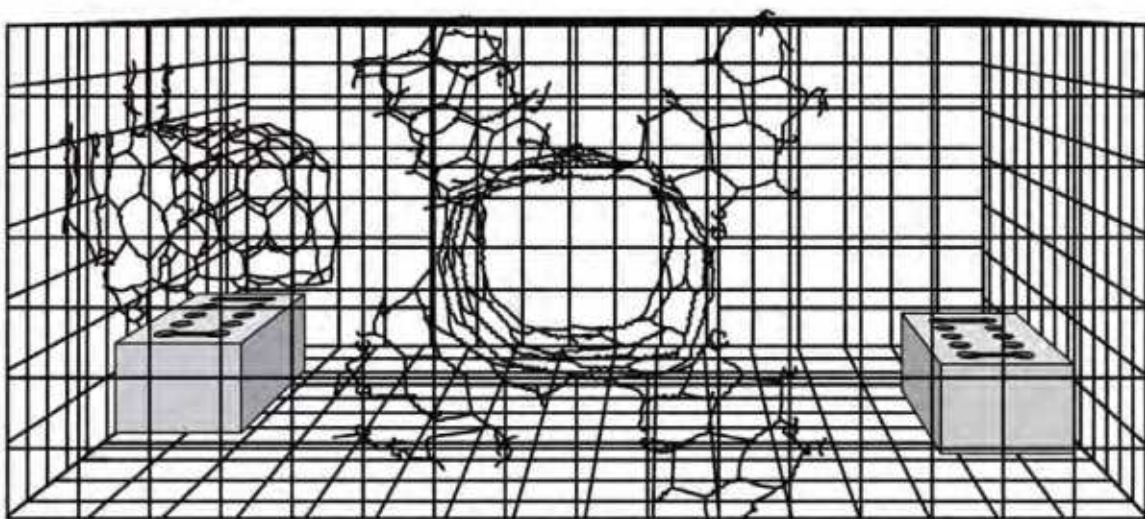
Beehive pots are used to target rock lobsters in southern Australia. They are dome shaped, constructed of a wire frame over which wire or cane is woven. There is a single entrance at the top, which is usually cane lined. Across much of the fishery, escape gaps are installed near the base of the pot to release undersized rock lobsters and bycatch.



A beehive pot (Leland et al. 2012)

Steel pots with an entrance at the top (as for beehive pots) tend to be used for Southern Rock Lobster fishing in deeper water. They can be rectangular or round, and are made from steel covered in synthetic mesh.

Rectangular traps, which are used in waters off New South Wales to target Eastern Rock Lobster, are larger and of a different design from those used for Southern Rock Lobster. They are smaller than rectangular fish traps, and have side entrances.



A rectangular rocklobster trap (Leland et al. 2012)

Crab traps and pots

There are many different shapes and sizes of crab traps and pots; they are generally of a similar size to rock lobster pots. They are baited and left to fish for several hours to several days. Crab traps are rigged, set and hauled in a similar manner to fish traps, and are retrieved either manually or by line hauler, depending on their size, configuration and deployment depth. Escape gaps are used in some crab fisheries to enable undersized crabs to exit the traps.

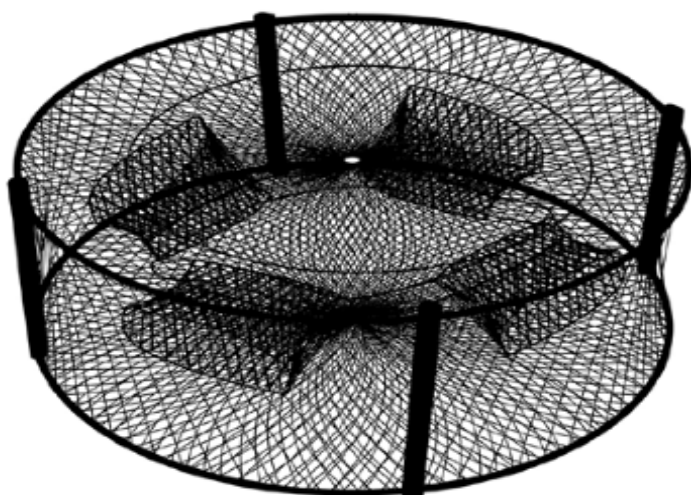
Mud Crab traps come in two main designs: rigid and collapsible. Rigid traps are formed from rectangular or hexagonal galvanised wire mesh, whereas collapsible traps consist of a steel frame covered with polyethylene mesh. Rigid traps are generally rectangular, and collapsible traps are rectangular or circular. All Mud Crab traps have at least one pair of opposing, horizontally tapered, side-entry funnels; circular traps may have two pairs, perpendicular to each other. Mud Crab traps are sometimes used to target Blue Swimmer Crabs where they coexist with Mud Crabs.

Blue Swimmer Crab traps are netted enclosures comprising two rings (usually about 1 m in diameter) separated from one another by three or four posts, or through the use of a positively buoyant upper ring and a weighted lower ring. The waist of the trap is constricted, such that the trap resembles an hourglass. Both the diameter and the height of the trap can vary substantially within or between fisheries. Blue Swimmer Crab traps are usually collapsible and may have one, two or three pairs of opposing side-entry funnels.

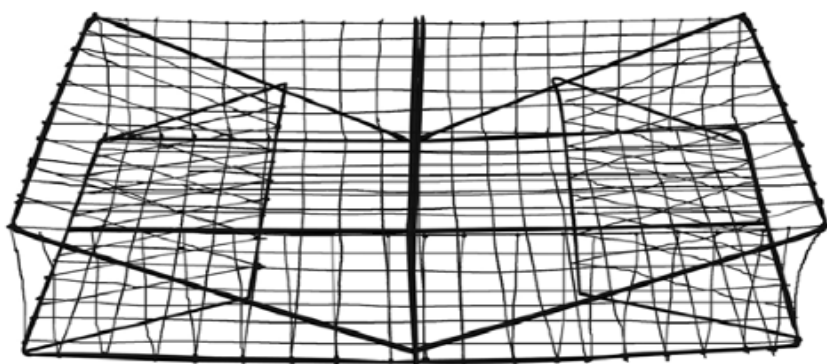


Blue Swimmer Crab traps

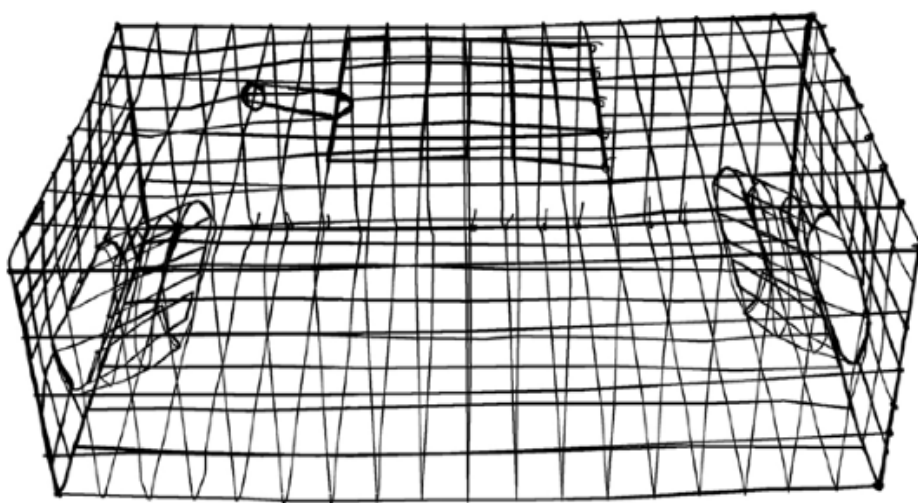
Giant Crab traps are similar to the steel pots used for rock lobster, with a top entrance. They are heavily weighted to prevent them being dragged by current movement on the *buoylines*.



Mud Crab trap—circular collapsible (Butcher et al. 2012)



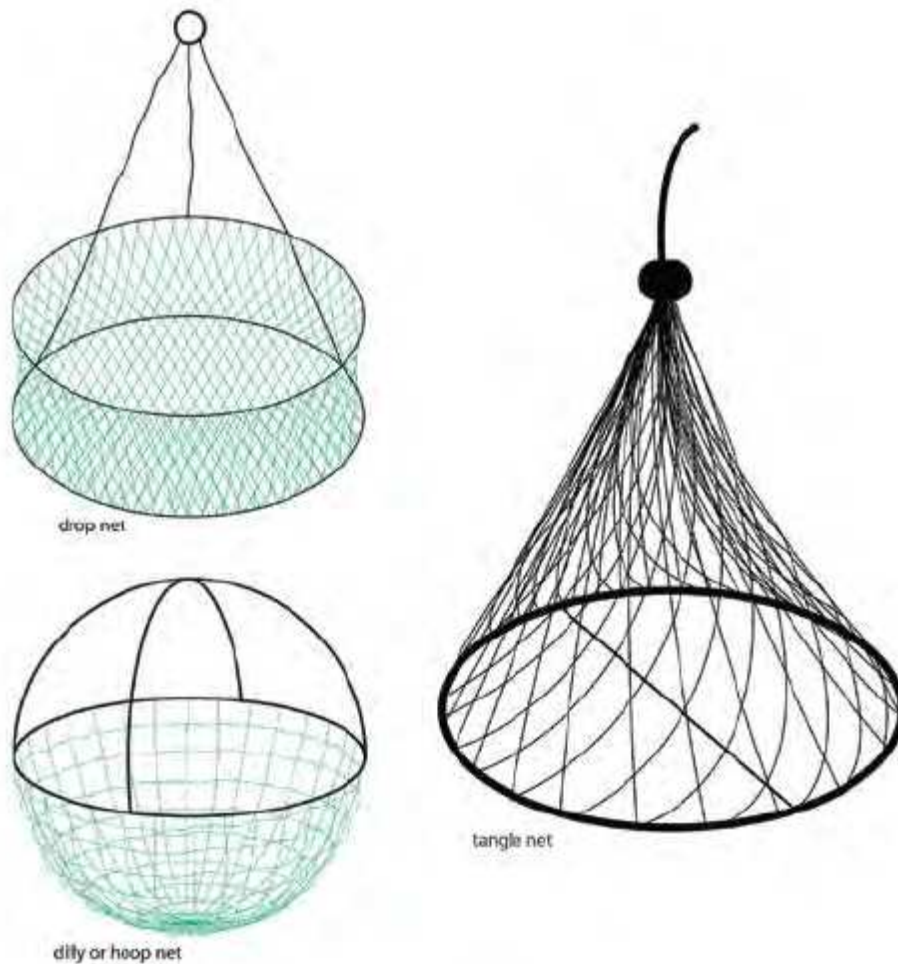
Mud Crab trap—rectangular collapsible (Butcher et al. 2012)



Mud Crab trap—rigid rectangular (Butcher et al. 2012)

Crustacean dillies, lift nets and tangle nets

Dillies (also known as lift nets and hoop nets) are generally configured as a steel hoop with a shallow bag and some bait above. Dillies are left on the sea floor for a matter of hours, and then lifted by bridles attached to the hoop in such a way that the frame remains horizontal and the catch is contained in the bag. Drop nets are of a similar configuration to dillies, but include an additional steel hoop connected to the original hoop by a collapsible mesh wall.



A drop net, dilly (hoop net) and tangle net (inverted dilly or witches hat net). Tangle net image sourced from Butcher et al. (2012)

Tangle nets (also known as inverted dillies and witches hats) have a similar design to dillies but use fine monofilament mesh inverted above the base ring with a small net float. Bait is secured to the base ring inside the mesh cone, and crustaceans become entangled in the mesh while attempting to reach the bait. Tangle nets have been prohibited in several jurisdictions to ensure that undersized crabs can be released without damage and to minimise bycatch of turtles. They are still commonly used in New South Wales.

Hawaiian-style flat tangle nets (also known as Spanner Crab nets or flat snares) comprise a square or circular steel frame across which a layer of multifilament mesh is tightly stretched, and bait is positioned centrally. These nets may be deployed individually or as part of a demersal line attached to a floatline for periods of 30 minutes to several hours.

Octopus traps or pots

Octopus traps or pots are, or have been, used commercially in central and southern Western Australia, South Australia and Tasmania. Octopus pots are made of plastic, pottery or PVC tubing, weighted with concrete, and typically have a volume of 4 litres. Octopus enter the pots seeking safe refuges.

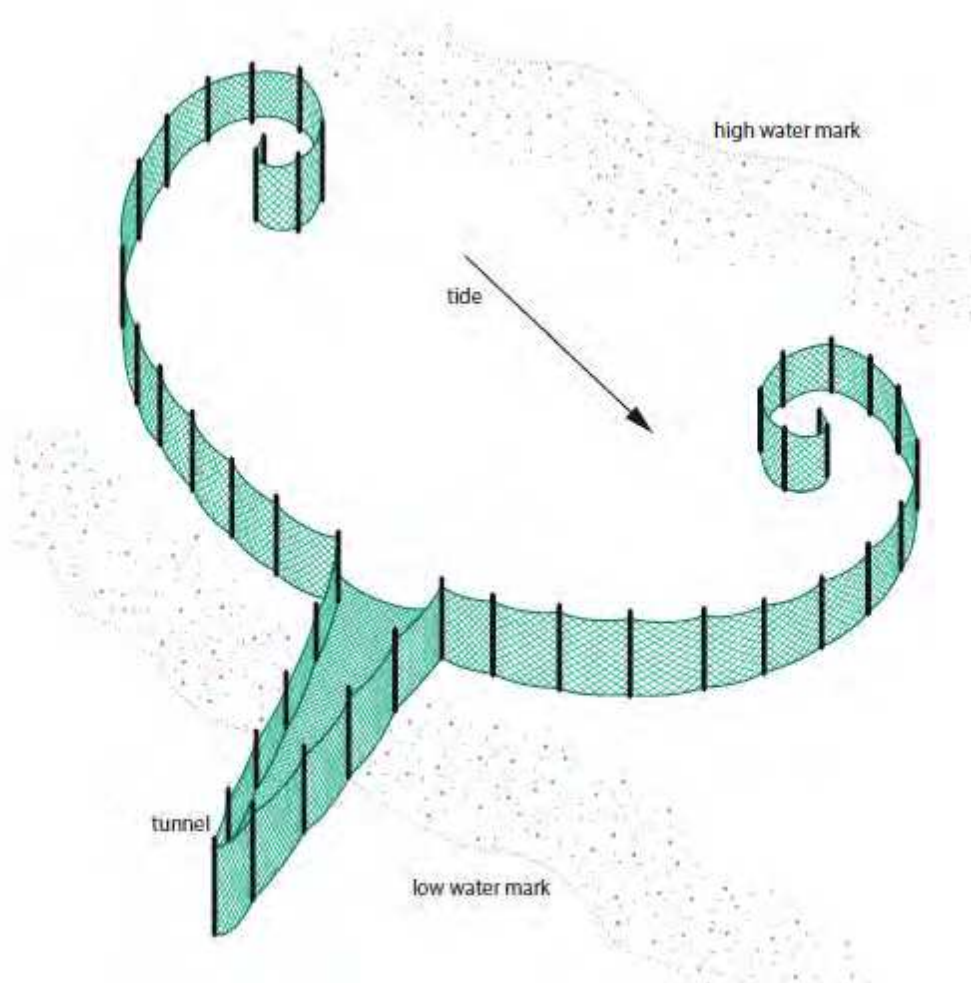
Pots are clipped along a demersal mainline at regular intervals, with up to 500 pots set on a single line. The mainline is weighted or anchored at both ends, with a haul-in line and buoy attached to each weight or anchor. The pots are left to fish for approximately 7–45 days, allowing the octopus to use them as a home. Pots are weighted to minimise movement of the gear in exposed waters.

Fish nets used as traps

Nets or netting material are used in many configurations to trap fish species.

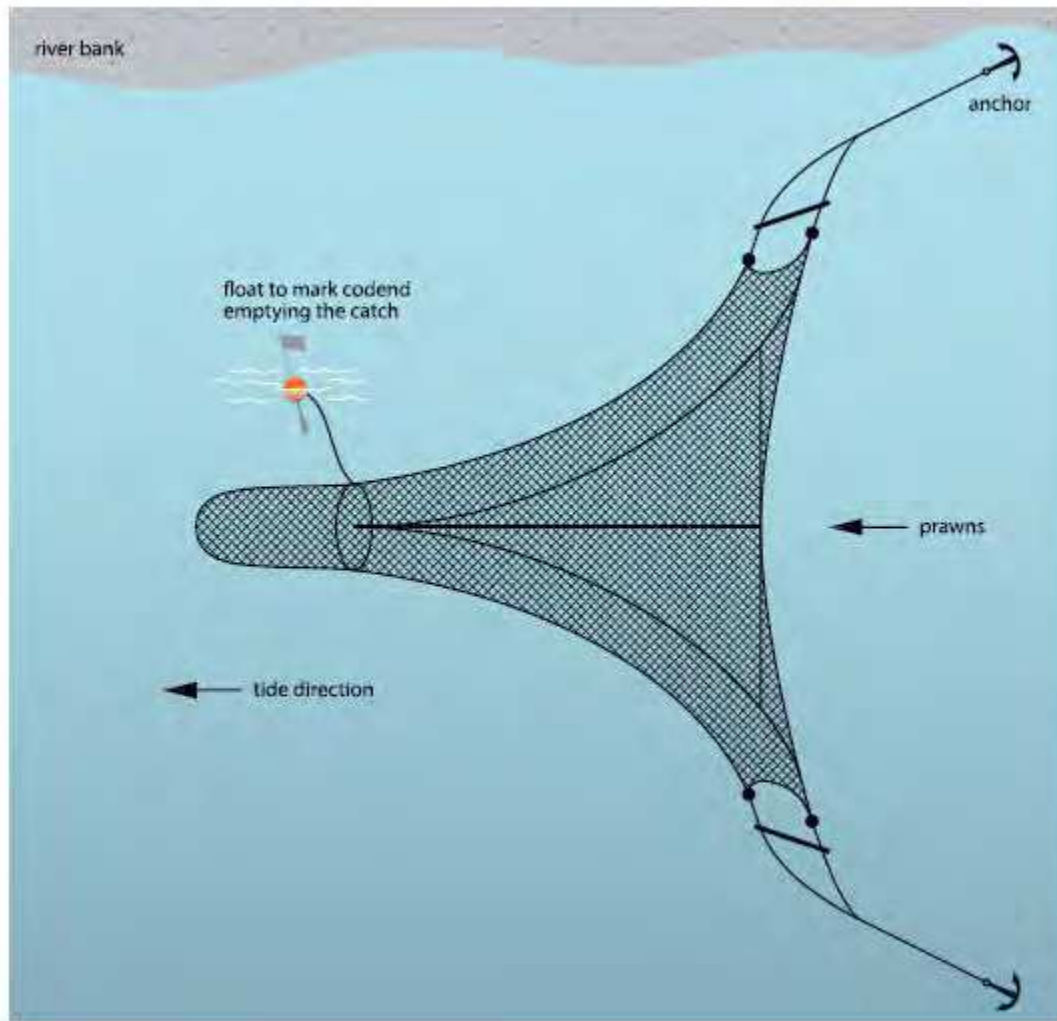
Lift nets (also called hoop nets) are used in southern Western Australia and (rarely) in Victoria to catch Australian Sardines and Australian Herring. The net resembles a large dilly with a weight in the end, forming a long, tapered bag. The net is set off wharfs or from small vessels. It can be used by night with a light, or by day with berley to attract fish. The net is hauled vertically, trapping the aggregation of fish.

Tunnel nets are used along the coast or in estuaries in southern Queensland to target many species, including mullet, Tailor, flathead and Luderick. The net is constructed of two long (up to a combined length of 1700 m) wings and a central pocket or 'tunnel'. An area in which fish concentrate, or a school of fish, is located at high tide, and the net is staked in position to form a large arrow shape, with the wing ends circling inwards to lead escaping fish back into the net. The net relies on fish encountering the net as they move with the receding tide. The fish become concentrated in the tunnel, which remains in the water at low tide. The tunnel section is finally lifted on board a dinghy and emptied.



A tunnel net

Stow nets (also called set pocket nets, pocket nets, stripe nets or stake nets) are used in estuaries and rivers of southern Queensland and New South Wales to target School Prawns and Bay Prawns. The gear resembles a small mesh prawn trawl and can be set in two ways. The first has the net staked by the wing ends across the current, using the current to open the net and wash the prawns into it. The second has the net set into the current, with stakes along the net to hold it open. The net is set close to the shore and catches the prawns as they move down the river into the incoming tide.



A stow net

Trap nets are used in southern Western Australia to target Australian Sardines and Australian Herring. The net may be a long, straight panel, or may include a pocket or bag at its inshore end. Trap nets are set in a configuration that resembles a '6' or 'G', and rely on the target species' natural circling behaviour to remain in the net. They are set during the migration period of the target species. Trap nets are set in the afternoon and are left to fish all night, with hauling occurring after dawn.

Dredges

Dredges (toothed mud dredges) are used extensively in waters off Victoria and Tasmania, including Bass Strait, to take Commercial Scallop. The Australian-designed scallop dredge consists of a heavy steel frame covered with steel mesh on all sides, except the front (that is, the towed side). A toothed bar mounted across the lower front of the dredge helps to 'dig' the scallops out of the substrate. The weight of the dredge keeps it on the seabed as it is towed. As the dredge is dragged across the seabed, the scallops or mussels in its path enter the dredge and are retained by the mesh. A drag can last for 10–60 minutes, after which the dredge is winched up to the back of the vessel. The dredge enters a tipper device on the back of the vessel, and the contents are tipped onto a sorting table.

Diving

Diving as a method of fishing is carried out in all states of Australia. Species targeted include abalone, Tropical Rock Lobster, Pearl Oyster, Sea Urchins and occasionally Commercial Scallop. The three styles of diving used in Australia are *snorkelling* (or free-diving), *scuba* (self-contained underwater breathing apparatus) *diving* and *hookah* diving (using surface-supplied air).

The five main gear components used in snorkelling or free-diving are a *face mask*, *flippers* or *fins*, a *snorkel*, a *weight belt* and a *wetsuit*. When free-diving, the diver's air supply is limited by lung capacity, and so snorkelling is a shallow-water activity. Scuba divers carry air tanks, in addition to the basic snorkelling gear, which enable them to stay under water longer and to work in deeper waters. Divers are still restricted by the amount of air that can be stored in the tank; if long periods under the water are required, hookah gear is used. Hookah divers are supplied with air via an *air line* from a compressor in a boat.

Divers in different fisheries also use several hand-held implements to aid in collection. Abalone divers use a chisel-like tool known as an *abalone iron* to remove the abalone from the rocks, and a *netting bag* to hold the abalone collected. Divers collecting Blue Mussel scrape them off pylons and rocks with a knife and place them in a bag. Divers collecting Tropical Rock Lobster use hand-held implements such as snares, nets or spears to catch the lobsters. Divers collecting Pearl Oyster, Sea Urchins and Commercial Scallop collect them by hand and place them in a bag similar to that used by abalone divers.



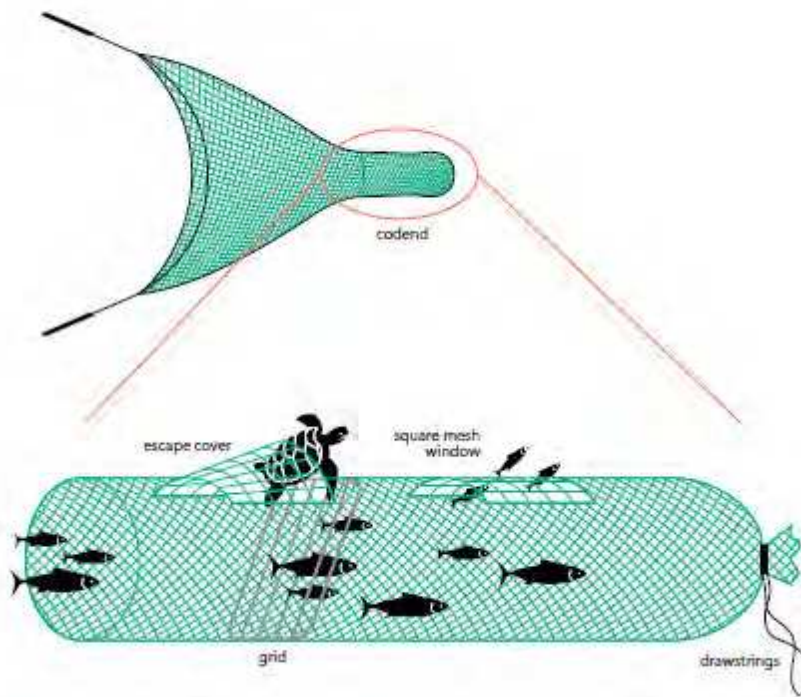
Hand-held implements

Hand-held implements, such as spears, are used commercially to catch a few species of crustaceans and fish, although they are mainly used by recreational fishers. *Hooks* are used in Western Australia and the Northern Territory to catch Mud Crab in mangrove areas, but are prohibited in other states. The hooks are made from a small-diameter, round, steel bar, with one end bent into a right-angle hook, which is hooked behind the crab to drag it out of its hole.

Bycatch reduction devices

A number of bycatch reduction devices have been implemented in Australian fisheries to allow nontarget species and other marine animals to escape from fishing gear without being brought on board. The following examples are only a few of the many devices being used across Australian fisheries.

Turtle excluder devices are compulsory in all Australian tropical prawn fisheries as an escape hatch for turtles and other species, such as sharks and rays; they also help to remove unwanted debris. If turtles cannot escape from a trawl net, they cannot reach the surface to breathe and may drown. Turtle excluder devices are made of a metal grid across the codend of the net, which forces turtles and other large objects out of the net while allowing prawns and other target species to be captured.



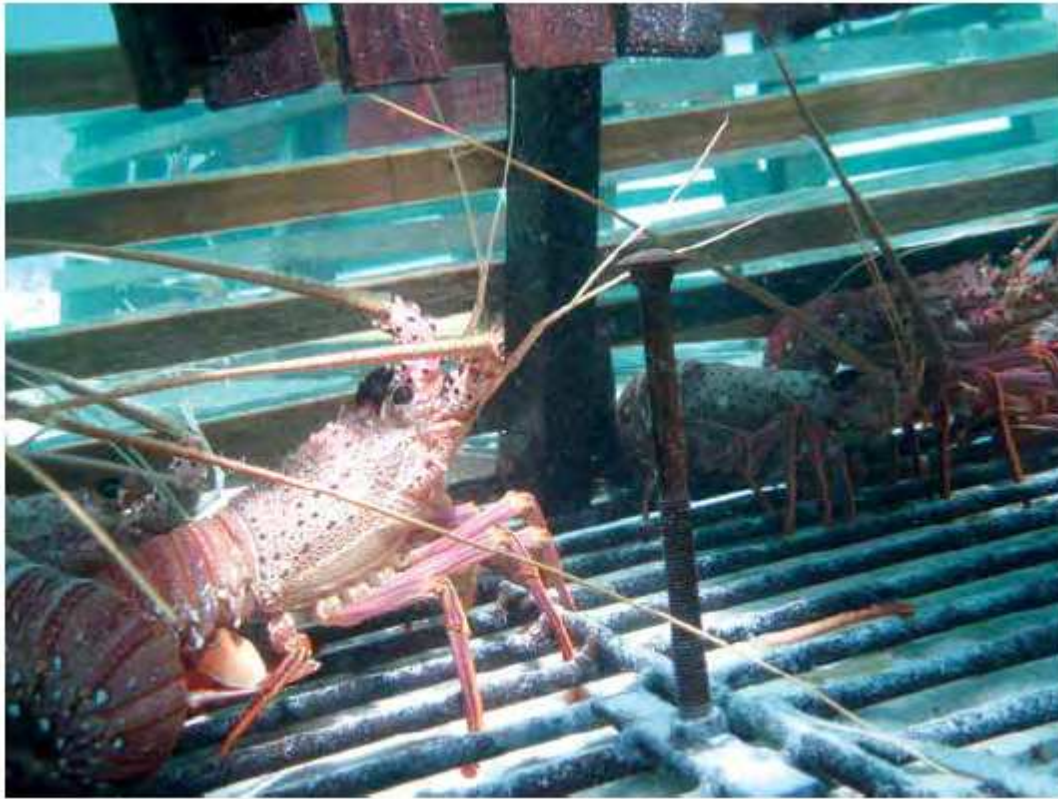
Typical design of a turtle excluder device in a trawl net



Turtle excluder device

Seal excluder devices are very similar to turtle excluder devices, but are designed for use by seals instead of turtles. They are used in the southern demersal trawl fisheries, where seals are more likely to be encountered.

Sea lion excluder devices are used in rock lobster fisheries to prevent sea lions entering and becoming stuck in traps. They typically consist of a steel bolt in the middle of the neck (opening) of the trap, which blocks access by sea lions but does not inhibit lobsters entering the pot.

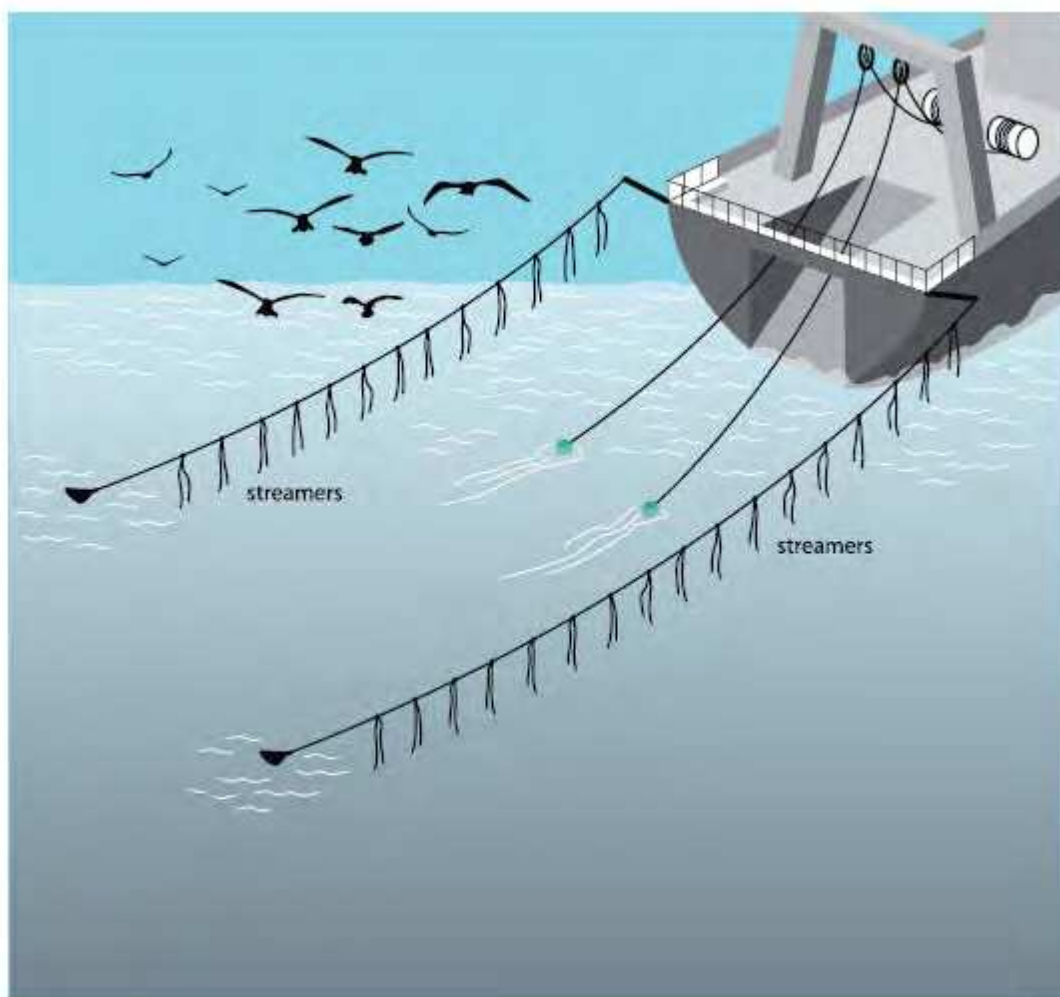


A rock lobster pot with a sea lion excluder device installed

Escape gaps are installed in traps and pots used in Southern Rock Lobster and Giant Crab fisheries to release bycatch during hauling.

Square-mesh panels consist of a panel of square mesh within the trawl net that provides a passage for nontarget or smaller fish to escape before they are caught in the codend. Often the whole codend is constructed from square-mesh netting, hung to maintain open meshes when the codend fills with catch. The construction of the 'square mesh' means that the meshes do not close up under pressure, as observed in traditional net constructions.

Tori lines (also called streamer lines) are bird-scaring devices towed behind the vessel. They are usually attached from a high point at the stern and consist of a backbone from which streamers hang down at regular intervals².



Tori lines

Underwater setting chutes allow hooks to be deployed below the sea surface, and therefore out of the reach and sight of foraging seabirds. This has traditionally been achieved by setting through a chute attached to the stern of a vessel that opens 1–2 metres below the surface.

Line weighting is used in demersal longline fisheries to deliver hooks to the target fishing depth as efficiently as possible, minimising the time that the hooks are within sight of seabirds.

Electronic monitoring systems are a form of fisheries surveillance in which equipment that is installed on fishing vessels provides information about the vessels' position and activity. More recent technology uses global positioning system (GPS) sensors and cameras to record and store video data of fishing activity. In Australia, video data are being used to observe interactions with threatened, endangered and protected species, such as seals, sea lions and dolphins. Observations made from the data have seen management changes introduced into a number of fisheries, which offer further protection for these species.

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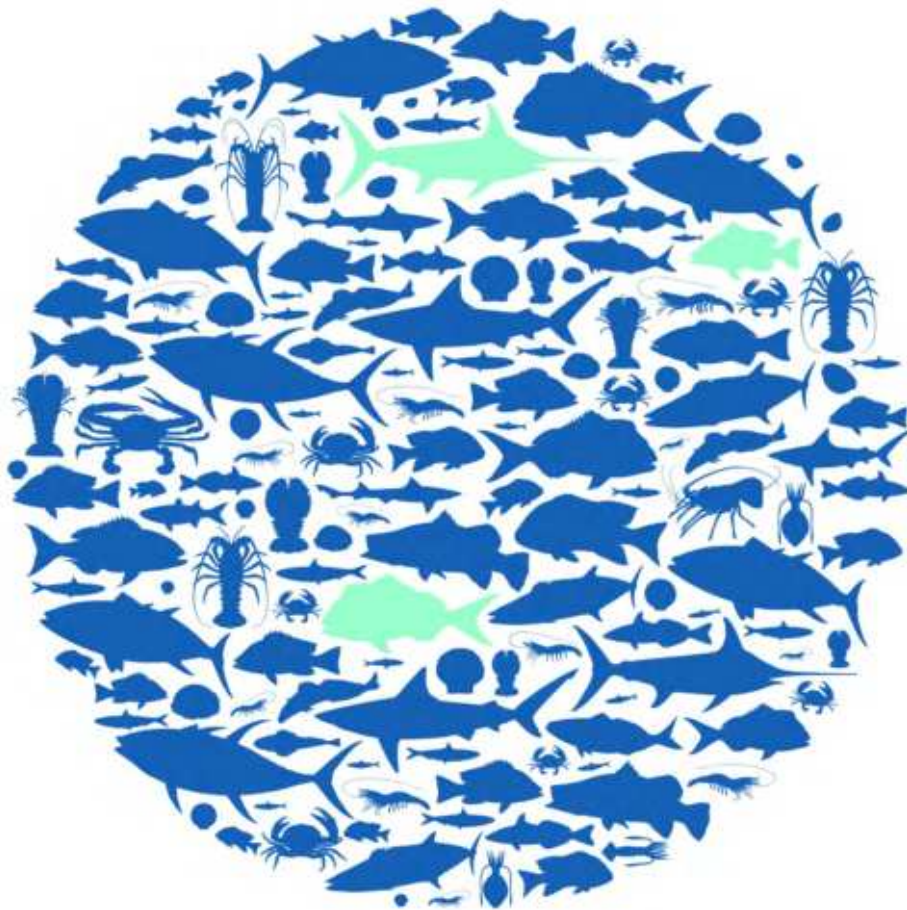
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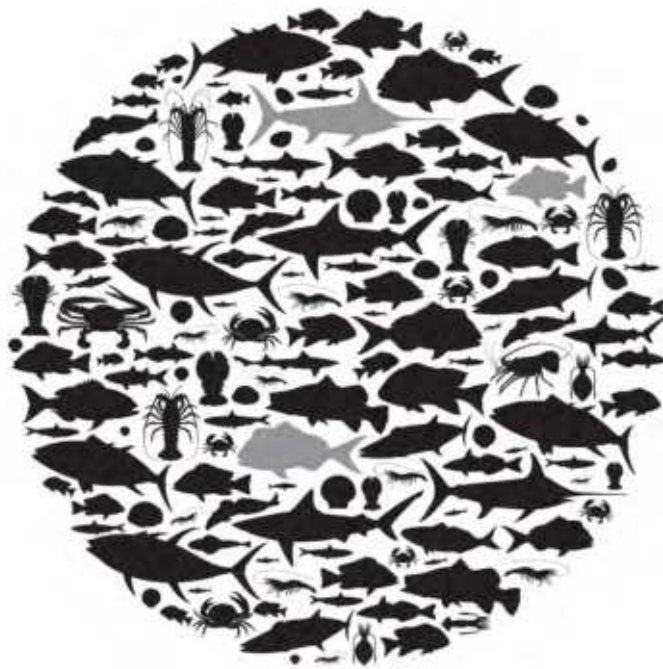
Line drawing: Allison Mortlock, Angellink 2012.



Molluscs



Molluscs: *Abalone*



1. Blacklip Abalone *Haliotis rubra*

Craig Mundy^a, Stephen Mayfield^b, Harry Gorfine^c and Geoffrey Liggins^d



Table 1: Stock status determination for Blacklip Abalone

Jurisdiction	South Australia			Victoria		
Stock	SAWZF	SACZF	SASZF	VWZF	VCZF	VEZF
Stock status	↓	↓				↓
	Transitional–depleting	Transitional–depleting	Sustainable	Overfished	Overfished	Transitional–depleting
Indicators	Catch, CPUE	Catch, CPUE	Catch, CPUE	Catch, CPUE	Catch, CPUE	Catch, CPUE

CPUE = catch per unit effort; SACZF = South Australian Central Zone Fishery; SASZF = South Australian Southern Zone Fishery; SAWZF = South Australian Western Zone Fishery; VCZF = Victorian Central Zone Fishery; VEZF = Victorian Eastern Zone Fishery; VWZF = Victorian Western Zone Fishery

Table 1 continued

Jurisdiction	Tasmania					New South Wales
Stock	TWZF	TCWZF	TNZF	TBSZF	TEZF	NSWAF
Stock status	↓	↓	↓		↑	↑
	Transitional–depleting	Transitional–depleting	Transitional–depleting	Sustainable	Transitional–recovering	Transitional–recovering
Indicators	Catch, CPUE	Catch, CPUE	Catch, CPUE	Catch, CPUE	Catch, CPUE	Catch, CPUE, mean weight

CPUE = catch per unit effort (kg/hr); NSWAF = New South Wales Abalone Fishery; TBSZF = Tasmanian Bass Strait Zone Fishery; TCWZF = Tasmanian Central Western Zone Fishery; TEZF = Tasmanian Eastern Zone Fishery; TNZF = Tasmanian Northern Zone Fishery; TWZF = Tasmanian Western Zone Fishery

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Stock structure

Empirical field studies¹ and molecular techniques^{2,3} strongly suggest that Blacklip Abalone (*Haliotis rubra*) fisheries comprise a large number of small, independent populations. Each biological stock may extend over only a few hundred metres, and each Blacklip Abalone fishery is likely to consist of an indeterminate number of small biological stocks (populations), which may number in the thousands for a single fishery management unit. Given the large number of biological stocks, it is not practical to assess each stock separately. Assessments of stock status in this chapter are provided at the management unit level (that is, for each spatial quota management area).

Stock status

None of the jurisdictions currently have a harvest strategy informed by modelled biomass with associated performance measures, reference points for those measures, and explicit decision rules prescribing management responses. Victoria did have such performance measures prescribed in its 2002 fishery management plan⁴, and these are still used in assessing two of its three stock management units.

All states rely on empirical performance measures, specifically catch, catch per unit effort (CPUE)—as kilograms (kg) of abalone meat harvested per hour—and commercial catch size structure. The annual catch in Blacklip Abalone fisheries is generally equivalent to the total allowable commercial catch (TACC), with negligible overcatch or undercatch of the TACC. In some jurisdictions, additional fishery-independent data are available from underwater research surveys; in Victoria this is extensive, encompassing 204 fixed monitoring stations spanning 23 years, and supports model-based analyses, but it is more limited in other states.

Undertaking assessment of abalone stock status is complicated by several factors, including:

- the high number of biological stocks
- changes to management unit boundaries and size limits
- absence of, and difficulty in determining, an empirical performance measure and reference point below which the fishery would be defined as recruitment overfished
- changes in fishing power, which impede comparisons of current and historical CPUE
- the multitude of factors that affect the effort component of CPUE
- the degree to which CPUE reflects abalone abundance.

This means that the assessments of Blacklip Abalone in this chapter were necessarily based on a weight-of-evidence approach, which involved careful cross-jurisdictional consideration and interpretation of information for each management unit.

The harvest strategy in the *Management plan for the South Australian commercial abalone fishery*⁵ includes a catch-weighted determination of stock status for the fishing zone. However, the harvest strategy does not identify a performance indicator and reference point below which the fishery would be defined as overfished. In addition, several weaknesses in the harvest strategy result in more optimistic assessments of stock status than those from more traditional weight-of-evidence methods^{6–8}. Consequently, in this assessment, commercial catch rates (CPUE) are used as the index of relative Blacklip Abalone abundance. This measure can, however, provide a more optimistic index of relative abundance than measures from fishery-independent surveys, because catch rates in dive fisheries can be hyperstable^{9,10}. Decreases in CPUE in abalone fisheries are considered to be a reliable indicator of decline in abalone abundance during periods when management arrangements remain unchanged, but can underestimate the magnitude of the reduction¹¹.

Data sources available in Victoria for this assessment included fishery-dependent data (commercial catch and effort, and shell length frequency reported by divers) and fishery-independent data (abundance of adults, sub-adults and juveniles, together with shell size frequency across all size classes, acquired during population surveys). In the Victorian Central and Eastern Zone management units, assessments were primarily based on outputs from a population dynamics model, and reference points for mature biomass prescribed for quota setting in the 2002 *Victorian Abalone Fishery management plan*⁴. This information was supplemented by trends in CPUE and abundance, which were analysed using two different statistical models. In the Western Zone Fishery, the effects of disease during 2006 to 2008 have precluded the ongoing use of the population

dynamics model; however, trends in CPUE, and trends in the abundance of sub-adult and adult size categories were used.

In Tasmania, stock status and TACC is determined by annual fishery assessment and a multi-workshop process (four workshops annually). Annual assessments of the Tasmanian fishery zones rely heavily on fishery-dependent data¹¹. There are no direct or derived estimates of biomass or fishing mortality, or agreed reference points or limits. Geometric mean CPUE and CPUE frequency distribution are key performance measures. Catch, catch rates, commercial catch size structure and diver observations are reviewed to form an expert opinion based on the weight of evidence. Each TACC is set at a level considered sustainable. The Tasmanian Abalone Fishery Management Plan Policy requires size limits to be established that allow two breeding seasons post-reproductive maturity. Research programs to obtain empirical data encompassing the variability in growth rates and size at reproductive maturity have been in progress since 1997, resulting in a range of legal minimum length (LML) regulations spanning 110 mm to 140 mm¹¹.

South Australian Western Zone Fishery management unit

The CPUE for Blacklip Abalone in the western zone management unit of South Australia increased steadily from 17.1 kg/hour in 1979 to more than 25.6 kg/hour in 2003, the highest level on record. Subsequently, CPUE has decreased each year. In 2013, CPUE was 20.8 kg/hour, 18 per cent below that in 2003, and the lowest since 1996. This evidence indicates, that although the biomass of this stock is not likely to be recruitment overfished, the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **transitional–depleting stock**.

South Australian Central Zone Fishery management unit

In the central zone management unit of South Australia, CPUE for Blacklip Abalone increased rapidly from 18.9 kg/hour in 1979 to 26.5 kg/hour in 1989, the highest level on record. From 1990 to 2003, CPUE was relatively stable, but variable among years. Since 2003, CPUE has decreased rapidly. In 2012 and 2013, CPUE was 18.5 and 19.2 kg/hour, respectively, the lowest since 1985. This evidence indicates that, although the biomass of this stock is not likely to be recruitment overfished, the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **transitional–depleting stock**.

South Australian Southern Zone Fishery management unit

The CPUE for Blacklip Abalone in the southern zone management unit of South Australia increased from 64 kg/hour in 1979–80 to more than 107 kg/hour in 2010–11, the highest level on record. Although CPUE has subsequently declined, in 2012–13 it was 94.6 kg/hour, remaining among the highest values on record. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished and that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Victorian Western Zone Fishery management unit

The CPUE trend for the Victorian Western Zone management unit as a whole has shown a significant decline during the period 2001 to 2013. Two change points in the trend can be identified: one in 2007 and another in 2011. The former coincides with a disease outbreak¹², when the rate of reduction in CPUE steepened significantly. The latter coincides with a shift in effort. Although the catch of 49 tonnes (t) for the 2012–13 quota year was only 15 per cent of the 280 t allocation for 2001–02¹³ the average CPUE of 54 kg/hour during 2013 was within the lower range of values observed before the impact of disease. Both these measures point to a significant decline in stock.

Trends in total abundance estimated from fishery-independent surveys indicate a high probability (greater than or equal to 0.8) that abundance on most reefs in the management unit has been depleting at an annual rate of 3–15 per cent since 2000^{14,15}. A declining trend in the abundance of sub-adults, at a rate of 10 per cent each year, was evident from 2001 to 2009, after which there was no significant change. This placed the number of future recruits to the stock in 2013 at 71 per cent below the average for 2001 to 2005. The trend in adult abalone increased by 17 per cent annually during 2002 and 2003, after which it declined at an annual

rate of 12 per cent until 2008. There was a marginally significant annual increase among the mature stock of 4 per cent from 2008 to 2013. This placed the number of future mature-sized abalone in the stock in 2013 at 31 per cent below the average for 2001 to 2005.

Decreases in the proportion of sub-adult abalone, below the LML, threaten the resilience of the stock. Negative trends in most indicators are evident on reefs that remained disease free, as well as on those that were affected by disease. Recovery cannot occur through growth alone, and will not occur during the next few years unless there is a consistent increase in the abundance of juvenile and sub-adult abalone. The above evidence indicates that the stock is likely to be recruitment overfished.

In response to concern about the level of fishing pressure, the TACC of 280 t (which had prevailed for 15 years) was reduced by 21 per cent by 2006. At the same time, size limits were increased voluntarily to protect breeding potential. Fishing pressure was adjusted following the disease outbreak in 2006. By 2008, the disease had abated, and fishing progressively resumed on disease-affected reefs from 2009, with a more conservative size limit of 135 mm. In the past couple of years, the catch on disease-free reefs was reduced to zero because of concerns that they had become depleted. Consequently, effort is more focused and, with increases in TACC (by 17 per cent in 2013), represents a risk of serial depletion^{9,10}. The stock remains depleted and has yet to show a measurable recovery at the scale of the management unit. While the current level of fishing pressure may allow the stock to recover from its recruitment overfished state, and there is some increase in spawning biomass, there is no statistically demonstrable increase in numbers of juveniles and sub-adults.

On the basis of the evidence provided above, the management unit is classified as an **overfished stock**.

Victorian Central Zone Fishery management unit

Between 2007 and 2009, populations in the Victorian central zone management unit were reduced substantially by disease in the region west of Cape Otway. Population dynamics modelling has shown that, for the remainder of this management unit, when compared with the reference biomass of 90 per cent of the biomass in 2000¹⁴, it was 80 per cent likely that biomass in 2013 had decreased by 16 per cent at Cape Otway, 26 per cent along the coastline encompassing the Mornington Peninsula and Phillip Island, and 10 per cent at those areas at Wilsons Promontory open to fishing^{15,16}. In other words, the most recent assessment for this management unit estimates that the mature biomass is 74–90 per cent of the reference biomass (2000)¹⁴. This is at or below what has been considered to be the minimum allowable biological limit for the stock before it would be considered to be recruitment overfished¹⁷.

The CPUE across the management unit declined significantly, by 33 per cent, from 2001 to 2013. The average CPUE for 2013 was 59 kg/hour, which is within the lower range of values reported between 2001 and 2005. In addition, the catch for the 2012–13 quota year was 44 per cent of the 700 t allocation for 2001–02. Both these measures point to a significant decline in stock.

Abundance of sub-adult-sized abalone declined at a rate of 16 per cent per year until 2004, followed by an annual decline of 8 per cent until 2013. This placed the number of sub-adults that will become future recruits to the stock in 2013 at 71 per cent below the average for 2001 to 2005. The abundance of larger, more mature adult abalone declined at 6 per cent per year during the decade from 2003 to 2013. This placed the number of adult abalone in the stock during 2013 at 55 per cent below the average for 2001 to 2005.

The TACC has been progressively reduced over the past 10 years from 616 t to 308 t during the 2012–13 fishing season. Despite this TACC reduction, significant declines in abundance have persisted throughout the zone, with the exception of some reefs located adjacent to the Mornington Peninsula back-beaches between Port Phillip Heads and Cape Schanck¹⁵.

Collectively, the modelled biomass, trends in abundance, and CPUE provide evidence that the central zone is recruitment overfished. Management measures are in place, but are unlikely to change the overall status of this stock in the short term. It is uncertain whether the current level of fishing pressure will allow the stock to recover from its recruitment overfished state, and measurable improvements in biomass are yet to be detected.

On the basis of the evidence provided above, the management unit is classified as an **overfished stock**.

Victorian Eastern Zone Fishery management unit

Biomass has been estimated by population dynamics modelling for the majority (75 per cent) of the Victorian eastern zone management unit. Biomass was either below the trigger reference point¹⁶ (Airport Management

Area) or marginally above, but nevertheless trending downwards, over the period 2008 to 2013 (Point Hicks to Little Rame).

Analysis of CPUE trends showed that there was a significant but gradual increase of 10 per cent until 2005, followed by a stable pattern that was neither significantly increasing nor decreasing. CPUE tends to be unresponsive to depletion in exploitable biomass until levels of stock become sufficiently low that divers are no longer able to compensate for the decrease by increasing their fishing power or concentrating their fishing effort on the areas that have yet to become depleted^{9,10}.

Trends in abundance estimated from fishery-independent surveys have also been modelled for most of the commercially productive reefs. For most areas within the management unit, it was found that abundance across all size classes has been decreasing annually at a rate of 3–9 per cent¹⁶. Sub-adult abalone abundance declined at 19 per cent annually from 2001 and 2004, after which there was no significant change. This placed the number of future recruits to the stock in 2013 at 50 per cent below the average for 2001 to 2005. In contrast, adult abalone increased at an annual rate of 15 per cent between 2001 and 2003, and then declined at 9 per cent annually until 2009, after which there was no significant change. This placed the number of adult-sized abalone in the stock in 2013 at 49 per cent below the average for 2001 to 2005.

The TACCs have been progressively reduced during the past 5 years, from 490 t to 433 t, in response to an ongoing decline in available biomass. Only some of this decline is due to overharvesting; range expansion of the Black Sea Urchin (*Centrostephanus rodgersii*) has led to the formation of extensive barrens—habitat that will not support abalone.

Collectively, the evidence suggests that the abalone biomass within this management unit is depleting. Management measures are in place, but these have not yet resulted in measurable improvements. Although the biomass of this stock is not likely to be recruitment overfished at present, the above evidence indicates that the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **transitional–depleting stock**.

Tasmanian Western Zone Fishery management unit

The Tasmanian western zone management unit has an LML of 140 mm. The Tasmanian Western Zone Fishery was split into the western and central western zones in 2007, with subsequent boundary changes in 2013. The TACC in this management unit was reduced in 2013 to 1001 t, associated with the zonal restructure and a downturn in CPUE¹¹. The TACC reduction reflects a management action to redistribute effort from the south to the underutilised north of the western zone. Spatial catch caps are set annually for four broad geographic regions within this zone, to prevent excess catch being harvested as a result of economic pressures. CPUE has declined gradually, from record highs in excess of 150 kg/hour in 2000 to less than 100 kg/hour in 2013. Accumulation of stock biomass following a period of underexploitation in the 1990s led to the high catch rates in the early 2000s. The continuous decline in CPUE over the past 14 years reflects the historically high TACCs set over the past decade. While the CPUE in 2013 is high relative to other management areas, it is continuing to decline, despite TACC reductions, and the rate of decline is increasing.

The above evidence indicates that, although the biomass in this management unit is not likely to be recruitment overfished, the stocks are likely to become recruitment overfished at the current level of fishing mortality.

On the basis of the evidence provided above, the management unit is classified as a **transitional–depleting stock**.

Tasmanian Central - western Zone Fishery management unit

The Tasmanian central western zone management unit has an LML of 132 mm. The Tasmanian Western Zone Fishery was split into the western and central western zones in 2007. The boundary between the western zone and the central western zone was moved northwards in 2013¹¹. This part of the west coast was underexploited in the mid-2000s, and spatial management measures were used to shift effort into this region. CPUE has oscillated over the past 15 years, but has declined over the past 5 years, suggesting that the biomass has decreased rapidly. Accordingly, the TACC in this management unit was reduced in 2013 to 105.1 t. CPUE has declined gradually, from around 140 kg/hour in 2008 to less than 80 kg/hour in 2013. CPUE continued to decline in 2013 despite a TACC reduction, and the rate of decline since 2010 has been sharp.

The above evidence indicates that, although the biomass in this management unit is not likely to be recruitment overfished, the stocks in the management unit are likely to become recruitment overfished at the current level of fishing mortality.

On the basis of the evidence provided above, the management unit is classified as a **transitional–depleting stock**.

Tasmanian Northern Zone Fishery management unit

The Tasmanian northern zone management unit and the Tasmanian Bass Strait fishery management unit were separated in 2003. Three different LMLs (120 mm, 127 mm and 132 mm) were in place during the reference year, reflecting the variation in growth rates within this zone. Catch and catch rates have varied between 2000 and 2013 as a function of changing market preference and adaptive management (that is, effort redistribution and change in LML). The TACC for the northern zone reached a peak of 402.5 t in 2011. Geometric mean CPUE varies across different geographic regions within the northern zone, but has fallen for the zone overall over the past 3 years, despite TACC reductions in 2012 and 2013¹¹.

The above evidence indicates that, although the biomass in this management unit is not likely to be recruitment overfished, the stocks in the management unit are likely to become recruitment overfished at the current level of fishing mortality.

On the basis of the evidence provided above, the management unit is classified as a **transitional–depleting stock**.

Tasmanian Bass Strait Zone Fishery management unit

The Tasmanian northern zone fishery was split into two zones in 2003, creating the Tasmanian northern zone fishery management unit and the Tasmanian Bass Strait fishery management unit¹¹. Two different LMLs (110 mm and 114 mm) were in place during the reference year, reflecting the variation in growth rates within this zone. Since the creation of this zone, catch and CPUE have been stable, except for 2007, when the fishery was closed because of concerns about the possible risk of transferring abalone viral ganglioneuritis (AVG) from Victoria to Tasmania. The TACC for the Bass Strait zone remains at 70 t, and the geometric mean CPUE has been stable at around 65 kg/hour¹¹.

The above evidence indicates that stocks in the Tasmanian Bass Strait zone are unlikely to be recruitment overfished and that the current level of fishing mortality is unlikely to cause these stocks to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Tasmanian Eastern Zone Fishery management unit

The Tasmanian eastern zone fishery management unit has an LML of 138 mm. Relative stock biomass in this fishery (estimated using CPUE as a proxy) has oscillated substantially since 1995, with evidence of an approximate 8-year cycle¹¹. Based on declining CPUE between 2000 and 2003, the TACC was reduced from 1190 t to 857 t in 2002, and to 770 t in 2004. Subsequent increases in CPUE and increasing median length of the commercial catch led to increases in the TACC of 5 per cent in 2008, 2009 and 2010, resulting in a TACC of 896 t by 2010. Rapid declines in CPUE in late 2010 resulted in a reduced TACC of 721 t for 2011. Further rapid decline in 2011 resulted in an additional TACC reduction to 549.5 t for 2012. In 2013, minor reductions in the TACC to 528.5 t were made to address local concerns in one subregion. In 2013, a slight increase in zonal geometric mean CPUE was observed, suggesting that the TACC reductions over the previous 3 years had achieved the objective of reducing exploitation to a level at which biomass could rebuild. However, the historically low CPUE and catch observed in 2012 suggest that biomass in this fishery is at its lowest point to date.

The above evidence indicates that biomass of the Tasmanian eastern zone fishery management unit is recruitment overfished. However, the current level of fishing pressure should allow the management unit to recover from its recruitment overfished state, and measurable improvements in biomass were detected in 2013.

On the basis of the evidence provided above, the management unit is classified as a **transitional–recovering stock**.

New South Wales management unit

The New South Wales Abalone Fishery is managed as a single management unit with a single TACC, set by an independent Total Allowable Catch Committee. Recent annual assessments have relied heavily on fishery-dependent data, including catch, CPUE and mean weight of abalone, summarised at a range of spatial scales. At present, there are no direct or derived estimates of biomass or fishing mortality.

Blacklip Abalone stocks have historically suffered from overfishing associated with serial depletion. Mortality events in the late 1990s and early 2000s, associated with infection by the *Perkinsus* parasite, further contributed to depletion of stocks from Jervis Bay to the north¹⁸. Catch rates fluctuated in the 1990s and early 2000s, with the lowest catch rate on record in 2005. The mean weight of catches at this time was close to the weight of abalone at the LML. The abundance of legal-sized abalone detected during a fishery-independent survey was low. These indicators are consistent with a stock that was, at this time, fished-down hard against the LML, was experiencing very high fishing mortality, had lost most of its age structure and resilience, and had significantly reduced breeding potential¹⁹.

Substantial reductions in the TACC, from 333 t during the 1990s through several stepwise decreases to 75 t in 2009–10, were intended to limit further depletion of the stock and facilitate stock recovery. The LML was increased from 115 mm to 117 mm across the fishery in 2008 and, subsequently, to 123 mm south of Wonboyn Lake. Consequently, since 2005, there has been a strong recovery in CPUE and mean weight of abalone in the catches in many, but not all, areas of the fishery. Improvements in these indicators have generally been greatest on the far south coast of New South Wales. Although stock rebuilding is continuing overall, it is spatially patchy. Low catches and modest increases in CPUE in the northern spatial components of the fishery suggest a slower recovery of stocks in these areas. Moreover, rebuilding is uncertain in areas of the fishery that were severely depleted by 2005 and that have not recently been fished¹⁹.

The above evidence indicates that the biomass of this stock was recruitment overfished during the 1990s and early 2000s, and that some spatial components of the fishery have not demonstrably recovered from this state. However, for the period 2006 to 2013, the indicators described above suggest a recovering stock.

Despite substantial increases in catch rates since 2005, the current TACC of 125 t is still relatively low compared with historical catches, to facilitate further rebuilding of stock. This evidence indicates that the current level of fishing pressure should allow the stock to recover from its recruitment overfished state.

On the basis of the evidence provided above, the biological stock is classified as a **transitional–recovering stock**.

Table 2: Blacklip Abalone biology^{2,11,20}

Longevity and maximum size	20–50 years; 150–220 mm SL
Maturity (50%)	~5 years; 80–130 mm SL

SL = shell length

Figure 1: Distribution of reported commercial catch of Blacklip Abalone in Australian waters, 2013 (calendar year)

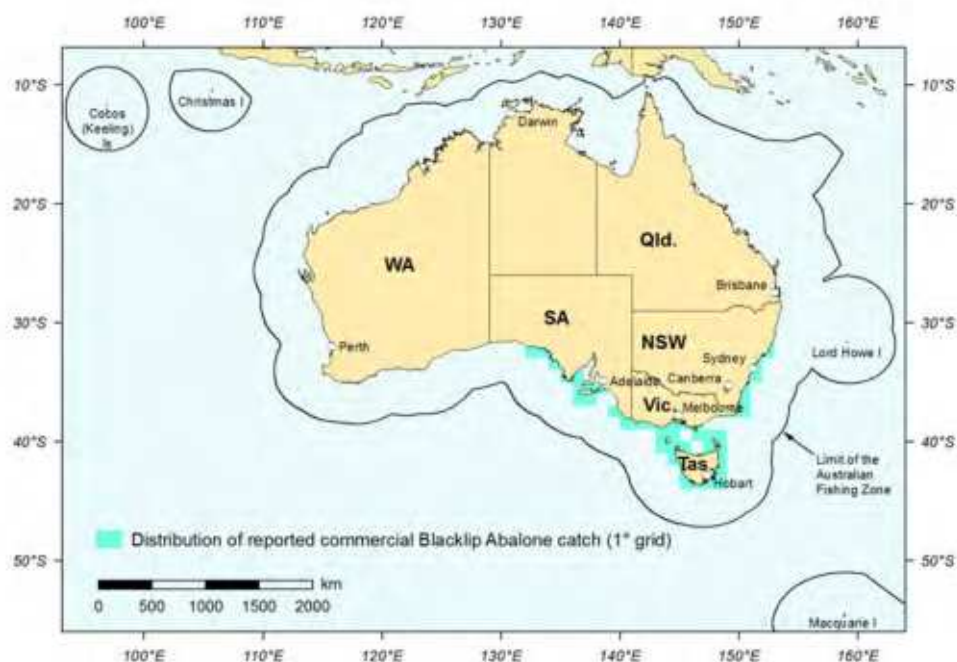


Table 3: Main features and statistics for Blacklip Abalone fisheries in Australia, 2013 (calendar year)

Jurisdiction	South Australia	Victoria	Tasmania	New South Wales
Fishing methods				
Commercial				
Diving	✓	✓	✓	✓
Recreational				
Diving	✓	✓	✓	
Free-diving		✓		✓
Indigenous				
Diving	✓	✓	✓	
Free-diving				✓

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
BLACKLIP ABALONE

Jurisdiction	South Australia	Victoria	Tasmania	New South Wales
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Size limits	✓	✓	✓	✓
Total allowable catch	✓	✓	✓	✓
Spatial closures		✓	✓	✓
Recreational				
Bag limits	✓	✓	✓	✓
Size limits	✓	✓	✓	✓
Spatial closures				✓
Indigenous				
Bag limits ^b	✓	✓	✓	✓
Size limits	✓	✓	✓	✓
Spatial closures				✓
Section 37(1)(c1), Aboriginal cultural fishing authority ^c				✓
Active vessels				
	30 in SAWZF 5 in SACZF 6 in SASZF	7 in VWZF 22 in VCZF 17 in VEZF	103 in TWZF 72 in TCWZF 76 in TNZF 58 in TBSZF 99 in TEZF	31 in NSWAF
Catch				
Commercial	25 t in SAWZF 135 t in SACZF 267 t in SASZF	52 t in VWZF 264 t in VCZF 427 t in VEZF	1001 t in TWZF 101.5 t in TCWZF 308 t in TNZF 70 t in TBSZF 528.5 t in TEZF	113 t in NSWAF
Recreational	Unknown	Unknown	Unknown	Unknown
Indigenous	Unknown	Unknown	Unknown	Unknown

Jurisdiction	South Australia	Victoria	Tasmania	New South Wales
Markets				
Domestic	✓	✓	✓	✓
Export	✓	✓	✓	✓

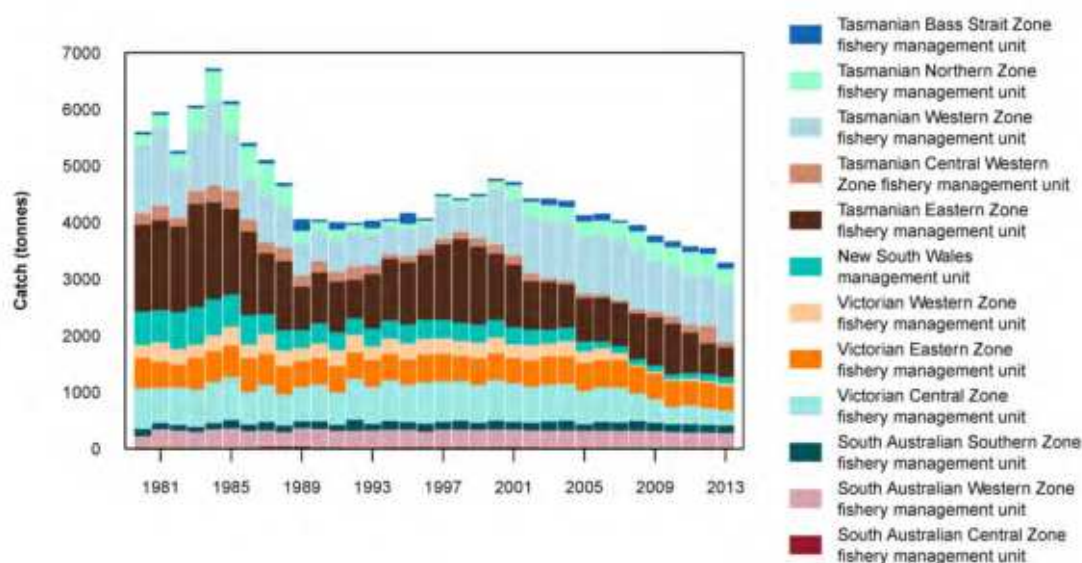
NSWAF = New South Wales Abalone Fishery; SACZF = South Australian Central Zone Fishery; SASZF = South Australian Southern Zone Fishery; SAWZF = South Australian Western Zone Fishery; TBSZF = Tasmanian Bass Strait Zone Fishery; TCWZF = Tasmanian Central Western Zone Fishery; TEZF = Tasmanian Eastern Zone Fishery; TNZF = Tasmanian Northern Zone Fishery; TWZF = Tasmanian Western Zone Fishery; VCZF = Victorian Central Zone Fishery; VEZF = Victorian Eastern Zone Fishery; VWZF = Victorian Western Zone Fishery

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (for example, different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Blacklip Abalone.

b The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

c The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Blacklip Abalone in Australian waters, 1980 to 2013 (calendar years)



Effects of fishing on the marine environment

- Blacklip Abalone are hand selected by divers operating from vessels that seldom anchor. Hence the fishery has negligible direct physical impact on the environment. There is also substantial evidence that the ecosystem effects of removing abalone are minimal^{21–23}.

Environmental effects on Blacklip Abalone

- Abalone Viral Ganglioneuritis (AVG) established in the wild fishery following initial infection in two land-based abalone aquaculture farms and two offshore experimental farms adjacent to the wild fishery in 2005²⁴. AVG is highly pathogenic, resulting in estimated mortalities of 60–95 per cent in infected wild populations.

- Southward and westward strengthening of the relatively oligotrophic East Australian Current into the inshore waters in eastern Victoria and Tasmania is thought to have triggered changes in near-shore community structure over the past two decades. This is primarily through range expansion of species such as the Black Sea Urchin (*Centrostephanus rodgersii*) from New South Wales to Tasmania and Victoria, and the significant reduction in Giant Kelp (*Macrocystis porifera*) biomass^{25–27}. This has resulted in localised depletion of abalone populations and a reduction in the habitat available for abalone^{28,29}.
- Above-average warm-water events were inferred to have resulted in minor mortalities of abalone in Tasmania in February 2010 (Tasmanian Abalone Divers, personal communication), although the spatial extent and magnitude of the mortality were not quantified. These events are expected to increase under most climate change scenarios.

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2. Greenlip Abalone *Haliotis laevis*

Stephen Mayfield^a, Craig Mundy^b, Anthony Hart^c and Harry Gorfine^d



Table 1: Stock status determination for Greenlip Abalone

Jurisdiction	South Australia			Tasmania
Stock	SAWZF	SACZF	SASZF	TGAF
Stock status		↓	Negligible ^a	
	Sustainable	Transitional–depleting		Undefined
Indicators	CPUE, fishery-independent surveys	CPUE, fishery-independent surveys		Catch

CPUE = catch per unit effort; SACZF = South Australian Central Zone Fishery; SASZF = South Australian Southern Zone Fishery; SAWZF = South Australian Western Zone Fishery; TGAF = Tasmanian Greenlip Abalone Fishery

a 'Negligible' means historically low catch; no stock status. Catch from the Southern Zone Fishery biological stock in 2013 was 5.24 tonnes. In the past 10 years, the average catch from this biological stock was 5.5 tonnes.

Table 1 continued

Jurisdiction	Victoria		Western Australia	
Stock	VWZF	VCZF	WAA2F	WAA3F
Stock status				
	Overfished	Overfished	Sustainable	Sustainable
Indicators	Catch	Catch	Catch, CPUE, catch length-frequency data, fishery-independent surveys	Catch, CPUE, catch length-frequency data, fishery-independent surveys

CPUE = catch per unit effort; VCZF = Victorian Central Zone Fishery; VWZF = Victorian Western Zone Fishery; WAA2F = Western Australia Area 2 Fishery; WAA3F = Western Australia Area 3 Fishery

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Stock structure

Greenlip Abalone is distributed across southern mainland Australia and northern Tasmania. The biological stock structure of Greenlip Abalone has recently been examined^{1,2}. Genetic evidence has confirmed that Greenlip Abalone comprise numerous independent biological stocks, but at a spatially broader extent than the biological stock structure evident for Blacklip Abalone³. There are many biological stocks across Tasmania, Victoria, South Australia and Western Australia. Given the large number of biological stocks, it is not practical to assess each separately. Instead, status for Greenlip Abalone is reported at the management unit level: the South Australian Western Zone Fishery management unit, the South Australian Central Zone Fishery management unit, the South Australian Southern Zone Fishery management unit, the Tasmanian Greenlip Abalone Fishery management unit, the Victorian Central Zone Fishery management unit, the Victorian Western Zone Fishery management unit, the Western Australia Area 2 Fishery management unit and the Western Australia Area 3 Fishery management unit. Greenlip Abalone catches from the South Australian Southern Zone Fishery management unit are negligible and, consequently, stock status is not assessed.

Stock status

Undertaking assessments of abalone stock status is complicated by several factors, including:

- the high number of biological stocks, each at a different level of depletion
- changes to management unit boundaries and size limits
- absence of a performance indicator and reference points above or below which the fishery would be defined as sustainable or recruitment overfished, respectively
- changes in fishing power, which impede comparisons of current and historical catch per unit effort (CPUE)
- the multitude of factors that affect the effort component of CPUE
- the degree to which CPUE reflects abalone abundance.

Assessment of stock status also varies among jurisdictions and management units.

The harvest strategy in the *Management plan for the South Australian Commercial Abalone Fishery*⁴ includes a catch-weighted determination of stock status for the fishing zone. However, the harvest strategy does not identify a performance indicator or a reference point below which the fishery would be defined as recruitment overfished. In addition, several weaknesses in the harvest strategy result in more optimistic assessments of stock status than those from more traditional weight-of-evidence methods^{5,6}. Consequently, in this assessment, commercial catch rates (CPUE; kilograms of meat per hour) are used as indices of relative Greenlip Abalone abundance. This measure can, however, provide a more optimistic index of relative abundance than measures from fishery-independent surveys, because catch rates in dive fisheries can be hyperstable⁵⁻⁹. Decreases in CPUE in abalone fisheries are considered to be a reliable indicator of declines in abalone abundance, but can underestimate the magnitude of the reduction^{5,6,9}.

The *Victorian abalone fishery management plan*¹⁰ also does not identify a performance indicator or a reference point below which the fishery would be defined as recruitment overfished. In the absence of this key performance indicator, catch history and historical surveys are used to make inferences about stock status.

Catches in the Western Australia Area 2 and Area 3 abalone fisheries are controlled by a total allowable commercial catch (TACC), set by a harvest control rule that uses standardised CPUE as the key performance indicator¹¹ against specified limit, threshold and target reference points. The fishery is defined as recruitment overfished if the standardised CPUE is below the limit reference point.

In Tasmania, commercial catch history and diver observations are used to inform stock status.

South Australian Western Zone Fishery management unit

The CPUE for Greenlip Abalone in the South Australian Western Zone fishery management unit was relatively stable between 1983 and 1996. It then increased rapidly, reaching a peak in 2003. Since 2003, CPUE has decreased each year. In 2013, it was 22 per cent below the 2003 peak and at the lowest level since 1998. Despite these decreases, CPUE across the zone and in many fishing grounds remains above that observed through the 1990s, which preceded a substantial increase in abundance occurring in at least the Western and

Central zones of South Australia. from 2000. In addition, fishery-independent survey densities at long-term sites are similar to those in the 1990s, the legal minimum length of 14.5 cm allows several years of spawning to occur before recruitment to the fishery, and large Greenlip Abalone continue to dominate the catch⁵. The stock is unlikely to be recruitment overfished and, based on the current CPUE, the level of fishing pressure is unlikely to cause the stock to become recruitment overfished. However, the recent decreases in CPUE and redistribution of catch from traditional Greenlip Abalone to traditional Blacklip Abalone fishing grounds will be carefully monitored to ensure timely responses to any change in stock status.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

South Australian Central Zone Fishery management unit

The CPUE for Greenlip Abalone in the South Australian Central Zone Fishery management unit was stable from 1979 to 1998. CPUE increased substantially from 1999 to 2001, when it reached its peak. Since 2002, CPUE has declined steadily, with the overall decline being 21 per cent over a 12-year period. The latest fishery-independent survey densities at Tiparra Reef, historically the key fishing ground, were also low relative to previous years⁶. As the TACC has remained unchanged, there has also been a large redistribution of catch from Tiparra Reef to other fishing grounds. For several of these grounds, catches and/or catch rates have not been sustained. The stock is not yet considered to be in a recruitment overfished state because CPUE remains above that in the mid-1990s, prior to a large increase in abundance, and the legal minimum length of 13.5 cm allows several years of spawning to occur before recruitment to the fishery. However, the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **transitional–depleting stock**.

Tasmanian Greenlip Abalone Fishery management unit

The reporting of effort against a combined harvest of Greenlip Abalone and Blacklip Abalone in the Tasmanian Greenlip Abalone Fishery management unit makes interpretation of CPUE as a proxy for Greenlip Abalone abundance problematic. Use of CPUE is also confounded by changes in fishery selectivity due to changes in the market, and variable approaches to Greenlip Abalone harvest by divers, which vary spatially. For example, fishers in some areas specifically target Greenlip Abalone, whereas in other areas Greenlip Abalone is taken as bycatch while targeting Blacklip Abalone. A high reliance on diver observations and commercial catch history is necessary for setting of annual TACCs, but there is insufficient information to confidently classify status⁹.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Victorian Western Zone Fishery management unit

Population abundance and size structure estimates from data collected during the late 1980s and 1990s indicated that the stock was small and mostly concentrated in Portland Bay¹². Surveys conducted almost a decade later showed potential for a limited fishery on Julia Bank¹³, as well as Minerva and Hospital Reefs¹⁴. Prior to 2006–07, reported catches were limited and Greenlip and Black Abalone were allocated as a combined TACC with an average annual catch of 100 kg during 2001–05. A separate Greenlip Abalone TACC of 4.2 tonnes (t) was set for the 2006–07 quota-year (1st Apr–31st Mar) and maintained for the next two years. Following a reduction in Blacklip Abalone catches due to the occurrence of Abalone viral ganglioneuritis during 2006–07 and in response to an analysis of Greenlip Abalone sampling from Minerva and Hospital reefs¹⁴, the TACC was increased to 16 t for 2009–10 resulting in an annual catch of 18.9 t in the 2010 calendar year and an average catch of 14.8 t during 2009–2011. These catches were not sustained, with the TACC falling by 50 per cent between 2011 and 2012. The TACC was subsequently set at zero in 2013¹⁵, reflecting the highly depleted status of Greenlip Abalone stocks in the Western Zone. The above evidence indicates that the stock is likely to be recruitment overfished. While current fishing pressure is constrained by management to a level that may allow the stock to recover from its recruitment overfished state, measurable improvements are yet to be detected.

On the basis of the evidence provided above, the management unit is classified as an **overfished stock**.

Victorian Central Zone Fishery management unit

Greenlip Abalone continues to comprise a small component of the commercial abalone catch in the Victorian central zone fishery management unit. A study in 1996 concluded that the resource had failed to recover from overfishing during the 1960s and 1970s, despite modest catches during ensuing decades¹². The TACC has

remained unchanged at 3.4 t since 2009¹⁵, and annual catches have been below this amount. The above evidence indicates that the stock is likely to be recruitment overfished and that levels of current fishing pressure are expected to prevent the stock recovering from a recruitment overfished state.

On the basis of the evidence provided above, the management unit is classified as an **overfished stock**.

Western Australia Area 2 Fishery management unit

Standardised CPUE has been relatively stable in the Western Australia Area 2 Fishery since 2004 and, in 2013, was above the threshold reference point. Additional data, including length-frequency distributions from catch sampling and fishery-independent surveys, validate the standardised CPUE trend. The fishery has a legal minimum length of 14 cm, which allows 2–5 years of spawning to occur before recruitment to the fishery. Overall, the evidence indicates that Greenlip Abalone stocks in Area 2 are unlikely to be recruitment overfished and that the current level of fishing mortality is unlikely to cause these biological stocks to become recruitment overfished¹¹.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Western Australia Area 3 Fishery management unit

Standardised CPUE was relatively stable in the Western Australia Area 3 Fishery between 2004 and 2011, but declined to below the threshold reference point (10.98 kg/hour) between 2011 and 2013 (10.5 kg/hour). Additional data, including length-frequency distributions from catch sampling and fishery-independent surveys, validate the standardised CPUE trend. These triggered a 10 per cent TACC reduction for 2014, as required by the harvest control rule^{11,16}. If stocks continue on this trajectory, a larger TACC cut, of at least 30 per cent, will be initiated within 2 years. In addition, the fishery has a legal minimum length of 14 cm, which allows 2–5 years of spawning to occur before recruitment to the fishery. Overall, the evidence indicates that Greenlip Abalone stocks in Area 3 are unlikely to be recruitment overfished and that the reductions under the harvest control rule mean that it is unlikely that the stock will become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Table 2: Greenlip Abalone biology^{5,6}

<i>Longevity and maximum size</i>	20 years; 200 mm SL
<i>Maturity (50%)</i>	4–5 years; 75–120 mm SL

SL = shell length

Figure 1: Distribution of reported commercial catch of Greenlip Abalone in Australian waters, 2013 (calendar year)

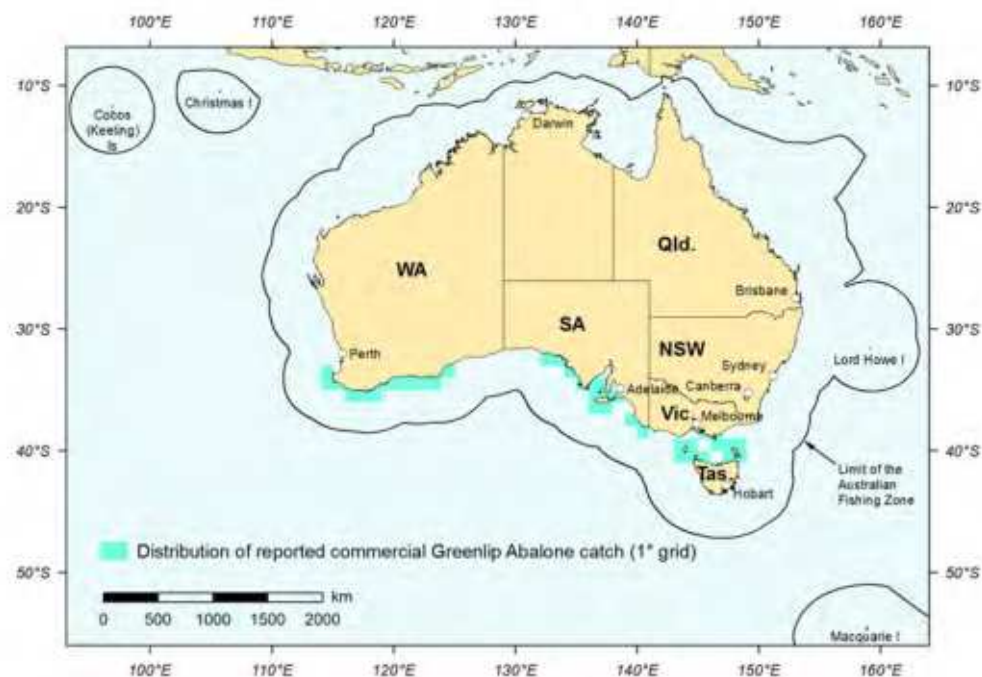


Table 3: Main features and statistics for Greenlip Abalone fisheries in Australia, 2013 (calendar year)

Jurisdiction	South Australia	Tasmania	Victoria	Western Australia
Fishing methods				
Commercial				
Diving	✓	✓	✓	✓
Recreational				
Diving	✓	✓	✓	✓
Indigenous				
Diving	✓	✓		✓
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Size limits	✓	✓	✓	✓
Total allowable catch	✓	✓	✓	✓

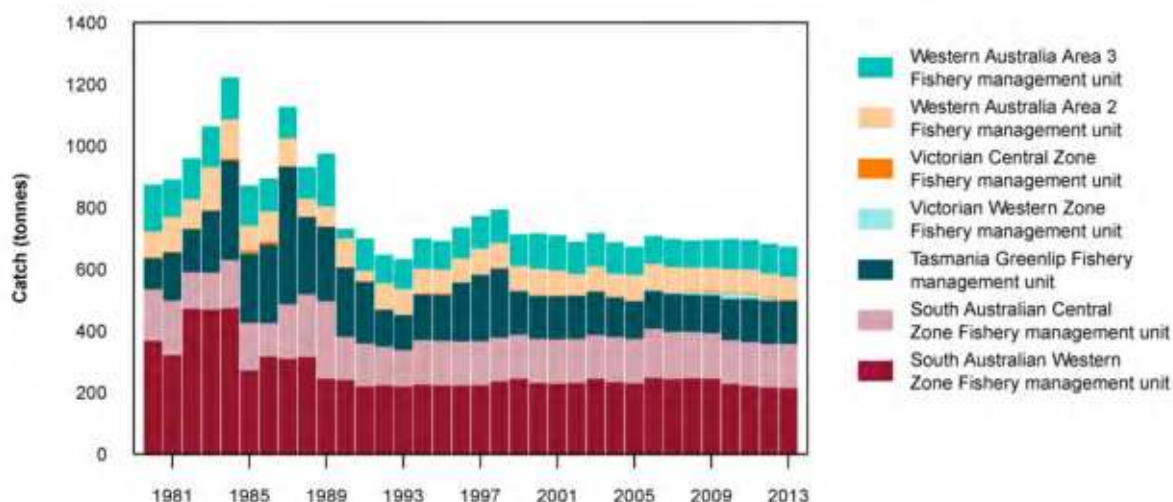
Jurisdiction	South Australia	Tasmania	Victoria	Western Australia
Recreational				
Bag limits	✓	✓	✓	✓
Size limits	✓	✓	✓	✓
Indigenous ^{a,b}				
Bag limits	✓	✓		✓
Size limits	✓	✓		✓
Active vessels				
	6 in SACZF 23 in SAWZF	121 in TGF	16 in VCZF 0 in VWZF	6 in WAA2F 7 in WAA3F
Catch				
Commercial	143 t in SACZF 217 t in SAWZF	140 t in TGF	1 t in VCZF 0 t in VWZF	75 t in WAA2F 91 t in WAA3F
Recreational	Unknown	Unknown	Unknown	8 t
Indigenous ^{a,b}	Unknown	Unknown	0 t	Unknown
Markets				
Domestic	✓	✓	✓	✓
Export	✓	✓	✓	✓

SACZF = South Australian Central Zone Fishery; SAWZF = South Australian Western Zone Fishery; TGF = Tasmanian Greenlip Abalone Fishery; VCZF = Victorian Central Zone Fishery; VWZF = Victorian Western Zone Fishery; WAA2F = Western Australia Area 2 Fishery; WAA3F = Western Australia Area 3 Fishery

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Greenlip Abalone.

b Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catch of Greenlip Abalone in Australian waters, 1980 to 2013 (calendar years)



Effects of fishing on the marine environment

- Because Greenlip Abalone is hand selected by commercial divers operating from vessels that seldom anchor, the fishery has limited direct physical impact on the environment. There is also substantial evidence that the ecosystem effects of removing abalone are minimal^{17–19}. All fisheries have export certification under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

Environmental effects on Greenlip Abalone

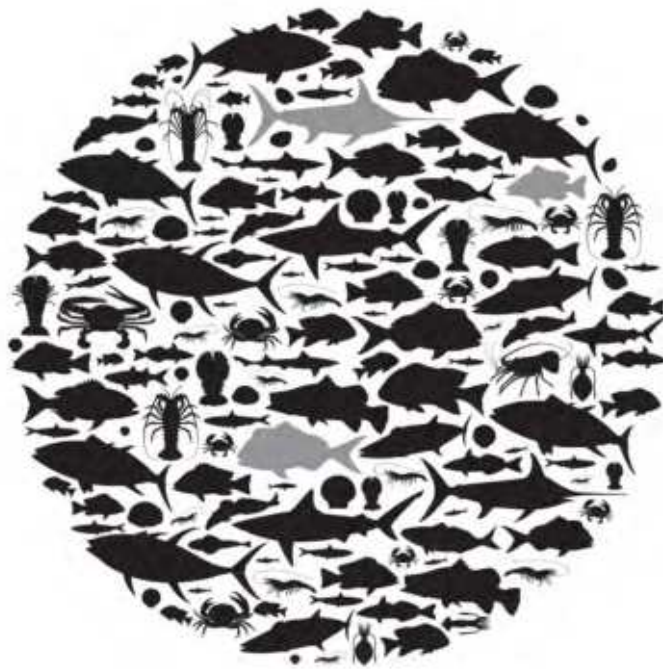
- Southward and westward strengthening of the warm East Australian Current into the relatively cold inshore waters in Tasmania has changed near-shore community structure and productivity, primarily through expansion of the range of the urchin *Centrostephanus rodgersii* from New South Wales to Tasmania^{20–22}. This has resulted in localised depletions of abalone populations and a reduction in the habitat available for abalone^{23,24}.

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Molluscs: *Pipi*



3. Pipi *Donax deltoides*

Greg Ferguson^a, Daniel Johnson^b and James Andrews^c



Table 1: Stock status determination for Pipi

Jurisdiction	South Australia	Victoria	New South Wales
<i>Stock</i>	South Australia (LCF, MSF)	Victoria (BF, OF)	New South Wales (EGF)
<i>Stock status</i>			
	Sustainable	Undefined	Undefined
<i>Indicators</i>	Fishery-independent relative abundance, size frequencies	Catch	Catch, CPUE

BF = Bait Fishery (Victoria); CPUE = catch per unit effort; EGF = Estuary General Fishery (New South Wales); LCF = Lakes and Coorong Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); OF = Ocean Fisheries (Victoria)

Stock structure

Pipi is common on high-energy sandy beaches from southern Queensland to the mouth of the Murray River in South Australia¹.

High genetic variation between populations on either side of Bass Strait suggests at least two biological stocks, with the East Australian Current and South Australian Current acting as key drivers of gene flow on the east and south coasts of Australia, respectively². This was supported by a study of Pipi from Fraser Island, Queensland, to southern New South Wales, suggesting a single biological stock with genetic mixing driven by ocean currents associated with the East Australian Current; however, the timescale over which patterns in genetic variation may have occurred is unknown¹. For locations west of Bass Strait in South Australia and western Victoria, no evidence of genetic structuring of Pipi has been detected². The degree of larval mixing is thought to be related to spawning and larval duration, although these are poorly understood²⁻⁵. Although no genetic differences were detected among Pipi populations on beaches along the east coast of Australia, in any

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^c Department of Environment and Primary Industries, Victoria

given year most recruits are likely to be self-seeded or come from nearby, adjacent beaches¹. This is likely also the case for the fisheries located to the west of Bass Strait.

Despite the work outlined above, there is still too much uncertainty around the biological stock delineation of Pipi to determine stock status at the biological stock level. Hence, status is reported at the jurisdictional level for South Australia, Victoria and New South Wales.

Stock status

South Australia

Indigenous Australians have occupied the Coorong region in south-eastern South Australia for at least 16 000 years and have harvested Pipi (also known as Goolwa Cockles in South Australia) for the past 10 000 years⁶. Middens in the vicinity of the Murray River mouth in South Australia are composed almost exclusively of the shells of adult Pipi⁷.

Fishers with quota for Pipi from the Lakes and Coorong Fishery, and the Marine Scalefish Fishery operate on the ocean beaches of Younghusband Peninsula, adjacent to the Coorong. Quota holders from the Marine Scalefish Fishery are subject to the same management arrangements (including the annual total allowable commercial catch) as the Lakes and Coorong Fishery. Combined fishery-dependent data from these two fisheries and annual fishery-independent estimates of relative biomass of Pipi on Younghusband Peninsula provide the key performance indicators for these fisheries. A minimum legal length of 35 mm is in place to allow spawning to occur at least once before recruitment to the fishery³. In 2006, available information suggested that the Pipi resource was depleted during the mid to late 2000s⁸. Since 2007, the fishery has been managed under an annual total allowable commercial catch. From 2009, increasing mean annual relative biomass and increasing complexity of size structures suggest recovery of the resource, probably as a result of conservative total allowable commercial catches that have been in place since 2009³. The above evidence from the South Australian commercial fisheries indicates that the biomass of this stock is not recruitment overfished and that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

Estimates of recreational catch are available from telephone-based surveys in the 2000 and 2007 financial years. In 2000, the National Recreational and Indigenous Fishing Survey estimated recreational catch from South Australia to be 22.9 tonnes (t)⁹, representing 1.8 per cent of the total recreational and commercial catch of Pipi. In 2007, the South Australian Recreational Fishing Survey estimated that recreational catch was 5 t, representing 0.8 per cent of the total recreational and commercial catch¹⁰. The small catch of Pipi from the recreational fishery is unlikely to affect the overall status classification in South Australia.

On the basis of the evidence provided above, Pipi in South Australia is classified as a **sustainable stock**.

Victoria

The presence of middens is evidence that Pipi was harvested historically by Indigenous communities along the Victorian coastline⁶. The harvesting of fish for customary purposes is managed under permit in Victoria, and no permits have been issued for Pipi in recent years. Since 2013, a size limit of 35 mm has applied to the waters of south-western Victoria to the west of Lake Yambuk. In addition to the size limit, management of the recreational fishery includes daily catch limits.

Until recently, the commercial and recreational fisheries of Pipi were directed towards the supply of bait, and fewer than five commercial licences were generally active in any one year. Commercial catches from Discovery Bay have increased over the past few years, but little information is available on the commercial Pipi fishery in Victoria. In 2000, the National Recreational and Indigenous Fishing Survey estimated recreational harvest (numbers) from Victoria to be 638 401 Pipi¹¹, but an estimate of harvest weight was not available. The impacts of recreational harvesting are thought to be localised around beach access points¹². Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Pipi in Victoria is classified as an **undefined stock**.

New South Wales

The harvest of Pipi in New South Wales is shared between commercial, recreational and Indigenous fishers. Commercial landings have declined from more than 500 t in 2004 to less than 65 t in recent years, despite a significant increase in price over this period. In 2011, a 6-month closure of the commercial fishery and output

controls limiting catch to 40 kg per fisher per day were implemented in an attempt to stabilise the fishery. A minimum legal length of 45 mm is in place to allow spawning to occur before recruitment to the fishery¹³. Recreational catch was estimated at 7 t in 2000, based on the National Recreational and Indigenous Fishing Survey¹¹. There are no recent estimates of recreational or Indigenous landings of Pipi. Insufficient information is available to classify the status of this stock.

On the basis of the evidence provided above, Pipi in New South Wales is classified as an **undefined stock**.

Table 2: Pipi biology^{3,4,13}

Longevity and maximum size	South Australia: 3–5 years; 61 mm New South Wales: 1–2 years; 75 mm
Maturity (50%)	South Australia: ~10 months; 28 mm New South Wales: 1 year, 37 mm

Figure 1: Distribution of reported commercial catches of Pipi in Australian waters, 2012 (financial year)

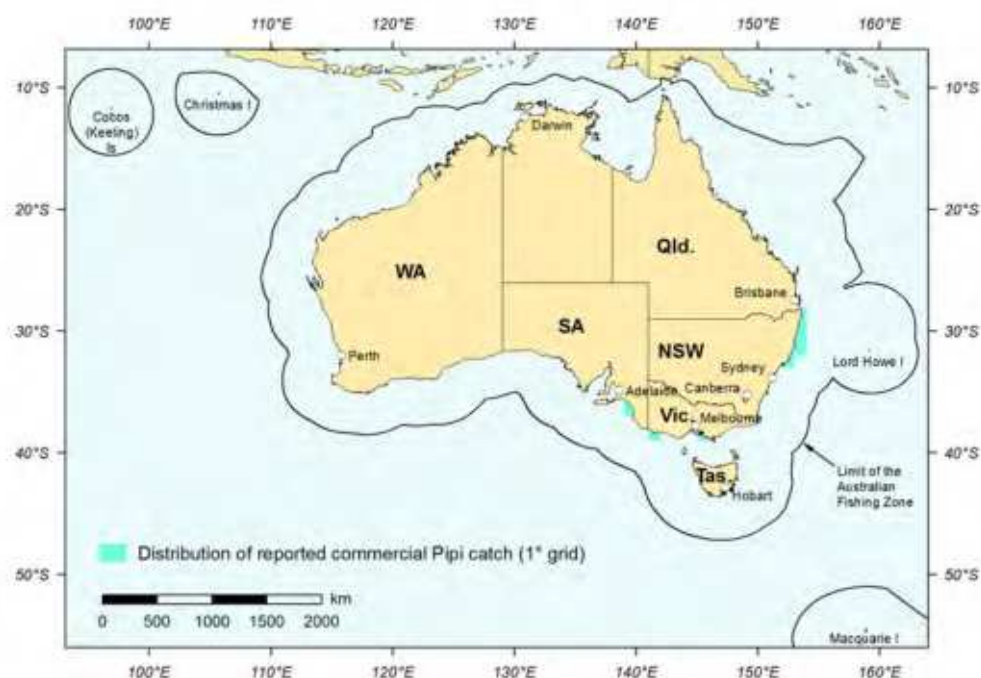


Table 3: Main features and statistics for Pipi fisheries in Australia, 2012 (financial year)

Jurisdiction	South Australia	Victoria	New South Wales
Fishing methods			
Commercial			
Pipi rake	✓		
Hand gathering	✓	✓	✓
Dip net		✓	

Jurisdiction	South Australia	Victoria	New South Wales
Recreational			
Pipi rake/bait spade/fork	✓		
Hand gathering	✓	✓	✓
Indigenous ^{a,b}			
Pipi rake/bait spade/fork	✓		
Hand gathering	✓		✓
Management methods			
Commercial			
Catch limits	✓		
Size limits	✓	✓	✓
Trip limits			✓
Gear limits	✓	✓	✓
Limited entry	✓	✓	✓
Spatial closures	✓	✓	✓
Temporal closures	✓		✓
Recreational			
Size limits	✓		
Bag limits	✓	✓	✓
Possession limits	✓	✓	✓
Seasonal closures	✓		
Spatial closures	✓	✓	
Gear restrictions	✓	✓	✓
Indigenous ^{b,c}			
Size limits	✓		
Bag limits	✓		✓
Section 37(1)(c1), Aboriginal cultural fishing authority			✓

Jurisdiction	South Australia	Victoria	New South Wales
Active vessels			
Commercial ^d	20 licences in LCF 2 licences in MSF	2 fishers in BF 7 fishers in OF	30 licences in EGF
Catch			
Commercial ^e	443 t in LCF and MSF	76 t in BF and OF	63 t in EGF
Recreational	22.9 t (in 2000) 5 t (in 2007)	Unknown	Unknown
Indigenous	Unknown	Unknown	Unknown
Markets			
Domestic	✓	✓	✓
Export			

BF = Bait Fishery (Victoria); EGF = Estuary General Fishery (New South Wales); LCF = Lakes and Coorong Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); OF = Ocean Fisheries (Victoria)

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (for example, different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Papi.

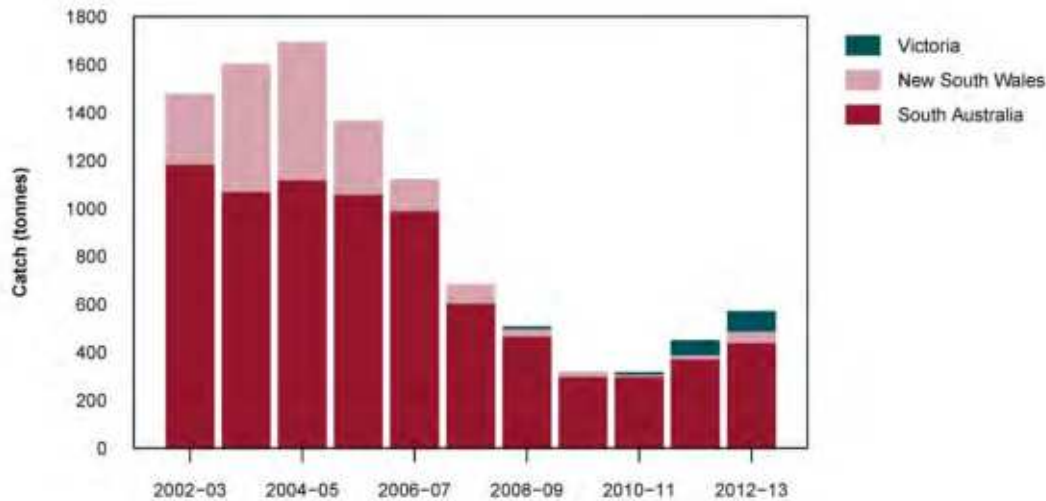
b The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

c The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

d Because Papi is collected from beaches, 'vessels' are not used. Hence, numbers of licences and fishers are presented here instead of vessel numbers. Licences refer to the number of licence holders with an endorsement to take Papi for sale.

e Catches from the MSF in South Australia, and the BF and OF in Victoria cannot be reported separately for confidentiality reasons as there are fewer than five licences.

Figure 2: Commercial catch of Pipi in Australian waters, 2002–03 to 2012–13 (financial years)



Note: For Victoria, there were no catches from 2002–03 to 2007–08, and catches for 2009–10 are not reported for confidentiality reasons as there were fewer than five licences.

Effects of fishing on the marine environment

- Since Pipi are collected by hand or using hand rakes, the fishery has limited physical impact on the environment. The impacts of mechanical grading of Pipi are unknown. Relatively high levels of recreational vehicle traffic (more than 20 vehicles per day) have been identified as having the potential to affect populations of Pipi on sandy beaches on the eastern Australian coast¹⁴. In South Australia, relatively low levels of vehicle traffic (fewer than 10 vehicles per day, including commercial vehicles) occur on Younghusband Peninsula where the commercial fishery is located.

Environmental effects on Pipi

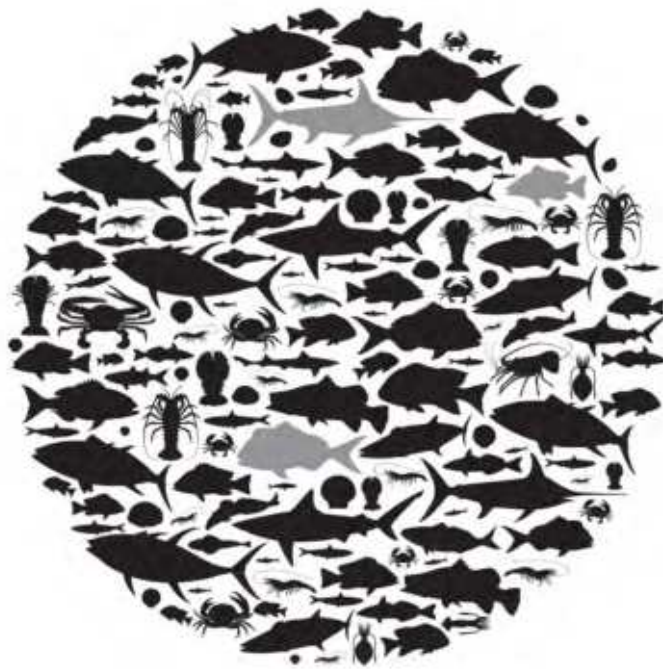
- Mortality events have been recorded for populations of Pipi. For example, in 1984, an estimated 2.5 million mostly adult Pipi were found dead on Goolwa beach, west of the mouth of the Murray River¹⁵. It was postulated that an extended period of low salinity following flooding from the Murray River may have resulted in mortality due to osmotic stress or starvation^{15,16}.
- During the peak spawning season (September–October), the prevailing currents in south-eastern South Australia flow in a north-westerly direction⁴. Because larvae may remain in the plankton for at least 14 days after spawning⁵, changes to the nearshore currents during the spawning period may impact recruitment to the beach.

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Molluscs: *Scallops*



4. Commercial Scallop *Pecten fumatus*

Jayson Semmens^a, Harry Gorfine^b, Nic Marton^c, David Jarvis^d and Justin Bell^a



Table 1: Stock status determination for Commercial Scallop

Jurisdiction	Commonwealth	Tasmania	Victoria
Stock	Commonwealth (BSCZSF)	Tasmania (TSF)	Victoria (VSF)
Stock status			
	Undefined	Undefined	Undefined
Indicators	Proportion of spawning stock protected by spatial closure, minimum size limits, survey results	Proportion of spawning stock protected by spatial closure, minimum size limits, survey results	Proportion of spawning stock protected by spatial closure, minimum size limits, survey results

BSCZSF = Bass Strait Central Zone Scallop Fishery (Commonwealth); TSF = Tasmanian Scallop Fishery; VSF = Victorian Scallop Fishery

Stock structure

Multiple Commercial Scallop beds are fished commercially in Commonwealth, Tasmanian and Victorian waters. Commercial Scallops in Port Phillip Bay (Victoria) and the D'Entrecasteaux Channel (Tasmania) are genetically distinct from each other, as well as from scallops in most other locations in south-eastern Australia^{1,2}. Although Commercial Scallops in Bass Strait are considered a single stock, they do show some genetic variation, most likely due to nonrandom dispersal and subsequent settlement of larvae¹. Given this complex genetic mosaic, Commercial Scallops have been assessed at the jurisdictional level.

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^d Department of Primary Industries, Parks, Water and Environment, Tasmania

Stock status

Management of scallop fisheries is complex, with all three jurisdictions using slightly different management strategies. Scallop stocks have shown repeated ‘boom and bust’ phases in the past, with the busts often resulting in extended fishery closures. Sustainability objectives are strongly reliant on the minimum size limit in each jurisdiction—an area is only open to fishing if less than 20 per cent of the scallops are under the minimum size. Estimating the biomass of Commercial Scallops is difficult because of highly variable recruitment³. In Victoria, the fishery may also be closed if average meat weight falls below 10 grams.

Commonwealth

Commercial Scallops in the Bass Strait Central Zone Scallop Fishery were considered recruitment overfished until 2007. Following 3 years of closure due to low scallop abundance and concerns about overfishing, the Bass Strait Central Zone Scallop Fishery was reopened in 2009 under a new harvest strategy⁴. Commercial Scallops experienced a reported die-off in 2010. In 2012, the harvest strategy was revised to provide more flexibility⁵.

Elements of the Commonwealth harvest strategy include:

- surveys to estimate biomass and determine areas of high density
- a set of decision rules that are used to open an area to fishing, including a minimum size limit of 90 mm shell length and a maximum discard rate (20 per cent) of animals below this size
- identification of at least two viable fishing areas, with a minimum of 40 per cent of the combined pool of viable areas closed to fishing
- a requirement that closed viable fishing areas contain a minimum of 500 tonnes (t) of estimated biomass in total.

Abundance surveys in 2013 estimated around 4000 t of Commercial Scallop across two beds, but only around 650 t were densely aggregated. These beds also contained a high proportion (31–71 per cent) of undersized scallops. The fishery was opened with an exemption from the 90 mm minimum size limit, and a temporary 85 mm limit applied instead. The latter size limit is still within the size range for scallops that are 3 years or older⁶. Only 189 t of the 1500 t total allowable catch (13 per cent) was harvested by the 13 active vessels in 2013.

Although management measures for the Bass Strait Central Zone Scallop Fishery are designed to prevent the stock from becoming recruitment overfished, it is not clear whether the stock biomass has recovered from its previous recruitment overfished state. Also unknown is the impact of the reported die-off in 2010 on total biomass and recruitment. As such, insufficient information is available to confidently classify the status of this stock⁷.

On the basis of the evidence provided above, Commercial Scallop in the Commonwealth is classified as an **undefined stock**.

Tasmania

The harvest of Commercial Scallops in Tasmanian waters is regulated through a minimum size limit of 90 mm shell length, which is a proxy for animals aged 3 years or older that have spawned at least twice⁶. The minimum size limit can be changed for specific areas of the fishery, if appropriate.

The Tasmanian fishery is managed similarly to the Bass Strait Central Zone Scallop Fishery. The main difference is that there is no requirement to close a proportion of the beds found during abundance surveys. This is because refuge for scallops is provided by the prohibition of fishing in waters less than 20 m deep, and the large number of dredge-prohibited areas around the state that protect scallop habitat.

The Tasmanian fishery was closed to fishing in 2009 and 2010 because of low scallop abundance and a high proportion of undersized animals. In 2013, industry statewide surveys generally found low levels of scallop abundance but did identify two beds containing commercial quantities that met the harvest strategy guidelines: one on the state’s north-west coast and the other on the east coast. These areas were subsequently opened for fishing, with a lower size limit of 85 mm applied to the north-west bed. This was considered appropriate given historically slow growth rates in this region and the fact that the revised size limit is still within the size range of scallops aged 3 years or more⁶.

Part of the east coast bed was voluntarily closed by industry in July 2013 when a large proportion of juveniles were discovered in the northern section. By the end of 2013, 1260 t of the 1489 t total allowable catch across both beds (85 per cent) had been taken by 13 vessels (half the number of vessels operating a decade earlier). Although harvesting is managed to prevent the stock becoming recruitment overfished, the historical status of the Tasmanian stock is unclear. In particular, it is not known whether the stock is recruitment overfished, and there is insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, Commercial Scallop in Tasmania is classified as an **undefined stock**.

Victoria

Surveys undertaken in 2009⁸ and 2012⁹ of the historically fished scallop beds found low scallop densities and negligible recruitment. Consequently, the total allowable catches for the 2010–11, 2011–12 and 2012–13 fishing seasons were set at zero. Landings and participation were also very low for the 2013–14 season, when 1.5 t per licence was allocated to facilitate exploratory fishing to collect information, in lieu of a more expensive biomass survey. Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Commercial Scallop in Victoria is classified as an **undefined stock**.

Table 2: Commercial Scallop biology^{1,2,6}

Longevity and maximum size	7 years; 120 mm shell length
Maturity (50%)	2 years; 70–80 mm shell length, depending on region

Figure 1: Distribution of reported commercial catch of Commercial Scallop in Australian waters, 2013 (calendar year)

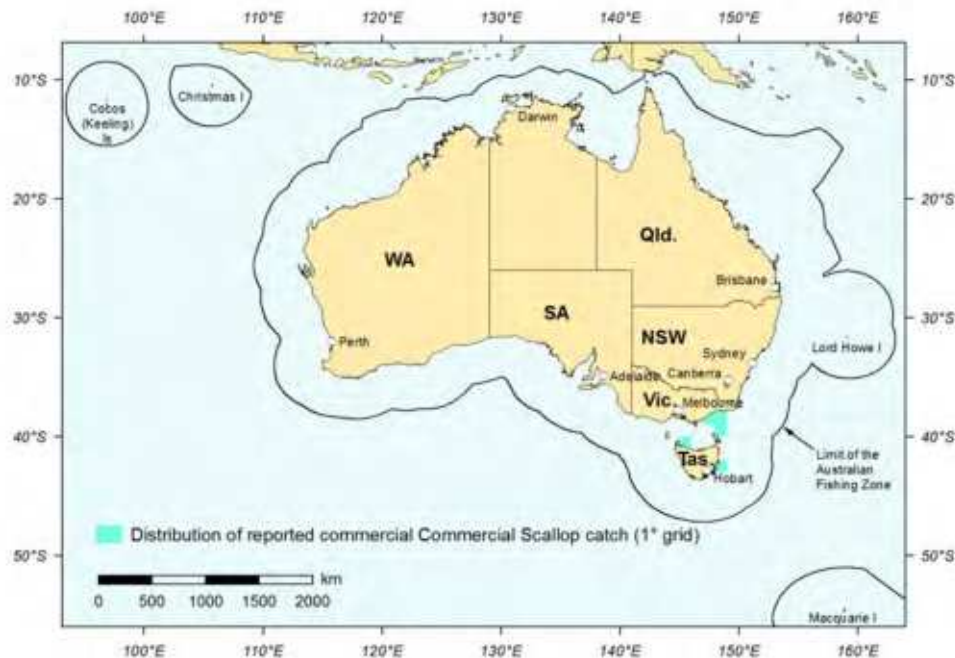


Table 3: Main features and statistics for Commercial Scallop fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth	Tasmania	Victoria
Fishing methods			
Commercial			
Dredge	✓	✓	✓
Recreational ^a			
Diving		✓	✓
Indigenous ^b			
		Unknown	Unknown
Management methods			
Commercial			
Limited entry	✓	✓	✓
Size limits	✓	✓	✓
Gear restrictions	✓	✓	✓
Total allowable catch	✓	✓	✓
Spatial closures	✓	✓	✓
Temporal closures	✓	✓	
Abundance estimation	✓	✓	✓
Recreational ^a			
Bag limits		✓	✓
Size limits		✓	✓
Spatial closures		✓	✓
Temporal closures		✓	
Indigenous ^{b,c}			
Bag limits		✓	
Size limits		✓	
Spatial closures		✓	
Seasonal closures		✓	

Jurisdiction	Commonwealth	Tasmania	Victoria
Active vessels			
	13 in BSCZSF	13 in TSF	2 in VSF
Catch			
Commercial	189 t in BSCZSF	1260 t in TSF	Confidential in VSF ^d
Recreational ^a		Unknown	Unknown
Indigenous ^{b,c}		Unknown	
Markets			
Domestic	✓	✓	✓
Export	✓		✓

BSCZSF = Bass Straight Central Zone Scallop Fishery (Commonwealth); TSF = Tasmanian Scallop Fishery; VSF = Victorian Scallop Fishery

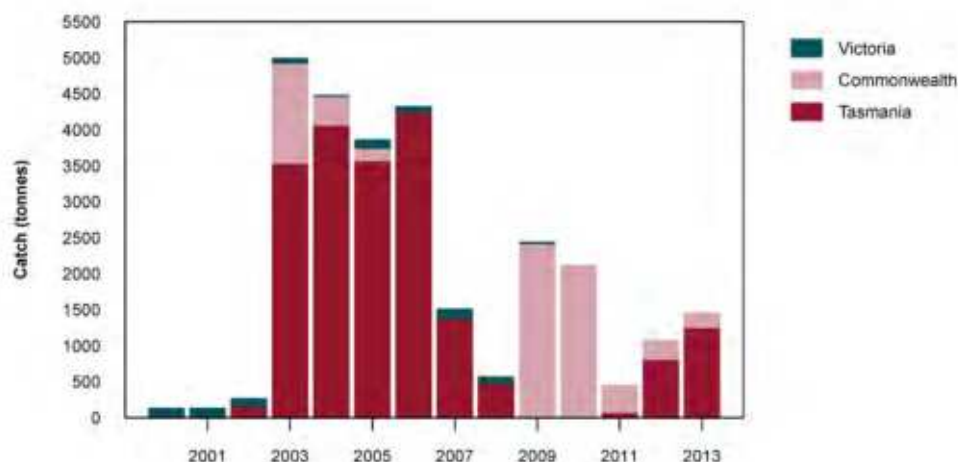
a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

c In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (for example, different catch and size limits or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Commercial Scallop.

d To protect commercial confidentiality of data, the catch in the VSF cannot be reported because there are fewer than five licence holders.

Figure 2: Commercial catch of Commercial Scallop in Australian waters, 2000 to 2013 (calendar years)



Note: To protect commercial confidentiality of data, the catch in Victoria from 2010 to 2013 cannot be reported because there were fewer than five licence holders.

Effects of fishing on the marine environment

- Scallops are targeted where they are abundant, and the effect on other species within the broader ecosystem tends to be minimal^{1,10}. An ecological risk assessment of the Bass Strait Central Zone Scallop Fishery found that none of the habitats assessed were at high risk of irreversible disturbance¹¹. Commercial Scallops and associated benthic communities generally recover very quickly from dredging operations^{12,13}. Commercial Scallops have been fished within the same regions repeatedly since the 1960s¹⁴ and so the effect of dredging on the current community structure is expected to be less significant than when the fishery began. The long-term dredge fishery may have already driven a shift in benthic community structure in favour of species that are less susceptible to dredging or can recover quickly^{15–17}.

Environmental effects on Commercial Scallop

- Changes in Commercial Scallop community structure can be driven by environmental factors as well as fishing¹². Recruitment of Commercial Scallops is intermittent and poorly understood³. Scallops often exhibit highly variable natural mortality, which is attributable to density-dependent food shortages, seabed bottom type, disease, environmental conditions, predation and unknown causes¹⁸. Stock relationships are heavily influenced by ocean currents¹. Climate change–induced shifts in ocean currents and/or upwelling events are expected to affect recruitment.

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5. Saucer Scallop *Amusium balloti*

Mervi Kangas^a and Brad Zeller^b



Table 1: Stock status determination for Saucer Scallop

Jurisdiction	Western Australia				Queensland
Stock	SBSMF	AIMWTMF	SWTMF	SCTF	ECOTF
Stock status					
	Environmentally limited	Environmentally limited	Sustainable	Sustainable	Sustainable
Indicators	Recruitment surveys, catch rate, catch	Recruitment surveys, catch rate, catch	Catch	Catch	Catch, CPUE

AIMWTMF = Abrolhos Islands and Mid-West Trawl Managed Fishery (Western Australia); CPUE = catch per unit effort; ECOTF = East Coast Otter Trawl Fishery (Queensland); SBSMF = Shark Bay Scallop Managed Fishery (Western Australia); SCTF = South Coast Trawl Fishery (Western Australia); SWTMF = South West Trawl Managed Fishery (Western Australia)

Stock structure

Saucer Scallops are distributed from Esperance in Western Australia, across the tropics, to the southern coast of New South Wales, and comprise two genetically discrete stocks¹. The western Australian stock spans most of the coast of Western Australia but, given the vast length of this coastline and the potential for regional differences in recruitment, four functionally independent management units (described below) have been established in this state. The stock classification for the western Australian stock is based on evidence from each of these management units.

The eastern Australian stock stretches from Innisfail in Queensland to Jervis Bay in New South Wales. No fishery for Saucer Scallop exists in New South Wales waters, and the stock classification presented here is at the management unit level, based on information from the commercial fishery in central and southern Queensland (latitude 22–27°S).

^a Department of Fisheries, Western Australia

^b Department of Agriculture, Fisheries and Forestry, Queensland

Stock status

Shark Bay Scallop Managed Fishery (Western Australia) management unit

The Shark Bay Scallop Managed Fishery (Western Australia) management unit employs a constant escapement policy to ensure carryover of spawning biomass to subsequent breeding seasons. Generally, catch rate target levels (400–450 kg meat weight per day) are used to limit fishing mortality during the key spawning period (April–June). Ceasing the take of scallops can be triggered by reaching this level, or during May, irrespective of catch rate².

Catch predictions for 2013 (based on fishery-independent surveys^{3,4} in November 2012²) were extremely low for both Denham Sound (10 tonnes [t]) and northern Shark Bay (20 t). These low yield predictions necessitated that the entire stock be protected to maximise spawning success, and the fishery remained closed (it was also closed for the 2012 season). Despite fishery closures in both 2012 and 2013, the spawning stock remains at record low levels, and poor recruitment is likely in 2014 even if environmental conditions improve. This decline in productivity appears to be due to several years of suppressed recruitment caused by record high water temperatures, associated with very strong La Niña climate events and a strong Leeuwin Current⁵.

A small area containing juvenile scallops was recently identified in Denham Sound and closed to prawn trawling in 2013 to provide additional protection of the spawning stock. This closure will also enable comparisons of scallop recruitment in areas closed and open to fishing, and demonstrate the relative impacts of natural phenomena and harvesting.

In summary, the stock biomass within this management unit has fallen to a level at which there is a significant risk of recruitment failure. Recent annual surveys indicate low scallop abundance, with catch predictions below the target level for resumption of fishing. This reduction has not been due to overfishing or lack of appropriate fisheries management; the low stock biomass is the result of a series of poor recruitment events associated with sustained unfavourable environmental conditions dating back to late 2010. The fishery has now been closed for several years to provide maximum protection to all remaining stock. Fisheries management has responded appropriately to the environmental change in productivity, with a complete cessation of fishing since November 2012.

On the basis of the evidence provided above, the management unit is classified as an **environmentally limited stock**.

Abrolhos Islands and Mid-West Trawl Managed Fishery (Western Australia) management unit

The Abrolhos Islands and Mid-West Trawl Managed Fishery (Western Australia) management unit is regulated in a similar manner to the Shark Bay Scallop Managed Fishery. The impact on the spawning biomass is limited by:

- fishing after the peak spawning period
- setting the duration of fishing according to catch predictions (based on pre-season surveys)
- closing the fishery at a minimum catch rate threshold (250 kg meat weight per day)
- not opening sections of the fishery if scallop abundance is considered too low².

Annual pre-season surveys indicate very low recruitment since 2011. The 2012 abundance estimate was the lowest since 1997, most likely due to high water temperatures associated with the very strong La Niña climate events and strong Leeuwin Current, combined with poor recruitment in previous years. Consequently, the fishery was not opened in 2012.

Predicted catches for 2013 and 2014 were also below the target range (95–1830 tonnes [t] whole weight), and the fishery remains closed at the time of writing. It may take several years of favourable conditions for the stock to recover. Consideration is being given to intervention measures such as translocation, and release of hatchery-produced spat, to aid in rebuilding the spawning stock.

In summary, the stock biomass within this management unit has fallen to a level at which there is a significant risk of recruitment failure. Recent annual surveys indicate low scallop abundance, and catch predictions are below the target level for resumption of fishing. This reduction has not been due to overfishing or lack of appropriate fisheries management; the low stock biomass is the result of a series of poor recruitment events

associated with sustained unfavourable environmental conditions dating back to late 2010. The fishery has now been closed for several years to provide maximum protection to all remaining stock. Fisheries management has responded appropriately to the environmental change in productivity, with a complete cessation of fishing since June 2011.

On the basis of the evidence provided above, the management unit is classified as an **environmentally limited stock**.

South West Trawl Managed Fishery (Western Australia) management unit

The South West Trawl Managed Fishery (Western Australia) management unit is a comparatively small, low-activity fishery in which effort is related to the abundance of scallops in any given year, which can be highly variable. The few vessels that actively operate in the fishery cover only a small proportion of its area, and the limited harvest is unlikely to adversely impact the breeding stock². This modest level of fishing mortality is unlikely to cause the stock to become recruitment overfished, and the stock is unlikely to be recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

South Coast Trawl Fishery (Western Australia) management unit

The South Coast Trawl Fishery (Western Australia) management unit is a comparatively small, low-activity fishery in which effort is related to the abundance of scallops in any given year, which can be highly variable. The few boats (up to four) that are licensed to operate in the fishery cover only a small proportion of its area, and the limited harvest is unlikely to adversely impact the breeding stock². This modest level of fishing mortality is unlikely to cause the stock to become recruitment overfished, and the stock is unlikely to be recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

East Coast Otter Trawl Fishery (Queensland) management unit

The most recent quantitative assessment of the east coast biological stock applied two groups of models to commercial catch and catch-rate data (spanning the years 1977 to 2009) from the East Coast Otter Trawl Fishery (Queensland). The first group of models predicted a maximum sustainable yield (MSY) of 546 t, and the second group an MSY of 683 t. The catch in 2013 (504 t) fell short of both estimates, as did the average catch over the previous 5 years (538 t). However, annual catches have been highly variable since 1997 (when rotational area closures—scallop replenishment areas—were introduced), exceeding the upper MSY estimate (683 t) in 9 out of the past 17 years⁶.

Catch rates in the east coast biological stock have generally increased since 1999, with two notable exceptions: 2011 and 2012⁶. Scallop stocks often show marked annual variations in recruitment due to changes in a range of environmental conditions⁷. The decline in catch rates in 2011–12 was probably environmentally driven, as it coincided with major coastal flooding⁸. The precise causal mechanism of this anomaly is the subject of current research. The fishery recovered in 2013, with the overall catch rate exceeding the 1993 historical high⁶. The evidence above suggests that the biomass of this biological stock is unlikely to be recruitment overfished.

Although one group of 2009 stock assessment models suggested that the biomass of this stock may have been below the biomass at MSY (B_{MSY}) in the past, the other group of models did not⁹. Given that 45 per cent of the stock biomass is protected within the Great Barrier Reef Marine Park¹⁰, and the relative efficacy of the rotational management system, the risk of the stock becoming recruitment overfished at 2009 effort levels is considered to be low to intermediate^{11,12}.

In 2013, fishing effort, in terms of trawling time and the number of active vessels, was below the previous 4-year averages by 21 per cent and 9 per cent, respectively, and close to historical lows⁶. The fishing mortality rate in 2013 is therefore considered to be less than that in 2009. Likely causes of the recent decline in scallop fishing effort include depressed export prices, increased operational costs, and greater profit margins in other fisheries (such as Eastern King Prawn).

Fishing pressure on this biological stock is managed by rotational area closures, temporal closures, a 9 cm shell height minimum size limit, and a ban on daytime trawling. In 2013, roughly 23 per cent of vessels catching Saucer Scallop in the East Coast Otter Trawl Fishery used square-mesh codends to reduce discard mortality of

undersized product¹³. The evidence above indicates that the current level of fishing mortality is unlikely to cause the east coast biological stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Table 2: Saucer Scallop biology¹

Longevity and maximum size	Maximum of 4 years; 140 mm SH
Maturity (50%)	1 year; 85–90 mm SH

SH = shell height

Figure 1: Distribution of reported commercial catch of Saucer Scallop in Australian waters, 2013 (calendar year)

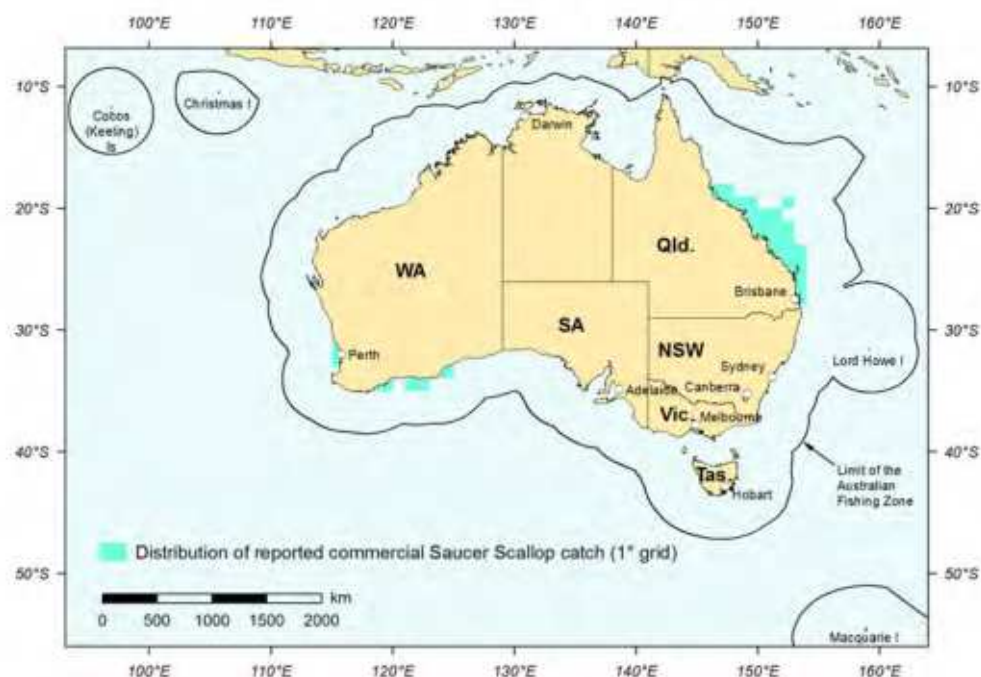


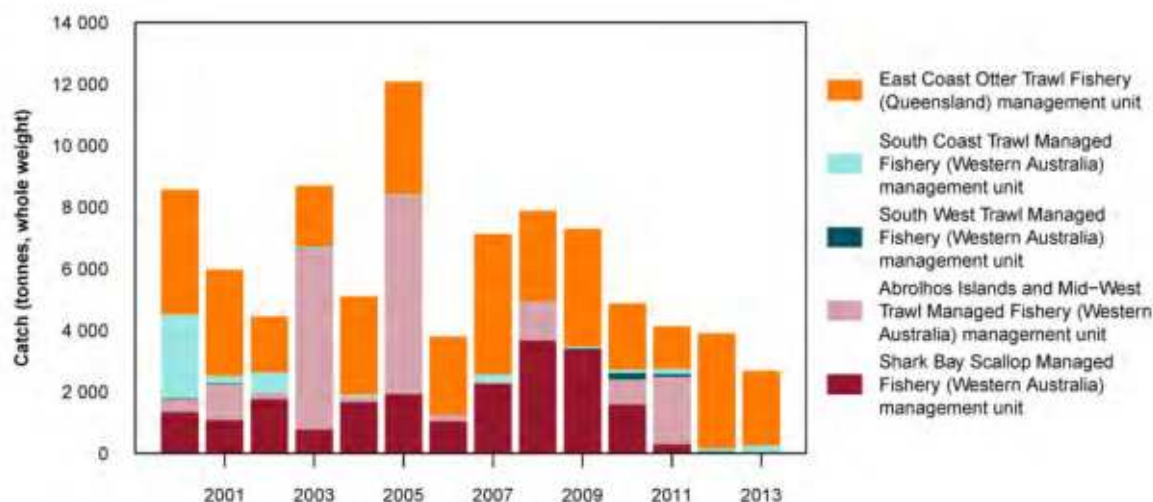
Table 3: Main features and statistics for Saucer Scallop fisheries in Australia, 2013 (calendar year)

Jurisdiction	Western Australia	Queensland
Fishing methods		
Commercial		
Demersal otter trawling	✓	✓
Recreational		
	None	None
Indigenous		
	None	None

Jurisdiction	Western Australia	Queensland
Management methods		
Commercial		
Limited entry	✓	✓
Size limits		✓
Vessel restrictions		✓
Catch limits	✓	
Effort limits	✓	
Spatial closures	✓	✓
Rotational closures		✓
Recreational		
	None	None
Indigenous		
	None	None
Active vessels		
	5 in SCTF 2 in SWTMF	126 in ECOTF
Catch		
Commercial	253 t in SCTF 8 t in SWTMF	2427 t in ECOTF
Recreational	No catch	No catch
Indigenous	No catch	No catch
Markets		
Domestic	✓	✓
Export		✓

ECOTF = East Coast Otter Trawl Fishery (Queensland); SCTF = South Coast Trawl Fishery (Western Australia);
SWTMF = South West Trawl Managed Fishery (Western Australia)

Figure 2: Commercial catch of Saucer Scallop in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Habitat effects of Western Australian Saucer Scallop fisheries are considered low risk, with trawl vessels generally sweeping a small proportion of the designated trawl area. Furthermore, the physical impact of this gear on the sandy habitats within these areas is negligible¹⁴.
- Food chain effects of Western Australian Saucer Scallop fisheries are deemed low risk, with the total biomass taken by these operations being small. High variability in natural recruitment and therefore scallop stock abundance⁹ also means that few predators will have become highly dependent on this species¹⁴.
- Bycatch reduction devices are mandatory in the Shark Bay Scallop Managed Fishery (Western Australia) and the Abrolhos Islands and Mid-West Trawl Managed Fishery (Western Australia), as are turtle excluder devices in the East Coast Otter Trawl Fishery (Queensland). These gear modifications are effective in limiting bycatch of larger species such as turtles, sharks, rays and sea snakes¹⁵. Compliance monitoring of bycatch reduction devices and vessel activities (through vessel monitoring systems) occurs in each management area. From 2009 to 2011, the Queensland Government provided material and financial incentives to promote the adoption of square-mesh codends in the East Coast Otter Trawl Fishery, to reduce bycatch of smaller aquatic organisms¹³.

Environmental effects on Saucer Scallop

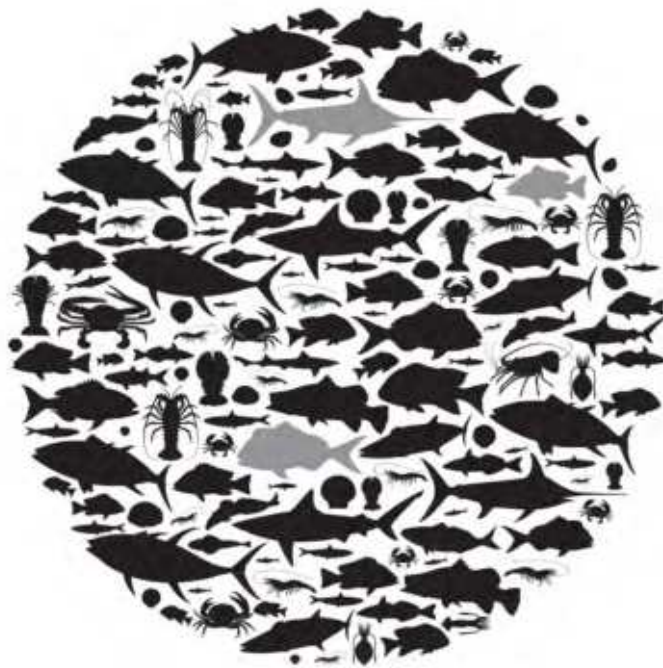
- Strong La Niña events and/or a strong Leeuwin Current often result in below-average scallop recruitment and may necessitate the closure of the Shark Bay Scallop Managed Fishery (Western Australia) and/or the Abrolhos Island and Mid-West Trawl Managed Fishery (Western Australia)^{16–19}. Research into possible relationships between abiotic/oceanographic factors and Saucer Scallop population dynamics on the eastern seaboard commenced in 2013.

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Molluscs: *Octopus*



6. Pale Octopus *Octopus pallidus*

Timothy Emery^a, Klaas Hartmann^a, Corey Green^b and Mike Steer^c



Table 1: Stock status determination for Pale Octopus

Jurisdiction	Tasmania	Victoria	South Australia
Stock	Tasmania (TOF)	Victoria (PPBF, RLF, TF)	South Australia (MSF, NZRLF, SZRLF)
Stock status	↓		Negligible ^a
	Transitional–depleting	Undefined	
Indicators	CPUE	Catch	

CPUE = catch per unit effort; MSF = Marine Scalefish Fishery (South Australia); NZRLF = Northern Zone Rock Lobster Fishery (South Australia); PPBF = Port Phillip Bay Fishery (Victoria); RLF = Rock Lobster Fishery (Victoria); SZRLF = Southern Zone Rock Lobster Fishery (South Australia); TF = Trawl Fishery (Victoria); TOF = Tasmanian Octopus Fishery

a 'Negligible' means historically low catch; no stock status. *Octopus* spp. catch from the MSF in 2013 was 7.6 tonnes; average catch in the past 10 years was 14.3 tonnes.

Stock structure

Pale Octopus is distributed from the Great Australian Bight around Tasmania to southern New South Wales. There is evidence suggesting that Pale Octopus is a highly structured biological stock with discrete subpopulations in Bass Strait (less than 100 km apart) because of limited dispersal and isolation by distance, but further information is required to confirm the overall population structure across southern Australia^{1,2}. For the purposes of this assessment, the stock status is assessed at a jurisdictional level.

Stock status

Tasmania

In Tasmania, where most of the total commercial catch is taken, stock status is based on consideration of commercial catch-and-effort data, which are assessed by determining fishery performance indicators and comparing them with reference points. Commercial catch and catch per unit effort (CPUE) are used as proxies, as there are insufficient data to calculate fishing mortality or biomass. These are compared with the reference periods 2000–01 to 2009–10 for catch, and 2004–05 to 2009–10 for CPUE. Since November 2004, a 50-pot sampling program has been conducted in the fishery. Under this program, fishers are required to collect all octopuses caught in 50 randomly selected pots from a single line, representing 10 per cent of a standard commercial line.

In the Tasmanian Octopus Fishery, catches have fluctuated around 85 (±7) tonnes (t) since 2005–06 but reached a historical high of 117 t in 2012–13. Effort also fluctuated around 299 900 (±14 250) pot-lifts between

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b Department of Environment and Primary Industries, Victoria

c South Australian Research and Development Institute

2005–06 and 2011–12, but over the last two fishing seasons has increased to an average of 425 800 pot-lifts. The standardised CPUE, calculated from the 50-pot random sampling program, suggests a decline in catch rate, particularly over the past three fishing seasons (2011–12 to 2013–14), to around 60 per cent of the 2004–05 reference year. This was after CPUE fluctuated at around 88 per cent over the previous five fishing seasons. The unstandardised CPUE from the 50-pot random sampling program (0.32 octopuses per pot-lift) has been less than the lowest number of octopuses per pot-lift from the historical reference period (0.39 octopuses per potlift between 2004–05 and 2009–10), therefore exceeding the trigger reference point.

Although semelparous species such as Pale Octopus have high interannual variability in catch due to seasonality, and variations in recruitment, food availability, behaviour and individual migration³, the recent decline in CPUE, coupled with an increase in fishing effort, suggests that fishing mortality could be reducing the spawning biomass and affecting recruitment. Brooding female octopuses are the most vulnerable to fishing pressure, as they use pots as shelters to deposit their eggs^{4,5}. Consequently, the removal of brooding females may adversely affect egg production. Scientific studies have previously found evidence of size-selective fishing in Tasmania, with female weight-at-age decreasing and growth increasing across sampling seasons, potentially impacting egg production and future recruitment to the fishery⁵. The above evidence indicates that the stock is not yet considered to be in a recruitment overfished state, but the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, Pale Octopus in Tasmania is classified as a **transitional–depleting stock**.

Victoria

In Victoria, octopus is a byproduct species caught across various fisheries, primarily in the Rock Lobster Fishery. During the past decade, up to 90 fishers have reported landing octopus species, but catches have remained low, averaging 27.4 t over this period. Catch in 2013 was 24.9 t. Pale Octopus is undifferentiated from other octopus species in Victoria, and therefore stock assessment methods cannot be formally employed. Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Pale Octopus in Victoria is classified as an **undefined stock**.

Table 2: Pale Octopus biology^{4,6,7}

Longevity and maximum size	1.5 years; 1.2 kg
Maturity (50%)	Females 473 g, males <250 g

Figure 1: Distribution of reported commercial catch of Pale Octopus in Australian waters, 2013 (calendar year)

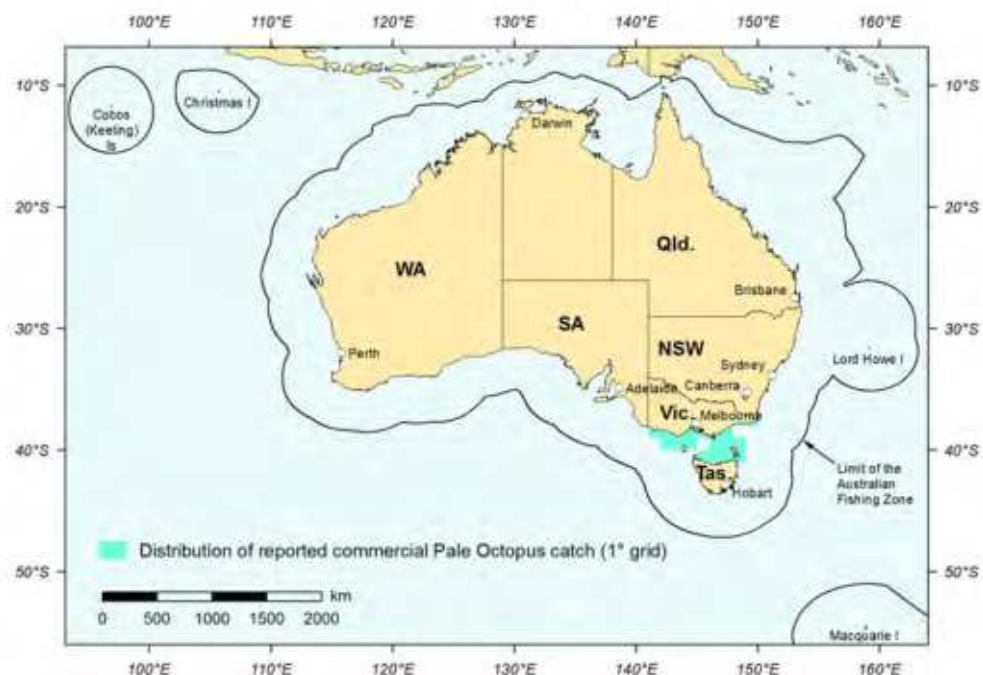


Table 3: Main features and statistics for Pale Octopus fisheries in Australia, 2013 (calendar year)

Jurisdiction	Tasmania	Victoria
Fishing methods		
Commercial		
Trap/pot	✓	✓
Fish/prawn trawl		✓
Net/seine		✓
Recreational		
Hand collection/hook/net/spear	✓	✓
Indigenous ^a		
Hand collection/hook/net/spear	✓	
Management methods		
Commercial		
Limited entry	✓	✓
Gear restrictions	✓	✓

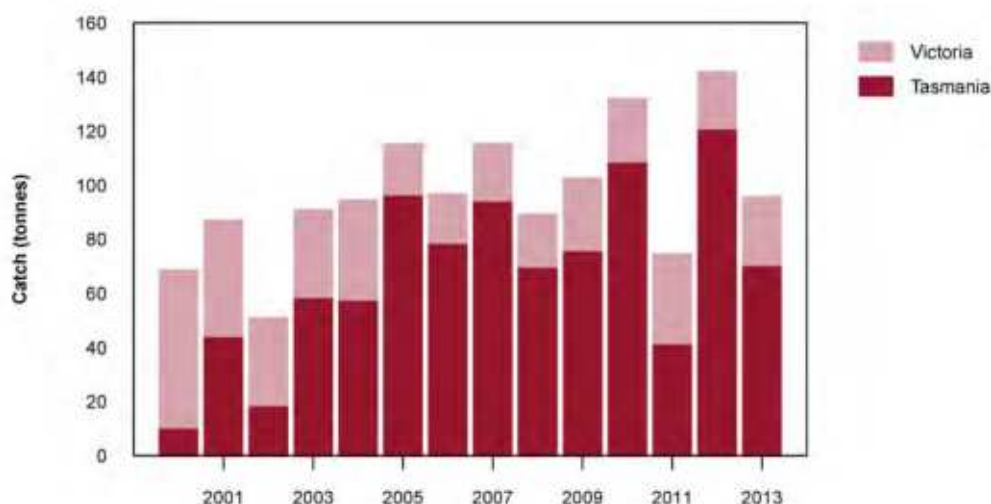
Jurisdiction	Tasmania	Victoria
Recreational		
Bag limits	✓	✓
Indigenous ^a		
Bag limits	✓	
Active commercial vessels		
	2 in TOF	6 in PPBF 66 in RLF 8 in TF
Catch		
Commercial	70.6 t in TOF	0.9 t in PPBF ^b 16.2 t in RLF ^b 7.8 t in TF ^b
Recreational	1149 octopus landed (2007–08)	Unknown
Indigenous ^a	Unknown	None
Markets		
Domestic	✓	✓
Export		

PPBF = Port Phillip Bay Fishery (Victoria); RLF = Rock Lobster Fishery (Victoria); TF = Trawl Fishery (Victoria); TOF = Tasmanian Octopus Fishery

^a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Pale Octopus.

^b In Victoria, Pale Octopus catch is undifferentiated from other octopus species.

Figure 2: Commercial catch of Pale Octopus in Australian waters, 2000 to 2013 (calendar years)



Note: In Victoria, Pale Octopus catch is undifferentiated from other octopus species.

Effects of fishing on the marine environment

- In Tasmania, fishing vessels for Pale Octopus do not operate at night, and no bait is used in the pots, so they do not attract seabirds⁸. Surface gear is minimal, encompassing two buoys and ropes for each surface line; this means that the likelihood of entanglement of marine mammals is lower than for rock lobster fisheries, which set more buoys and ropes⁸. The pots are lightweight and set on sandy bottom, and have been found to have little impact on benthic assemblages⁹.
- Bycatch in the octopus fishery in Tasmania is low, and protected species interactions have been minimal, with seals the only species reported. Seal interactions are relatively rare (28 interaction records since 2000–01), and result in lost catch and gear damage⁸. Entanglement of migrating whales in pot fisheries has been reported in Western Australia. No interactions with whales have been reported in Tasmania, despite Bass Strait covering part of the migratory route of Southern Right Whales⁸.

Environmental effects on Pale Octopus

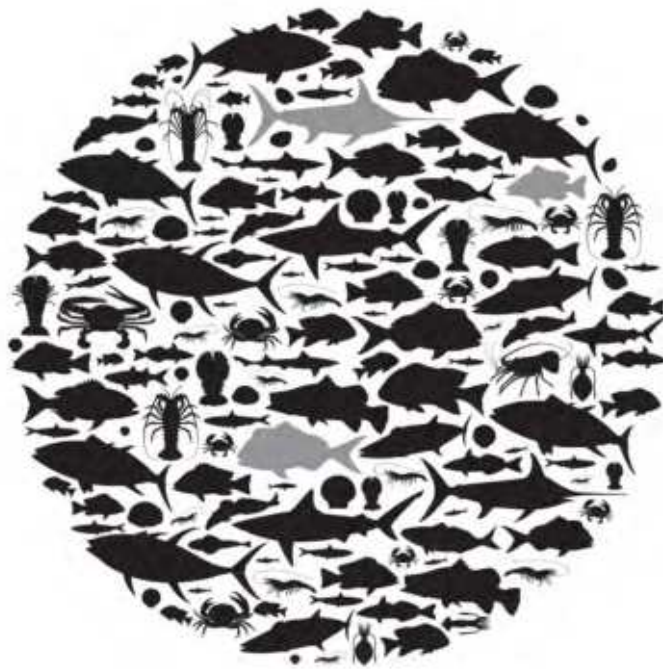
- Octopus species are known for having high individual growth plasticity¹⁰, short life spans (less than 2 years)¹¹ and biological processes (including growth and egg production) that are strongly influenced by environmental factors such as seasonal temperature^{3,4}. If environmental conditions are unfavourable during the optimal spawning period (late summer to early autumn), significant declines in recruitment can occur as a result of suboptimal growth, and reduced egg production and fecundity^{4,6}. Additionally, Pale Octopus hatched during summer and autumn may grow faster and mature earlier, with potentially higher fecundity due to warmer temperatures, than those hatched during winter and spring^{4,6}.

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Molluscs: *Squids*



7. Gould's Squid *Nototodarus gouldi*

Rocio Noriega^a, Justin Bell^b and Jeremy Lyle^b



Table 1: Stock status determination for Gould's Squid

Jurisdiction	Commonwealth, Tasmania
Stock	Southern Australian (CTS, GABTS, SSJF, TSF, WDTF)
Stock status	Sustainable
Indicators	Catch rates, total catch

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector (Commonwealth); SSJF = Southern Squid Jig Fishery (Commonwealth); TSF = Tasmanian Scalefish Fishery; WDTF = Western Deepwater Trawl Fishery (Commonwealth)

Stock structure

A single biological stock of Gould's Squid is assumed throughout southern Australian waters. Genetic studies are limited, but support this hypothesis¹. Analysis of chemical elements in statoliths has also shown that some Gould's Squid caught in Victorian waters and the Great Australian Bight were hatched in various regions off southern Australia². Status is reported at the biological stock level.

Stock status

Southern Australian biological stock

No formal stock assessment is available for the Gould's Squid biological stock in Australia. Gould's Squid is short lived (less than 1 year), spawns multiple times during its life, and displays highly variable growth rates, and size and age at maturity¹. These characteristics mean that the population can rapidly increase in biomass during favourable environmental conditions; it is therefore less susceptible to becoming recruitment overfished than longer-lived species. However, as the fishery targets individuals less than 1 year of age, there is potential for the population to be recruitment overfished if insufficient animals survive long enough to reproduce. The total fishing effort in the Southern Squid Jig Fishery (Commonwealth) decreased markedly from the peak fishing effort of 15 600 jig hours in 1997, to a historical low of 617 jig hours in 2010, although effort increased to moderate levels in 2011 to 2013. Changes in fishing effort largely reflect economic factors, rather than changes in Gould's Squid catch rates; high operating costs and low prices are the main drivers of

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the contraction of the Southern Squid Jig Fishery (Commonwealth)³. Fishing effort in the Commonwealth Trawl Sector and Great Australian Bight Trawl Sector has also substantially decreased since 2001^{4,5}. The above evidence indicates that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished⁶.

Combined total catch since 2000 has been below 3000 tonnes (t) (Figure 2), which is well below the historical peak of 7914 t taken by foreign jig fishing vessels in 1979–80. The nominal catch rates from the Commonwealth Trawl Sector and the Tasmanian Scalefish Fishery have been stable over time^{7,8}. Depletion analysis also suggests that the stock has not become recruitment overfished as a result of jigging or demersal trawling pressure in past seasons³. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished⁶.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Gould's Squid biology¹

Longevity and maximum size	<1 year; 350–400 mm ML
Maturity (50%)	6–9 months; 170–300 mm ML

ML = mantle length

Figure 1: Distribution of reported commercial catch of Gould's Squid in Australian waters, 2013 (calendar year)

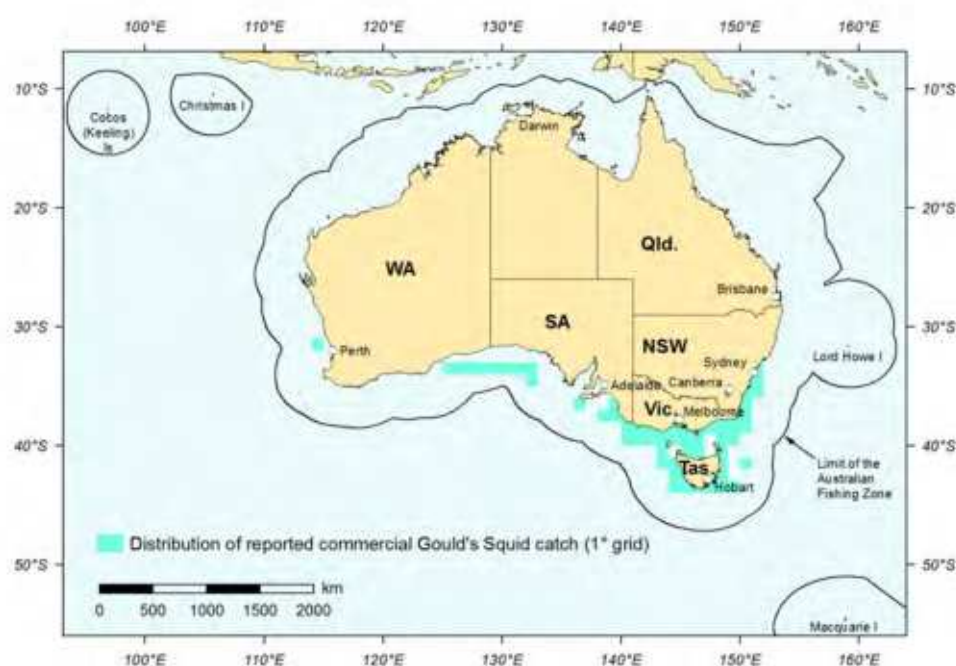


Table 3: Main features and statistics for Gould's Squid fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth	Tasmania
Fishing methods		
Commercial		
Automatic squid jigging machines	✓	✓
Hand jigging	✓	✓
Trawling	✓	
Recreational ^a		
Rod and line (squid jigs)		✓
Indigenous ^b		
		Unknown
Management methods		
Commercial		
Limited entry	✓	✓
Vessel restrictions	✓	✓
Effort limits	✓ (SSJF only)	
Spatial closures		✓
Trigger limits ⁹	✓	
Temporal closures		✓
Recreational ^a		
Bag limits		✓
Gear restrictions		✓
Temporal closures		✓
Spatial closures		✓
Indigenous ^b		
Bag limits		✓

Jurisdiction	Commonwealth	Tasmania
Active vessels		
	51 in CTS 6 in GABTS 8 in SSJF 2 in WDTF	7 in TSF ^c
Catch		
Commercial ^d	663 t in CTS 61 t in GABTS 166 t in SSJF <0.1 t in WDTF	976 t in TSF
Recreational ^a		37 t in 2007–08
Indigenous ^b		Unknown
Markets		
Domestic	✓	✓
Export	✓	

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector (Commonwealth); SSJF = Southern Squid Jig Fishery (Commonwealth); TSF = Tasmanian Scalefish Fishery; WDTF = Western Deepwater Trawl Fishery (Commonwealth)

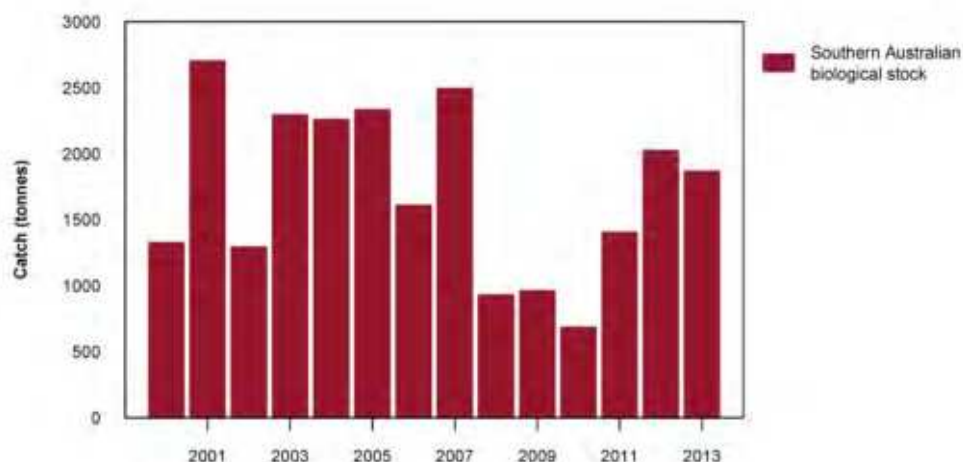
a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

c Vessels allowed to operate in the Tasmanian Scalefish Fishery need an automatic squid jig licence to operate more than four automatic jig machines. In 2013, squid were recorded in the landings of 28 vessels, but more than 99 per cent of the catch was from 7 vessels that hold automatic squid jig licences.

d Approximately 35 t (Great Australian Bight Trawl Sector) and 5 t (Commonwealth Trawl Sector) reported as Southern Calamari in 2013 could be misidentified Gould's Squid. The Australian Fisheries Management Authority is working to clarify this issue.

Figure 2: Commercial catch of Gould's Squid in Australian waters, 2000 to 2013 (calendar years)



Note: Catch includes Commonwealth Trawl Sector, Southern Squid Jig Fishery, Great Australian Bight Trawl Sector and Tasmanian Scalefish Fishery.

Effects of fishing on the marine environment

- Jig fishing methods are highly selective. An ecological risk assessment for the effect of fishing was completed for the Southern Squid Jig Fishery (Commonwealth) in 2006 and did not identify any indicators of threat to the environment from jig fishing¹⁰.
- There can be a substantial level of bycatch in the trawl sector fisheries. In 2006, mandatory requirements for otter trawls to use 90 mm square-mesh codend panels were introduced to reduce the catch of small species and juvenile fish¹¹.
- Interactions also occur with animals protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), including marine mammals (dolphins, seals and sea lions), seabirds, some shark species and seahorses and pipefish (syngnathids). These interactions are reported quarterly by the Australian Fisheries Management Authority¹² and on-board observer programs are used to validate the reporting in commercial logbooks.
- In 2007, the South East Trawl Fishing Industry Association 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 generally¹³. Operators have developed other mitigation protocols that have further reduced seal mortalities, including using breakaway ties that keep the net closed until it is below depths that seals regularly inhabit, adopting techniques to close the trawl opening during recovery to minimise opportunities for seals to enter the net, switching off gantry lights that are not required during night trawling to avoid attracting bait species and seals, and dumping offal only when the boat is not engaged in deploying or hauling gear¹³.
- In 2011, AFMA mandated individual vessel seabird management plans¹⁴. The seabird action plans are used in the Commonwealth Trawl Sector to mitigate the impacts of trawling on seabirds. Seabird mitigation measures include warp deflectors ('pinkys'), bird bafflers (a system of ropes and PVC piping that protects the warp cable) and seal excluder devices.
- The effects of trawl fishing on the marine environment are assessed through an environmental risk assessment and risk management framework and mitigated through spatial closures, and the implementation of bycatch and discard workplans in the Commonwealth Trawl Sector and Great Australian Bight Trawl Sector fisheries.

Environmental effects on Gould's Squid

- The Gould's Squid biological stock can vary significantly in abundance between years, and environmental conditions are widely acknowledged as influences on larval and juvenile survival². Environmental factors such as sea temperature and nutrient concentrations have also been linked to growth rate, particularly for females¹. Gould's Squid is a fast-growing species with a short life span¹, and the stock is able to respond rapidly when conditions are favourable. However, at any given time, the southern Australian stock comprises a single cohort of less than 1 year of age. This means that prolonged detrimental environmental conditions have the potential to reduce abundance for more than a year. Therefore, any detrimental environmental impact on recruitment has the potential to cause drastic impacts on abundance.

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8. Southern Calamari *Sepioteuthis australis*

Jeremy Lyle^a, Corey Green^b, Michael Steer^c, Amy Smoothey^d and Andrew Penney^e

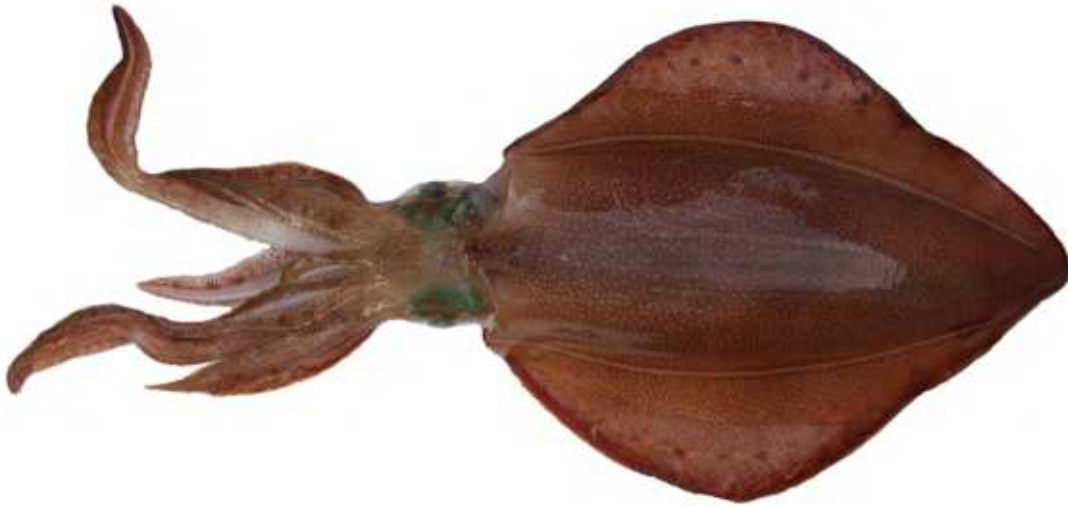


Table 1: Stock status determination for Southern Calamari

Jurisdiction	South Australia	Tasmania	Victoria	New South Wales	Commonwealth
<i>Stock</i>	South Australia (MSF, NZRLF, SAPF, SZRLF)	Tasmania (SF)	Victoria (CIF, ITF, OF, PPBF, WPF)	New South Wales (EGF, OHF, OTF, OTLF)	Commonwealth (CTS)
<i>Stock status</i>					
	Sustainable	Undefined	Sustainable	Undefined	Undefined
<i>Indicators</i>	Catch, effort, CPUE trends	Catch, effort, CPUE trends	Catch, effort, CPUE trends	Catch, effort, CPUE trends	Catch

CIF = Corner Inlet Fishery (Victoria); CPUE = catch per unit effort; CTS = Commonwealth Trawl Sector; EGF = Estuary General Fishery (New South Wales); ITF = Inshore Trawl Fishery (Victoria); MSF = Marine Scalefish Fishery (South Australia); NZRLF = Northern Zone Rock Lobster Fishery (South Australia); OF = Ocean Fishery (Victoria); OHF = Ocean Haul Fishery (New South Wales); OTF = Ocean Trawl Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales); PPBF = Port Phillip Bay Fishery (Victoria); SAPF = South Australia Prawn Fisheries; SF = Scalefish Fishery (Tasmania); SZRLF = Southern Zone Rock Lobster Fishery (South Australia); WPF = Western Port Bay Fishery (Victoria)

Stock structure

The biological stock structure across the distributional range of Southern Calamari is complex and potentially dynamic. It involves three genetic types with overlapping distributions, and possible stocks off Western Australia, South Australia, New South Wales and Tasmania (data are not available for Victoria)^{1,2}. Life history dynamics, and studies of movement and statolith microchemistry in Tasmania also suggest some localised biological stock structuring³. In the absence of definitive information on biological stock boundaries, stock status is reported at the jurisdictional level.

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^c South Australian Research and Development Institute

^d Department of Primary Industries, New South Wales

^e Australian Bureau of Agricultural and Resource Economics and Sciences

Stock status

South Australia

The most recent stock assessment for Southern Calamari⁴ in South Australia considered that the resource was being harvested within sustainable limits. Since this assessment, the statewide commercial catch of Calamari has remained relatively high, exceeding 400 tonnes (t) for the past 2 years. Recreational catch is likely to be similar. Catch rates have remained relatively high in both the jig and the hauling net sectors of the fishery, indicating that the biomass of this stock is unlikely to be recruitment overfished and the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, Southern Calamari in South Australia is classified as a **sustainable stock**.

Tasmania

In Tasmania, the fishery for Southern Calamari developed rapidly in the mid-1990s, with landings peaking at around 100 t between 1997–98 and 2003–04. Management interventions, such as seasonal closures on some key spawning grounds and the introduction of species-specific licences in the south-east, have spread subsequent fishing effort throughout the state and decreased both catch and effort targeted at the species. Catch-per-unit-effort trends have shown a decline in some areas, and egg abundances have declined in one of the key spawning grounds⁵. However, major changes in management have dramatically changed fishing practices; as a result, long-term catch-and-effort data are unavailable, and insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Southern Calamari in Tasmania is classified as an **undefined stock**.

Victoria

Victoria's 2008 stock assessment suggested that the abundance of Southern Calamari had increased since 1998 and that there was no need to change existing management arrangements⁶. The biomass of this stock was unlikely to be recruitment overfished at that time. Although catch has declined in the past 3 years (2011 to 2013), it remains consistent with long-term catch trends (going back more than 35 years), indicating that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, Southern Calamari in Victoria is classified as a **sustainable stock**.

New South Wales

Commercial landings in New South Wales have gradually declined in recent years, but catch rates are reasonably stable. Southern Calamari is mostly caught by ocean trawlers in the Sydney to Port Stephens area. Recreational anglers in New South Wales also take significant quantities of Southern Calamari in estuaries and near-shore ocean waters.

The biology of the species has not been studied in New South Wales, and no formal stock assessment has been undertaken. Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Southern Calamari in New South Wales is classified as an **undefined stock**.

Commonwealth

Commonwealth fishers take a small catch of Southern Calamari in the Danish-seine component of the Southern and Eastern Scalefish and Shark Fishery. This undoubtedly comprises individuals from biological stocks that spawn, and spend the majority of their lives, in inshore state waters. A larger quantity of squid caught in trawls and reported as Southern Calamari is probably Gould's Squid (*Nototodarus gouldi*) and is not included here. Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Southern Calamari in the Commonwealth is classified as an **undefined stock**.

Table 2: Southern Calamari biology^{1,7,8}

Longevity and maximum size	<1 year; 550 mm ML, 3–4 kg
Maturity (50%)	3–6 months; 150–200 mm ML

ML = mantle length

Figure 1: Distribution of reported commercial catch of Southern Calamari in Australian waters, 2013 (calendar year)

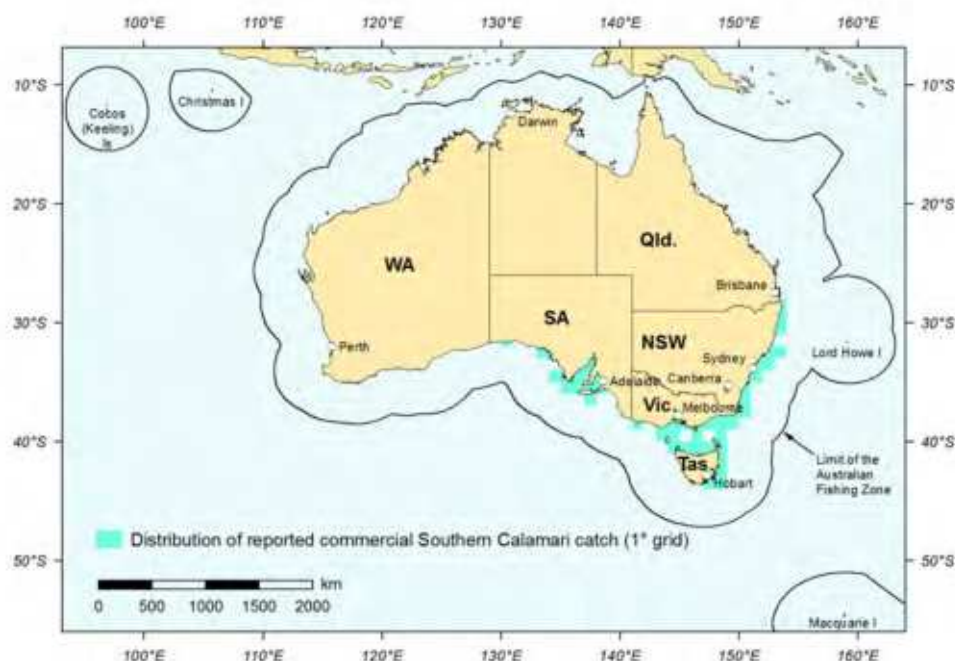


Table 3: Main features and statistics for Southern Calamari fisheries in Australia, 2013 (calendar year)

Jurisdiction	South Australia	Tasmania	Victoria	New South Wales	Commonwealth
Fishing methods					
Commercial					
Squid jigs	✓	✓	✓	✓	
Beach seine/haul net	✓	✓	✓	✓	
Dip net	✓	✓			
Spearfishing		✓			
Trawl	✓		✓	✓	✓

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SOUTHERN CALAMARI

Jurisdiction	South Australia	Tasmania	Victoria	New South Wales	Commonwealth
Recreational ^a					
Squid jigs	✓	✓	✓	✓	
Spearfishing		✓	✓		
Indigenous ^{b,c}					
Squid jigs	✓	✓		✓	
Spearfishing		✓			
Management methods					
Commercial					
Limited entry	✓	✓	✓	✓	✓
Size limits	✓				
Vessel restrictions	✓			✓	
Catch limits		✓			✓
Effort limits		✓	✓		✓
Gear limits	✓	✓	✓	✓	✓
Temporal closures (spawning season)		✓			
Spatial closures		✓			
Recreational ^a					
Bag limits	✓	✓	✓	✓	
Temporal closures (spawning season)		✓			
Spatial closures		✓			
Indigenous ^{b-e}					
Bag limits	✓	✓		✓	
Temporal closures (spawning season)		✓			
Spatial closures				✓	
Section 37(1)(c1), Aboriginal cultural fishing authority				✓	

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SOUTHERN CALAMARI

Jurisdiction	South Australia	Tasmania	Victoria	New South Wales	Commonwealth
Active vessels					
	229 in MSF 40 in SAPF 10 in NZRLF and SZRLF combined	60 in SF	16 in CIF 8 in ITF 3 in OF 23 in PPBF 1 in WPF	4 in EGF Confidential in OHF ^f 50 in OTF 12 in OTLF	11 in CTS
Catch					
Commercial	396 t in MSF 32 t in SAPF 2.8 t in NZRLF and SZRLF combined	66 t in SF	9 t in CIF <0.1 t in ITF <0.1 t in OF 21 t in PPBF <0.1 t in WPF	0.19 t in EGF Confidential in OHF ^f 29.2 t in OTF 0.23 t in OTLF	0.4 t in SESSF
Recreational ^a	300 t (2007–08)	45 t (2007–08)	45 t (2007)	10–40 t (annual)	
Indigenous ^{b–e}	Unknown	Unknown	Nil	Unknown	
Markets					
Domestic	✓	✓	✓	✓	✓
Export					

CIF = Corner Inlet Fishery (Victoria); CTS = Commonwealth Trawl Sector; EGF = Estuary General Fishery (New South Wales); ITF = Inshore Trawl Fishery (Victoria); MSF = Marine Scalefish Fishery (South Australia); NZRLF = Northern Zone Rock Lobster Fishery (South Australia); OF = Ocean Fishery (Victoria); OHF = Ocean Haul Fishery (New South Wales); OTF = Ocean Trawl Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales); PPBF = Port Phillip Bay Fishery (Victoria); SAPF = South Australia Prawn Fisheries; SF = Scalefish Fishery (Tasmania); SZRLF = Southern Zone Rock Lobster Fishery (South Australia); WPF = Western Port Bay Fishery (Victoria)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

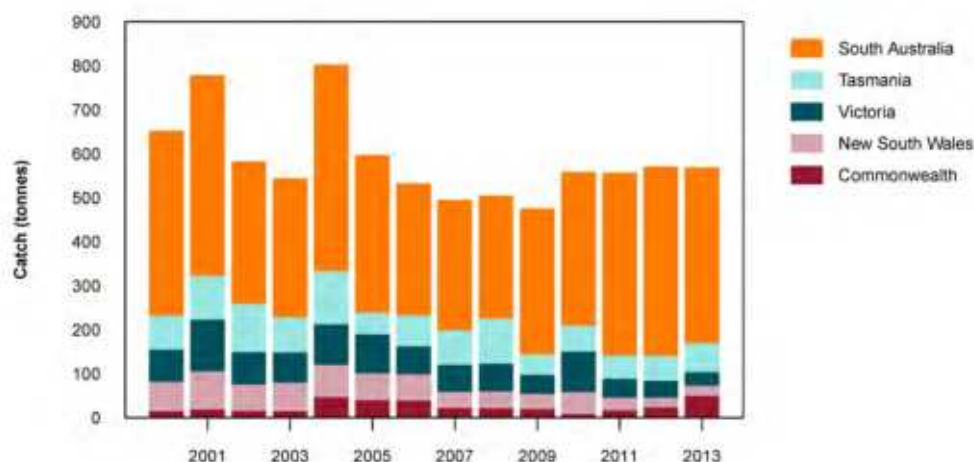
c In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (for example, different catch and size limits or equipment). The Indigenous category in Table 3 refers to customary fishing by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Southern Calamari.

d The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

e The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

f Confidentiality clauses prevent reporting of fishery statistics for fewer than six vessels in New South Wales.

Figure 2: Commercial catch of Southern Calamari in Australian waters from 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Beach seine/haul netting takes place over inshore seagrass habitats but has been shown to have negligible impact on seagrass or benthic invertebrate assemblages⁹. Jigs have little bycatch and do not negatively affect the environment.
- Trawling, used in the Commonwealth Trawl Sector and the Ocean Trawl Fishery (New South Wales), has potential for interactions with threatened, endangered and protected species. These fisheries have in place bycatch and discarding workplans or bycatch catch triggers to reduce these interactions and environmental impacts.
- In 2006, mandatory requirements for otter trawls to use 90 mm square-mesh codend panels were introduced to reduce the catch of small species and juvenile fish in the Commonwealth Trawl Sector¹⁰.
- Interactions also occur with animals protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), including marine mammals (dolphins, seals and sea lions), seabirds, some shark species and seahorses and pipefish (syngnathids). These interactions are reported quarterly by the Australian Fisheries Management Authority¹¹ and on-board observer programs are used to validate the reporting in commercial logbooks.
- In 2007, the South East Trawl Fishing Industry Association 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 generally¹². Operators have developed other mitigation protocols that have further reduced seal mortalities, including using breakaway ties that keep the net closed until it is below depths that seals regularly inhabit, adopting techniques to close the trawl opening during recovery to minimise opportunities for seals to enter the net, switching off gantry lights that are not required during night trawling to avoid attracting bait species and seals, and dumping offal only when the boat is not engaged in deploying or hauling gear¹².
- In 2011, AFMA mandated individual vessel seabird management plans¹³. The seabird action plans are used in the Commonwealth Trawl Sector to mitigate the impacts of trawling on seabirds. Seabird mitigation measures include warp deflectors ('pinkys'), bird bafflers (a system of ropes and PVC piping that protects the warp cable) and seal excluder devices.
- The effects of trawl fishing on the marine environment are assessed through an environmental risk assessment and risk management framework and mitigated through spatial closures, and the implementation of bycatch and discard workplans in the Commonwealth Trawl Sector.

- Danish-seining has the potential to affect seahorses and pipefish (syngnathids) because Danish-seiners operate in relatively shallow waters and use nets with a small mesh size. An ecological risk assessment (ERA) indicated that the Spiny Pipehorse was at low risk because the fishery overlaps with only a small portion of the range of this species¹⁴.

Environmental effects on Southern Calamari

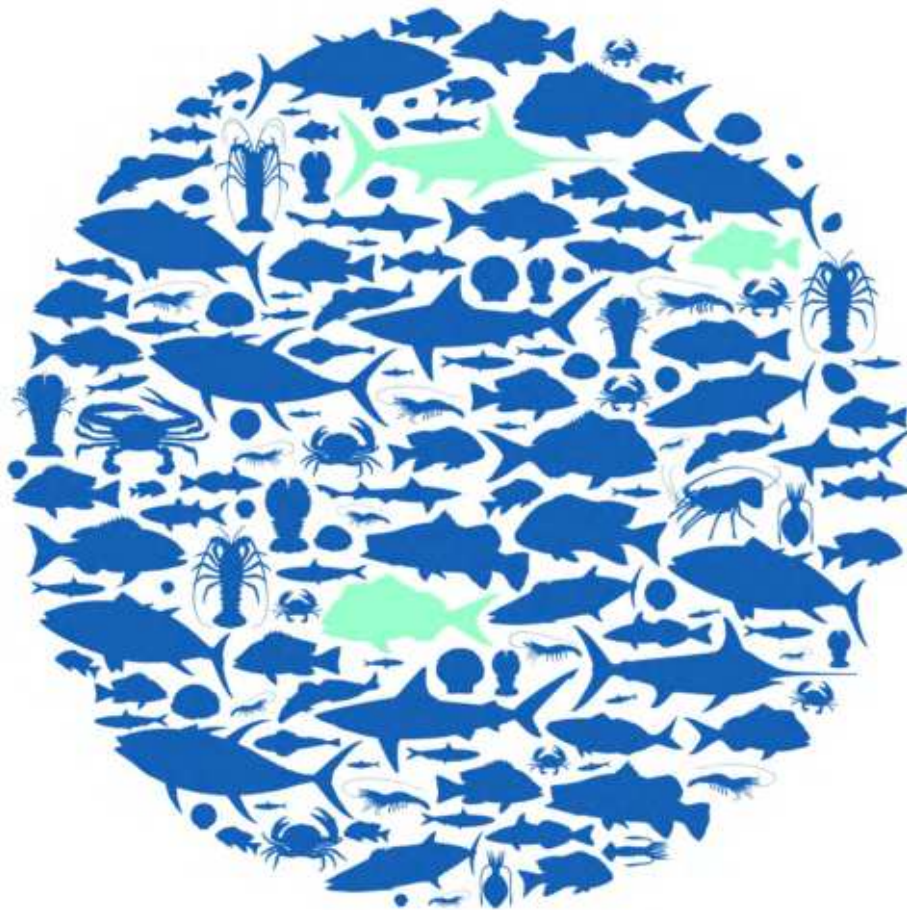
- Southern Calamari has a highly variable life cycle. The influence of environmental factors on survival, growth and reproductive investment is complex and varies considerably from year to year⁸; the mechanisms remain poorly understood.
- Spawning occurs in shallow inshore waters, with egg mop deposits attached to seagrass, macro-algae and reef substrates¹⁵. Environmental pressures on these habitats include the effects of coastal development, marine pollution, ocean warming and changing weather patterns¹⁶. These pressures have the potential to influence spawning dynamics and success. It is also likely that seasonal environmental changes (such as changes in water temperature over preferred spawning areas) have an effect on annual spawning and recruitment success, contributing to the high interannual variability in biomass of this species¹⁷.

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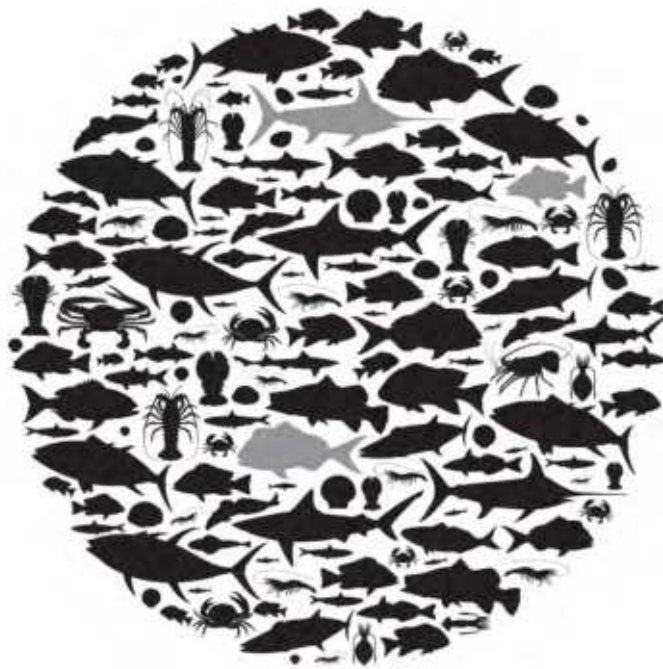
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Crustaceans



Crustaceans: *Crabs*



9. Blue Swimmer Crab *Portunus armatus* (formerly *Portunus pelagicus*)

Danielle Johnston^a, Stephen Wesche^b, Craig Noell^c and Daniel Johnson^d



Table 1: Stock status determination for Blue Swimmer Crab

Jurisdiction	Western Australia				
Stock	Shark Bay (SBCIMF, SBPMF)	Cockburn Sound (CSCMF)	Peel–Harvey Estuary (PHECF)	Western Australian north coast (EGPMF, NBPMF, PDCF)	Western Australian south-west coast (EF, JASDGLMF, MBDCF, SCEMF, SCRCF, SWTMF, WSCMF)
Stock status					
	Environmentally limited	Environmentally limited	Sustainable	Sustainable	Sustainable
Indicators	Catch, CPUE, fishery-independent juvenile and breeding stock abundance	Catch, CPUE, fishery-independent juvenile and residual index, egg production index	Catch, CPUE	Catch, CPUE	Catch

CPUE = catch per unit effort; CSCMF = Cockburn Sound (Crab) Managed Fishery (Western Australia); EF = Estuaries Fisheries (Condition) (Western Australia); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); JASDGLMF = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Zone 1 and Zone 2) (Western Australia); MBDCF = Mandurah to Bunbury Developing Crab Fishery (Western Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); PDCF = Pilbara Developmental Crab Fishery (Western Australia); PHECF = Peel–Harvey Estuary Crab Fishery (Area 2 of West Coast Estuarine Managed Fishery) (Western Australia); SBCIMF = Shark Bay Crab (Interim) Managed Fishery (Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); SCRCF = Swan and Canning

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Rivers Crab Fishery (Area 1 of West Coast Estuarine Managed Fishery) (Western Australia); SWTMF = South West Trawl Managed Fishery (Western Australia); WSCMF = Warnbro Sound Crab Managed Fishery (Western Australia)

Table 1 continued

Jurisdiction	Queensland	South Australia			New South Wales
Stock	North-eastern Australian (BSCF, ECOTF)	Spencer Gulf (BCF, MSF)	Gulf St Vincent (BCF, MSF)	West coast (MSF)	South-eastern Australian (EGF, OTF)
Stock status			↑		
	Sustainable	Sustainable	Transitional–recovering	Undefined	Undefined
Indicators	Catch, CPUE, fishery-independent juvenile abundance	Fishery-independent legal-sized and pre-recruit abundance	Fishery-independent legal-sized and pre-recruit abundance	Catch	Catch, CPUE

BCF = Blue Crab Fishery (South Australia); BSCF = Blue Swimmer Crab Fishery (Queensland); CPUE = catch per unit effort; ECOTF = East Coast Otter Trawl Fishery (Queensland); EGF = Estuary General Fishery (New South Wales); MSF = Marine Scalefish Fishery (South Australia); OTF = Ocean Trawl Fishery (New South Wales)

Stock structure

Blue Swimmer Crab is distributed in Australia from Cape Naturaliste in Western Australia north to the Northern Territory, across Queensland, down the east coast and to the New South Wales – Victoria border. They are also found in the warmer waters of the South Australian gulfs¹. While most chapters in the *Status of key Australian fish stocks reports* consider a single fishery to be a management unit, the term ‘management unit’ in this chapter can also describe a compilation of multiple fisheries.

In Western Australia, stock delineation of Blue Swimmer Crab is unknown; for this state, reporting of stock status is therefore at the management unit level^{2,3}. There are three major management units off the Western Australian coast between Cape Naturaliste and Nickol Bay (Shark Bay, Cockburn Sound and Peel–Harvey Estuary). The two other Western Australian management units discussed in this chapter each comprise several minor fisheries.

In South Australia, research has identified three separate biological stocks of Blue Swimmer Crab—in Spencer Gulf, in Gulf St Vincent and on the coastline west of the Eyre Peninsula^{4,5}; the latter is referred to as the ‘west coast’ biological stock. Stock structure on the east coast of Australia is uncertain, involving overlapping stocks or a semicontinuous stock². Due to the geographic separation between the major fishing grounds for Blue Swimmer Crab in New South Wales and Queensland, they are managed as two separate biological stocks. In each of the above cases where biological stock delineation is known, reporting is at the biological stock level.

Stock status

Shark Bay management unit

The Shark Bay fishery for Blue Swimmer Crab expanded rapidly between 2000 and 2010. In 2010, it was Australia’s highest producing Blue Swimmer Crab fishery, with landings of 828 tonnes (t) (collectively caught by the dedicated crab trap sector and as byproduct by the trawl sector). In late 2011, the crab stock in Shark Bay was found to be at historically low levels as a result of recruitment failure and the mortality of adult stock. This was attributed to the unprecedented environmental conditions that were experienced in Shark Bay during late 2010 to early 2011: the marine heatwave in summer 2010–11, and two flooding events, with associated increased turbidity, in December 2010 and February 2011. These events also affected a number of fish stocks in the Gascoyne region. The low stock abundance of Blue Swimmer Crabs was confirmed by a fishery-independent trawl survey in November 2011 and by the very low commercial crab trap catch rates

experienced at that time (less than 1 kg per trap-lift). Above-average water temperatures continued in the summers of 2011–12 and 2012–13.

The decline in abundance led to a voluntary closure of both the trap and trawl commercial sectors of the crab fishery in April 2012. This was followed by intensive monitoring of the resource and its recovery, using a combination of fishery-independent trawl- and trap-based surveys. These surveys were designed to target key deepwater trawl grounds and inshore trapping grounds that historically have been used to target crabs. Only a partial recovery of the crab stock in Shark Bay occurred during 2012 and 2013, with improved biomass levels of legal (equal to or greater than 135 mm carapace width) and sublegal (less than 135 mm carapace width) crabs in 2013, as well as strong recruitment pulses. However, these levels remain well below target levels for spawning biomass and recruitment, and there is insufficient evidence to suggest that stock biomass has recovered above the limit reference point. Nevertheless, the data provided some confidence for a limited commercial fishing season in 2013–14, based on a total allowable commercial catch (TACC) of 400 t.

A formal catch allocation within the commercial sectors was made in June 2013 (trap sector—66 per cent, prawn trawl sector—33.8 per cent, scallop trawl sector—0.2 per cent). The fishery is also being transitioned from an interim status to a fully managed status, which will incorporate a system of individual transferable quotas of entitlement, to apply across all three commercial sectors in Shark Bay. It is envisaged that the new management plan will be implemented in early 2015.

The above evidence indicates that spawning stock biomass has decreased to a point at which average recruitment levels are significantly reduced. This is primarily a result of substantial environmental changes, rather than overfishing, so the stock cannot be classified as recruitment overfished. Fisheries management has responded appropriately to the environmental change in productivity, and the evidence indicates that the current level of fishing pressure will allow the stock to continue to recover.

On the basis of the evidence provided above, the management unit is currently classified as an **environmentally limited stock**.

Cockburn Sound (Crab) Managed Fishery (Western Australia) management unit

Historically, variations in recruitment of Blue Swimmer Crabs in Cockburn Sound have depended on environmental conditions, which have resulted in large fluctuations in stock abundance and the annual commercial catch⁶. A shift by commercial fishers from using set nets to traps in the mid-1990s resulted in a marked increase in mean annual crab landings. Following a series of high catches (250–350 t) in the late 1990s, the catch declined significantly^{7,8}. Fishery-independent surveys indicated that low recruitment was generated by high fishing pressure, combined with poor environmental conditions, which reduced the spawning stock to low levels and required the closure of the fishery in December 2006^{6–8}. Recovery of the spawning stock and subsequent recruitment was slower than expected; fishery-independent trawl surveys indicated that the strength of recruitment and the spawning stock biomass did not improve sufficiently to reopen the fishery until December 2009. The fishing season for 2010 was restricted to 3.5 months to ensure that the catch level and size/sex composition would enable continued recovery of the spawning stock biomass. At this time, the fishery was considered as transitional–recovering.

Based on improving abundances of juveniles (0+ years) and residuals (1+ years), and egg production levels in 2010, 2011 and 2012, management restrictions were eased. This included lengthening the season to 6 months (December–June) and decreasing in the minimum size to the pre-closure size limit of 130 mm carapace width, while retaining the 20 per cent reduction in trap numbers⁹. However, catch did not improve significantly, remaining at around 50 t, with catch rates declining significantly through each of the 2010, 2011 and 2012 fishing seasons, from 1.1 kg per trap-lift to 0.5 kg per trap-lift. In 2013, despite a slight increase in catch to 62 t, fishery-independent trawl surveys indicated that there had been low recruitment, with levels similar to those preceding the closure in 2006. Although egg production (based on mature female abundance) in 2012 was acceptable, a very low proportion of berried females observed during commercial monitoring and fishery-independent trawl surveys between September 2012 and January 2013 may explain the very low recruitment observed in 2013. These low numbers of berried females may be attributed to a lack of growth and moulting of a large cohort of sublegal crabs that occurred over summer 2011–12. The role of the 2010–11 heatwave in the recruitment failure is not clear; some preliminary evidence suggests that crabs in Cockburn Sound were in poor nutritional condition, possibly due to a lack of prey. On this basis, an adaptive management approach was undertaken for the 2013–14 season, with the fishery closing early as a result of a very low stock biomass and low egg production.

The above evidence indicates that spawning stock biomass is likely to have decreased to a point at which average recruitment levels have been significantly reduced. This is primarily a result of substantial environmental changes, rather than overfishing, so the stock cannot be classified as recruitment overfished. Fisheries management has responded appropriately to the environmental change in productivity, and the evidence indicates that the current level of fishing pressure will allow the stock to continue to recover.

On the basis of the evidence provided above, the management unit is classified as an **environmentally limited stock**.

Peel–Harvey Estuary Crab Fishery (Western Australia) management unit

The gradual conversion from targeting Blue Swimmer Crabs using gillnets to using hourglass traps in the Peel–Harvey Estuary between the mid-1990s and early 2000s resulted in an increase in annual crab catches, largely as a result of the increased efficiency of the traps. Conversion to traps increased crab fishing in autumn and winter, but most (62 per cent) of the catch and the highest catch rates are still taken between December and March¹⁰. Commercial catch levels have generally ranged between 50 and 100 t annually. A recreational survey conducted in the Peel–Harvey Estuary during 2007–08 estimated that the recreational take accounted for an additional 110–180 t, approximately 60–70 per cent of the total catch¹⁰.

Since complete gear conversion in 2001, annual commercial catch rates have fluctuated between 0.7 and 1.4 kg per trap-lift, but have generally remained above 1 kg per trap-lift. In 2010, catch per unit effort (CPUE) was 1.17 kg per trap-lift^{9,10}, and the stock was not considered to be recruitment overfished. In 2013, a catch of 107 t and a CPUE of 1.4 kg per trap-lift were the highest on record. The high catch and CPUE are within target ranges and well above threshold reference levels, indicating that the stock is currently fished at sustainable levels. The biomass of this stock is therefore unlikely to be recruitment overfished. The breeding stock in this region has additional protection because the size at maturity (86–98 mm carapace width) is well below the legal minimum size (127–130 mm). Spawning occurs outside the estuary following flushing of crabs from the estuary during winter, providing the spawning stock with further spatial protection. The protection offered by minimum size limits also ensures that fishing mortality is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, this management unit is classified as a **sustainable stock**.

Western Australian north coast management unit

The Western Australian north coast management unit is made up of a dedicated minor developing crab trap fishery and crab taken as byproduct in prawn trawl fisheries. Catch for these crab fisheries in 2013 ranged from 0.5 t in the Exmouth Gulf Prawn Managed Fishery and 7 t as byproduct in the same fishery to 16 t in the Pilbara Developmental Crab Fishery, with relatively low effort over large spatial areas. Catch and catch-rate data for the dedicated crab trap fishery (Pilbara Developmental Crab Fishery) indicate that stocks are fished at sustainable levels. The above evidence indicates that the biomass in this management unit is unlikely to be recruitment overfished and that current levels of fishing mortality are unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Western Australian south-west coast management unit

The Western Australian south-west coast management unit is made up of a number of dedicated minor crab trap and gillnet fisheries, as well as crab taken as byproduct in other net and trawl fisheries. Catch for these crab fisheries in 2013 ranged from less than 0.1 t in the Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery to 29 t in the Warnbro Sound Crab Managed Fishery and 32 t in the South Coast Estuarine Managed Fishery. Catch and catch-rate data for dedicated crab trap (Warnbro Sound Crab Managed Fishery, Mandurah to Bunbury Developing Crab Fishery) and gillnet (Swan and Canning Rivers Crab Fishery) fisheries indicate that stocks are fished at sustainable levels. The above evidence indicates that the biomass in this management unit is unlikely to be recruitment overfished and that current levels of fishing mortality are unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

North-eastern Australian biological stock

The two fisheries that target the north-eastern Australian biological stock of Blue Swimmer Crab operate primarily in southern Queensland, in an inshore and an offshore area. Before 1998, the major Blue Swimmer Crab fishery area was the inshore area, in and around Moreton Bay. Catch, effort and catch rates increased in the offshore area in 1998 when the fishery expanded into this region, which previously was lightly fished. Offshore catch and catch rate peaked in 2003, when the offshore catch contributed 75 per cent of the total catch in the fishery.

Since 2003, catch and effort have declined almost as rapidly as they increased. By 2013, they were at levels similar to those before the expansion. This rise and subsequent fall of catch and effort in the offshore area is of concern, and indicates a decline in fishable biomass for the offshore area and the biological stock as a whole. The catch and catch rates for the whole biological stock have shown a declining trend in recent years¹¹, with total recorded catch in 2013 being the lowest since 1997. A formal stock assessment is in progress to better determine current biomass levels for the whole biological stock. Fishery-independent recruitment surveys¹¹ show that recruitment has remained stable in the inshore area over the past 5 years, although limit reference points have not been established yet. The declining catch rate trend, driven by the offshore component, indicates that the biomass is likely to be declining. However, the biomass of the stock is not yet considered to be recruitment overfished.

Spatial closures within the Moreton Bay, Great Sandy Strait and Great Barrier Reef marine parks ensure that a substantial proportion of the Blue Swimmer Crab biomass is protected from fishing mortality. Management arrangements in Queensland prohibit the take of female crabs, and a minimum legal size limit ensures that a high proportion of male Blue Swimmer Crabs have an opportunity to mate before recruitment into the fishery. Blue Swimmer Crab biomass is believed to be linked to strength and duration of freshwater flow events, but no data are available to quantify the impact of environmental factors on natural mortality in recent years. It is unclear what effect the declining biomass in the offshore fishery area will have on stock recruitment, but current protection should be sufficient to ensure that fishing mortality will not cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Spencer Gulf biological stock

In South Australia, TACC levels have been set since 1996 that aim to harvest Blue Swimmer Crab resources within ecologically sustainable limits and protect the species from becoming recruitment overfished. Since 1999–2000, the TACC has been set at a level below the maximum historical catch for the fishery. A minimum legal size of 11 cm carapace width is enforced. Crabs close to the minimum legal size are approximately 14–18 months old and sexually mature, and females produce at least two batches of eggs within one season¹².

The primary measure of status for the Spencer Gulf biological stock is the relative abundance of legal-sized and pre-recruit crabs obtained in fishery-independent pot surveys, which have been conducted in most years since 2002. Relative abundance is compared with limit reference points that are defined in the South Australian Blue Crab Fishery management plan¹³. These reference points were set at the lower end of the observed range of relative abundances in the reference period 2002 to 2010, to ensure that relative abundance remains within the range of historical values during a period when the TACC was constant and considered to be harvested sustainably.

No survey was conducted in the Spencer Gulf fishing zone in 2013 because of a high abundance of pre-recruits in the 2012 survey, which permitted the option in the management plan to skip a survey. Relative abundance of legal-sized crabs in 2012 (9.2 crabs per pot-lift) was above the average for the 9-year reference period (6.9 crabs per pot-lift; range 5.1–9.1 crabs per pot-lift) and above the limit reference point (5 crabs per pot-lift). Relative abundance of pre-recruits in 2012 (8.8 crabs per pot-lift) was above the average for the 9-year reference period (5.3 crabs per pot-lift; range 2.3–10.1 crabs per pot-lift) and above the limit reference point (2 crabs per pot-lift). Given these abundance levels and the stable commercial catch history throughout the survey period¹⁴, the biological stock is not considered to be recruitment overfished.

In 2012–13, the TACC was 381.7 t, and almost all of this (377.4 t) was landed. This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock in this management unit is classified as a **sustainable stock**.

Gulf St Vincent biological stock

The process for determining the status of the Gulf St Vincent biological stock is the same as for the Spencer Gulf stock, using a similar fishery-independent pot survey design, and the same definition and usage of limit reference points.

Relative abundance of legal-sized crabs in 2013 (1.4 crabs per pot-lift) was below the average for the 9-year reference period (3.2 crabs per pot-lift; range 1.6–4.7 crabs per pot-lift) and just below the limit reference point (1.5 crabs per pot-lift). Relative abundance of pre-recruits in 2013 (1.2 crabs per pot-lift) was below the average for the 9-year reference period (4.4 crabs per pot-lift; range 0.4–10.7 crabs per pot-lift) and just below the limit reference point (1.5 crabs per pot-lift), although it was above the abundance in 2012 (0.8 crabs per pot-lift). Although the limit reference point was not developed to explicitly define the level below which the stock is recruitment overfished, the above evidence indicates that the biomass of this stock may be recruitment overfished.

In 2012–13, the TACC was 245.1 t, but only around half (53 per cent—129.0 t) was landed. In response to low relative abundances of pre-recruit crabs in the 2012 survey, a 6-month closure, a 20 per cent reduction in the TACC, and a 50 per cent reduction in recreational bag and boat limits were put in place for the 2013–14 season to promote stock recovery. Although the stock response to these actions will not be known until the stock assessment for the 2013–14 season is available (in 2015), supplementary fishery-dependent pot-sampling data from January to June 2013 indicated an increase in the abundance of pre-recruit crabs¹⁴.

Taking into account the management arrangements to promote stock recovery, and the small but measurable improvements in the abundance of pre-recruits in the fishery-independent survey and supplementary fishery-dependent sampling in 2013¹⁴, increases in the abundance of legal-sized and pre-recruit crabs in the 2014 survey would also be required to demonstrate further recovery of the stock. The above evidence indicates that the current level of fishing pressure should allow the stock to recover from its recruitment overfished state.

On the basis of the evidence provided above, the biological stock is classified as a **transitional–recovering stock**.

West coast biological stock

Blue Swimmer Crabs are harvested in low quantities (generally less than 50 t annually) on the west coast of South Australia as part of the Marine Scalefish Fishery. Fishers in this fishery target a range of species, and effort patterns generally reflect changes in seasonal abundance of the various species and their market prices. As for the Spencer Gulf and Gulf St Vincent biological stocks, a minimum legal size of 11 cm for Blue Swimmer Crab is enforced, under the assumption that growth rates and size at sexual maturity are similar for the west coast.

In 2013, 58 t was landed from the west coast. Given the multispecies nature of the Marine Scalefish Fishery, and the sustained low annual catches of Blue Swimmer Crabs in the fishery, it is unlikely that the west coast biological stock is recruitment overfished; however, insufficient information is available to classify its status.

On the basis of the evidence provided above, the biological stock is currently classified as an **undefined stock**.

South-eastern Australian biological stock

Blue Swimmer Crab occurs in coastal and estuarine waters along the New South Wales coastline. Recreational landings are not well documented but are thought to be significant, and occur throughout the range¹⁵. Five estuaries account for 95 per cent of commercial landings (the most important being Wallis Lake). New South Wales Blue Swimmer Crab populations are at the southern end of the species distribution along the east coast and have a limited spawning period (November–February), rather than the year-round spawning that occurs in more northern latitudes¹⁶. Commercial landings and catch rates from crab trapping have declined in recent years, and the majority of the catch is now reported from fish traps. Recreational landings are likely to be greater than the commercial catch, but no recent estimates are available. Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

Table 2: Blue Swimmer Crab biology^{17–19}

Longevity and maximum size	3–4 years; ~200 mm CW
Maturity (50%)	Varies among locations; 6–14 months; 86–98 mm CW

CW = carapace width

Figure 1: Distribution of reported commercial catch of Blue Swimmer Crab in Australian waters, 2013 (calendar year)

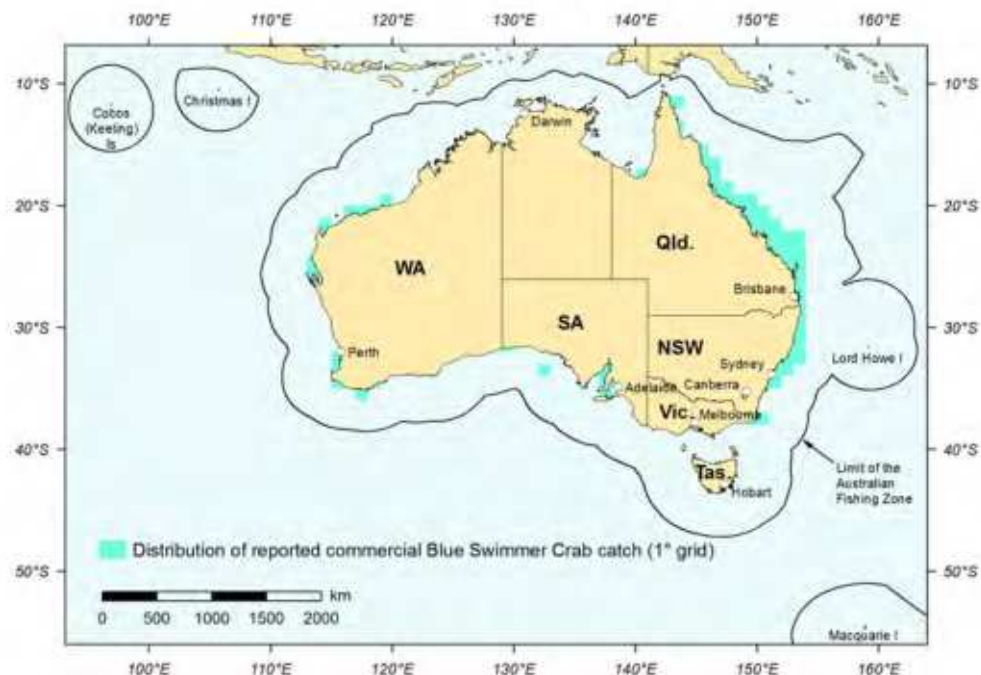


Table 3: Main features and statistics for Blue Swimmer Crab fisheries in Australia, 2013 (calendar year)

Jurisdiction	Western Australia	Queensland	South Australia	New South Wales
Fishing methods				
Commercial				
Crab trap	✓	✓	✓	✓
Gillnet	✓			✓
Haul net	✓			✓
Otter trawl	✓	✓		✓

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
BLUE SWIMMER CRAB

Jurisdiction	Western Australia	Queensland	South Australia	New South Wales
Recreational ^a				
Crab trap	✓	✓		✓
Drop net	✓		✓	
Diving	✓		✓	
Scoop net/dip net	✓			✓
Hook and line				✓
Indigenous				
Traditional apparatus		✓		
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Spatial zoning	✓		✓	✓
Vessel restrictions	✓			✓
Gear restrictions	✓		✓	✓
Effort limits	✓			
Size limits	✓	✓	✓	✓
Protection of female crabs		✓		
Protection of egg-bearing females	✓		✓	✓
Spatial closures	✓	✓	✓	✓
Temporal closures	✓		✓	
Total allowable catch	✓ (SBCIMF only)	✓ (ECOTF only)	✓	

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
BLUE SWIMMER CRAB

Jurisdiction	Western Australia	Queensland	South Australia	New South Wales
Recreational				
Size limits	✓	✓	✓	✓
Protection of female crabs		✓		
Protection of egg-bearing females	✓		✓	✓
General recreational licence or fishing boat licence (not species specific)	✓			✓
Spatial closures	✓	✓	✓	✓
Boat limits	✓		✓	
Bag limits	✓		✓	✓
Gear restrictions		✓	✓	✓
Indigenous ^{a,b}				
Gear restrictions		✓		
Section 37(1)(c1), Aboriginal cultural fishing authority				✓
Active vessels				
	1 in EF 4 in CSCMF 6 in EGPMF 1 in JASDGDLMF 2 in MBDCF 2 in NBPMF 1 in PDCF 10 in PHECF 3 in SBCIMF 18 in SBPMF 23 in SCEMF 1 in SCRCF 2 in SWTMF 1 in WSCMF	121 in BSCF 211 in ECOTF	6 in BCF 33 in MSF	130 in EGF 51 In OTF

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
BLUE SWIMMER CRAB

Jurisdiction	Western Australia	Queensland	South Australia	New South Wales
Catch				
Commercial	<0.5 t in EF 61 t in CSCMF 7 t in EGPMF <0.1 t in JASDGLMF 11 t in MBDCF <0.5 t in NBPMF 16 t in PDCF 107 t in PHECF 56 t in SBCIMF 16 t in SBPMF 32 t in SCEMF 8 t in SCRCF 1 t in SWTMF 29 t in WSCMF	342 t in BCSF 42 t in ECOTF	513 t in BCF 62 t in MSF	99 t in EGF 5 t in OTF
Recreational	97 t statewide ^c (2011–12) ²⁰	157 t (2005) ²¹	284 t (2007–08) ²²	223 t statewide (2000)
Indigenous	Unknown	Unknown	Unknown	
Markets				
Domestic	✓	✓	✓	✓
Export	✓			

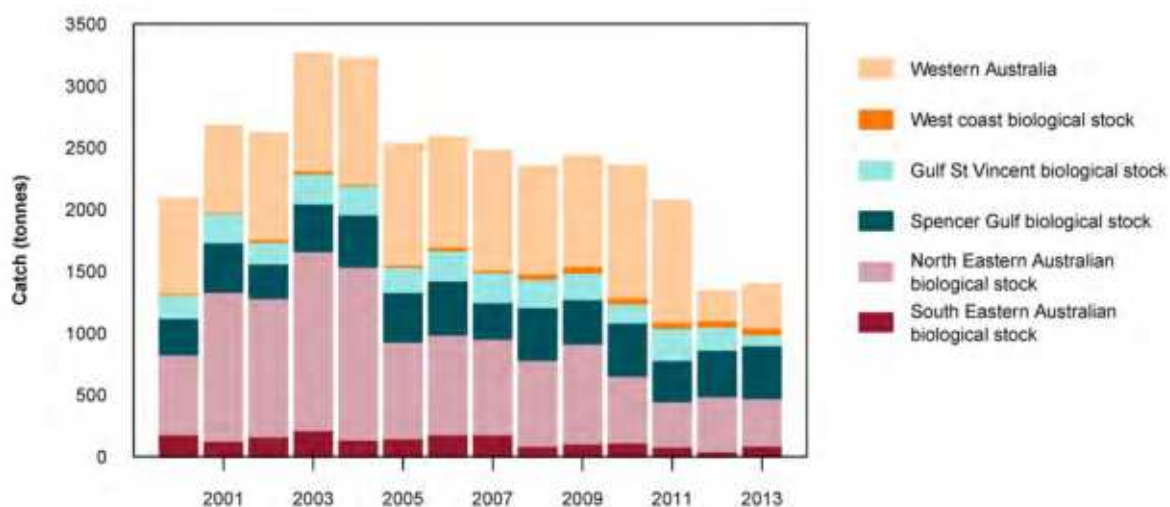
BCF = Blue Crab Fishery (South Australia); BCSF = Blue Swimmer Crab Fishery (Queensland); CSCMF = Cockburn Sound (Crab) Managed Fishery (Western Australia); ECOTF = East Coast Otter Trawl Fishery (Queensland); EF = Estuaries Fisheries (Condition) (Western Australia); EGF = Estuary General Fishery (New South Wales); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); JASDGLMF = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Zone 1 and Zone 2) (Western Australia); MBDCF = Mandurah to Bunbury Developing Crab Fishery (Western Australia); MSF = Marine Scalefish Fishery (South Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); OTF = Ocean Trawl Fishery (New South Wales); PDCF = Pilbara Developmental Crab Fishery (Western Australia); PHECF = Peel–Harvey Estuary Crab Fishery (Area 2 of West Coast Estuarine Managed Fishery) (Western Australia); SBCIMF = Shark Bay Crab (Interim) Managed Fishery (Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); SCRCF = Swan and Canning Rivers Crab Fishery (Area 1 of West Coast Estuarine Managed Fishery) (Western Australia); SWTMF = South West Trawl Managed Fishery (Western Australia); WSCMF = Warnbro Sound Crab Managed Fishery (Western Australia)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

b The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

c Boat-based recreational catch from 1 March 2011 to 29 February 2012²⁰.

Figure 2: Commercial catch of Blue Swimmer Crab in Australian waters, 2000 to 2013 (calendar years)



Note: Western Australian data were not provided at the level of the individual stocks reported in the Blue Swimmer Crab chapter.

Effects of fishing on the marine environment

- Because the commercial catch of crabs generally represents a relatively small proportion of the biomass, which is renewed annually, these fisheries are unlikely to have significant impacts on the food chain.
- Fishing with traps results in limited habitat disturbance because it is generally conducted over sand habitats that are resilient.
- Although part of the Blue Swimmer Crab catch in the Shark Bay Crab (Interim) Managed Fishery (Western Australia) is harvested during otter trawling operations for prawns in Shark Bay, this activity is highly regulated and restricted to a small proportion of the area.
- Due to the efficiency of traps for targeting Blue Swimmer Crabs, generally little or no bycatch is recorded.

Environmental effects on Blue Swimmer Crabs

- In South Australia, marine park boundaries are likely to overlap with a small proportion of Blue Swimmer Crab fishing habitat when they come into effect in October 2014. This is likely to protect a portion of the stock but may increase the intensity of fishing in other areas.
- There is some evidence to suggest that the distribution of Blue Swimmer Crab is extending further south in both of South Australia's gulfs^{5,14}. It is possible that this is related to climate change.
- The decline in annual catches of Blue Swimmer Crab in Gulf St Vincent (South Australia) in recent years has coincided with substantial increases in commercial catches of Snapper (*Chrysophrys auratus*). Trophodynamic modelling work is being done to investigate a potential causal relationship between the two species; Blue Swimmer Crab is known to be a major component of the diet of Snapper.
- Climate change impacts on Western Australian Blue Swimmer Crab stocks are currently under investigation. For Shark Bay, it appears that the record low winter temperatures (during the peak spawning period) and the extreme marine heatwave event during the summer of 2010–11 had a detrimental impact on recruitment and survival of juvenile and adult stocks. The winter water temperatures have now returned to historical levels, but summer temperatures in 2011–12 and 2012–13

were still slightly above the historical mean, which is consistent with the observed partial recovery of the stock in 2013 and 2014.

- Poor recruitment and egg production in the Cockburn Sound (Crab) Managed Fishery is not attributable to fishing pressure, since a conservative management approach has been taken since the fishery was reopened. Following the heatwave of 2010–11, a very large cohort of sublegal crabs did not moult over the 2011–12 summer, possibly because of competition between crabs for limited resources. This probably resulted in poor mating success during 2012 and low numbers of berried females during the 2012–13 spawning season, leading to the low recruitment in 2013. Preliminary evidence also suggests that crabs are in a poor nutritional condition, which may be contributing to low stock biomass.

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10. Giant Crab *Pseudocarcinus gigas*

Klaas Hartmann^a, Caleb Gardner^a, Adrian Linnane^b, Harry Gorfine^c and Jason How^d



Table 1: Stock status determination for Giant Crab

Jurisdiction	South Australia, Tasmania, Victoria, Western Australia
Stock	Southern Australian (ERLF, GCF [TAS], GCF [VIC], NZGCF, SCDSCF, SZGCF, WCDSCF)
Stock status	↓
	Transitional–depleting
Indicators	Percentage of egg production relative to unfished level, CPUE, proportion of spawning stock protected by minimum size limits

CPUE = catch per unit effort; ERLF = Esperance Rock Lobster Fishery (Western Australia); GCF (TAS) = Giant Crab Fishery (Tasmania); GCF (VIC) = Giant Crab Fishery (Victoria); NZGCF = Northern Zone Giant Crab Fishery (South Australia); SCDSCF = South Coast Deep Sea Crustacean Fishery (Western Australia); SZGCF = Southern Zone Giant Crab Fishery (South Australia); WCDSCF = West Coast Deep Sea Crustacean Fishery (Western Australia)

Stock structure

Giant Crab is considered to be a single biological stock from Western Australia to Tasmania because the species occurs in a continuous distribution across this range. The larval duration is around 50 days, with larval release occurring along the edge of the continental shelf. The shelf is a high-current area, facilitating dispersal. Oceanographic modelling has indicated that Giant Crab dispersal occurs over large spatial scales^{1–3}. Commercial catches off Tasmania occur in two distinct areas, although video sampling has shown that Giant Crab occurs at noncommercial densities between these areas³. Based on these findings, the stock status of Giant Crab is reported at a single biological stock level.

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Stock status

Southern Australian biological stock

The cross-jurisdictional southern Australian biological stock has components in Tasmania, Western Australia, South Australia and Victoria. Each jurisdiction assesses that part of the biological stock that occurs in its waters. Historically, the Tasmanian and Victorian fisheries have constituted the bulk of the Giant Crab fishery; however, both these states have had substantial reductions in total allowable commercial catch (TACC) over the past decade. The status presented here for the entire biological stock has been established using evidence from all four jurisdictions.

For the Tasmanian part of the biological stock (where the majority of the catch has historically been taken), a length-based model has been developed to estimate annual levels of biomass and egg production. The model is based on data that include catch-and-effort data from commercial fisheries⁴. It estimated that egg production is stable at 19 per cent of unfished levels⁵. Although this is adequate relative to benchmarks used in some crustacean fisheries⁶, the slow growth and longevity of Giant Crab increase its susceptibility to becoming recruitment overfished and lead to substantial uncertainty in the modelling. Despite TACC reductions to levels that are expected to result in stock rebuilding (see below), catch per unit effort (CPUE) has decreased gradually since the inception of the Tasmanian fishery, indicating an ongoing biomass decline. However, although in decline, this part of the stock is not yet considered to be recruitment overfished.

The TACC for the Tasmanian part of the biological stock has been reduced in several steps from 104 tonnes (t) in 2003–04 to 38.3 t in 2014–15, with the objective of increasing abundance and catch rates; the latest decrease was from 46.6 t to 38.3 t for the 2014–15 licensing year. The TACC is routinely undercaught by approximately 10 per cent because of limited quota trading and leasing. In the 2013–14 quota year (March–February), only 57 per cent of the TACC was taken. This is partly related to changes in industry regulation and partly to low CPUE. The ongoing decline in catch rates, despite substantial TACC reductions, indicates that the current level of fishing pressure is likely to cause the Tasmanian part of the stock to become recruitment overfished.

Management of fishing mortality in Victoria is through a TACC, and legal minimum lengths to protect mature undersized crabs. The legal minimum lengths aim to ensure that egg production remains at no less than 40 per cent of unfished levels⁷. However, there is considerable uncertainty around the population dynamics of larger females and hence the degree of protection provided by these limits. The TACC was set at 25 t from 2002 to 2009, but has been decreased over several years in response to declining catch rates, to 12 t in 2012–13. Despite these TACC reductions, there has been no observed increase in CPUE⁸. This part of the stock is not yet considered to be recruitment overfished; however, the ongoing decline in catch rates and the lack of response to TACC reductions indicates that, without more stringent constraints on catch, the current level of fishing pressure is likely to cause the Victorian part of the stock to become recruitment overfished within the next few years.

Fishing mortality in South Australia and Western Australia is also managed through TACCs and the same legal minimum length as in Victoria. Catches and catch rates in South Australia⁹ have been stable; however, there are some concerns about the reliability of these data. Combined with a lack of targeted fishery data in Western Australia, this means that insufficient information is available to confidently classify the status of these two parts of the biological stock.

The major component of the biological stock, in terms of historical biomass and catch, occurs in Tasmania and Victoria. As a result, the overall stock status classification is based only on the Tasmanian and Victorian parts of the stock.

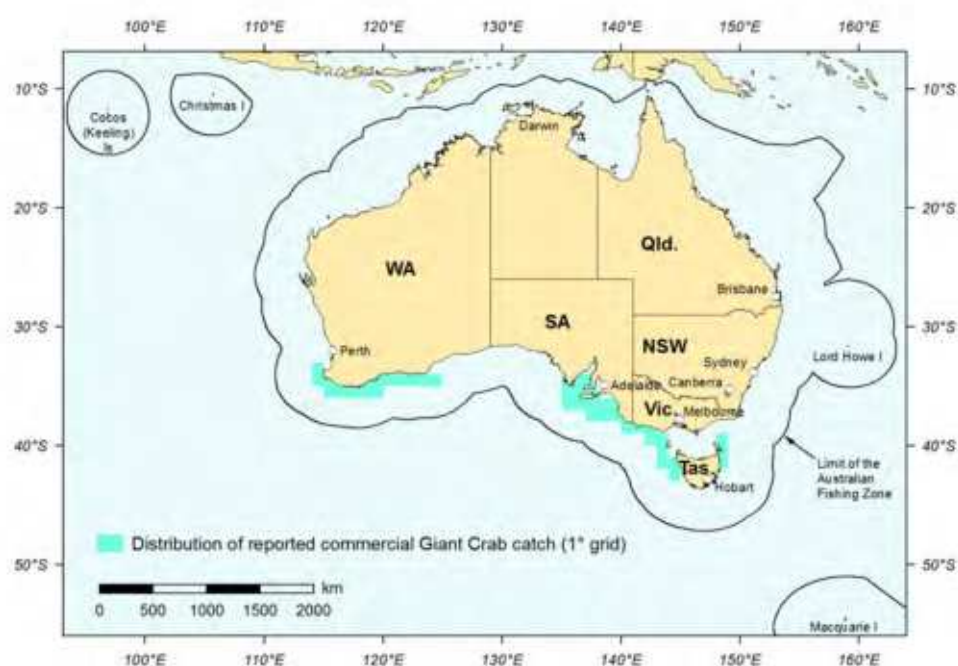
On the basis of the evidence provided above, the entire biological stock of Giant Crab is classified as a **transitional–depleting stock**.

Table 2: Giant Crab biology^{1–3,7}

Longevity and maximum size	30+ years; >200 mm CL; ~10 kg
Maturity (50%)	125–140 mm CL, depending on region

CL = carapace length

Figure 1: Distribution of reported commercial catch of Giant Crab in Australian waters, 2013



Note: Western Australian and Tasmanian data are for the 2013 calendar year; South Australian and Victorian data are for the 2012–13 fishing season (November 2012 – May 2013).

Table 3: Main features and statistics for Giant Crab fisheries in Australia, 2013

Jurisdiction	Tasmania ^a	Victoria ^b	South Australia ^b	Western Australia ^a
Fishing methods				
Commercial				
Crab pot	✓	✓	✓	✓
Recreational				
Crab pot	✓		✓	✓
Indigenous ^{c,d}				
Crab pot	✓		✓	✓
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Spatial closures	✓	✓	✓	✓
Temporal closures	✓	✓	✓	✓
Size limits	✓	✓	✓	✓

Jurisdiction	Tasmania ^a	Victoria ^b	South Australia ^b	Western Australia ^a
Quota	✓	✓	✓	✓
Recreational				
Possession limits	✓			
Size limits	✓	✓	✓	✓
Temporal closures	✓	✓	✓	✓
Indigenous ^{c,d}				
Possession limits	✓			
Size limits	✓	✓	✓	✓
Temporal closures	✓	✓	✓	✓
Active vessels				
	8 in GCF (TAS)	<5 in GCF (VIC)	<5 in NZGCF <5 in SZGCF	6 in ERLF 10 in SCDSCF 1 in WCDSCF
Catch				
Commercial	27 t in GCF (TAS)	10 t in GCF (VIC)	22 t in NZGCF and SZGCF	3 t in ERLF 8 t in SCDSCF <1 t in WCDSCF
Recreational	Negligible	None	Negligible	Negligible
Indigenous ^{c,d}	Negligible	None	Negligible	Negligible
Markets				
Domestic	✓	✓	✓	✓
Export	✓	✓	✓	✓

ERLF = Esperance Rock Lobster Fishery (Western Australia); GCF (TAS) = Giant Crab Fishery (Tasmania); GCF (VIC) = Giant Crab Fishery (Victoria); NZGCF = Northern Zone Giant Crab Fishery (South Australia); SCDSCF = South Coast Deep Sea Crustacean Fishery (Western Australia); SZGCF = Southern Zone Giant Crab Fishery (South Australia); WCDSCF = West Coast Deep Sea Crustacean Fishery (Western Australia)

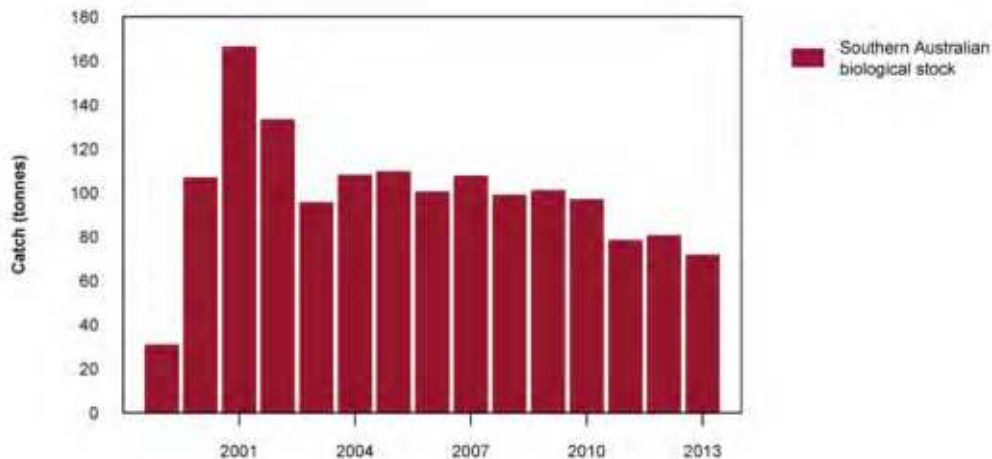
a Western Australian and Tasmanian data are for the 2013 calendar year.

b South Australian and Victorian data are for the 2012–13 fishing season (November 2012 – May 2013).

c In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Giant Crab.

d Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catch of Giant Crab in Australian waters, 1998 to 2013



Note: Western Australian and Tasmanian data are for the 2013 calendar year; South Australian and Victorian data are for the 2012–13 fishing season (November 2012 – May 2013).

Effects of fishing on the marine environment

- Bycatch in the Giant Crab fishery was sampled from more than 3000 traps. This research concluded that the fishery is of low risk to other species because of the small amount of trapping effort. Further, the majority of the bycatch consists of species (mainly Antlered Crab, Hermit Crab and Draftboard Shark) that do not have swim bladders and are returned to the sea with a high chance of survival⁵.
- No interactions with protected species have been reported by observers or fishers targeting Giant Crab. This result would be expected, given that Giant Crab is targeted in deep water, away from coastal areas frequented by animals, such as juvenile seals and cormorants, that could become caught in the traps or entangled in the lines⁵.
- The Giant Crab fishery is based mainly in habitats found along the edge of the continental shelf. This bryzoan turf habitat is formed from encrusting filter-feeding organisms growing on sandy and muddy sediments³. The risk to this habitat from Giant Crab fishing gear is considered to be low because gear is not dragged and has minimal drift, and the fishing footprint is insignificant relative to the size of the habitat area³.

Environmental effects on Giant Crab

- Recruitment is not distributed evenly, and some areas appear to have higher juvenile abundance than others. This is not a function of habitat but appears to be related to larval drift and thus movement by currents³. Changes in ocean currents resulting from climate change or upwelling events may affect this process and recruitment.

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11. Mud Crab *Scylla serrata*, *S. olivacea*

Mark Grubert^a, Megan Leslie^b and Daniel Bucher^c



Giant Mud Crab (*Scylla serrata*)

Table 1: Stock status determination for Giant Mud Crab

Jurisdiction	Western Australia, Northern Territory, Queensland	Queensland, New South Wales
Stock	Northern Australian (GOCMCF [Qld], KDMCF [WA], MCF [NT])	East coast (ECMCF [Qld], EGF [NSW])
Stock status		
	Sustainable	Sustainable
Indicators	Catch, effort, CPUE	Catch, effort, CPUE

CPUE = catch per unit effort; ECMCF [Qld] = East Coast Mud Crab Fishery (Queensland); EGF [NSW] = Estuary General Fishery (New South Wales); GOCMCF [Qld] = Gulf of Carpentaria Mud Crab Fishery (Queensland); KDMCF [WA] = Kimberley Developing Mud Crab Fishery (Western Australia); MCF [NT] = Mud Crab Fishery (Northern Territory)

Stock structure

Two species of Mud Crab are found in Australian waters: Giant Mud Crab (*Scylla serrata*) and Orange Mud Crab (*S. olivacea*). The former constitutes more than 99 per cent of the commercial Mud Crab catch in the Northern Territory and Queensland, and the entire commercial catch in New South Wales. The species composition in the Kimberley Developing Mud Crab Fishery (Western Australia) is uncertain, but is known to vary considerably between locations.

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The life history and biology of Giant Mud Crab in the Northern Territory and Queensland are well documented^{1–5} but, with some exceptions^{6,7}, corresponding information from Western Australia and New South Wales is scarce. There are no published accounts of the biology of Orange Mud Crab in Australian waters. Hence, all catch and biological information in this chapter refers to *S. serrata*, unless otherwise indicated.

Egg-bearing female Giant Mud Crabs migrate up to 95 km offshore to release their offspring², which can number up to 10.8 million per individual⁸. These features, coupled with a planktonic larval stage that can last for several weeks⁹, give this species significant capacity for dispersal.

A recent study on Giant Mud Crabs from around the Indo–West Pacific region¹⁰ revealed two genetically distinct stocks in Australian waters: a ‘northern Australian’ biological stock extending from south-west Western Australia across the tropics to the tip of Cape York (Queensland), and an ‘east coast’ biological stock stretching from the tip of Cape York to southern New South Wales.

The lack of gene flow between the two Australian stocks is most likely due to the narrow and turbulent Torres Strait (which prevents larvae from the Coral Sea entering the Arafura Sea and vice versa), and the southward flow of the East Australian Current.

Stock status

Northern Australian biological stock

The northern Australian biological stock spans three jurisdictions (Western Australia, the Northern Territory and Queensland), with each applying a different set of management controls. Size limits for Giant Mud Crabs vary across the north, but all ensure that at least 40 per cent of male crabs and 95 per cent of female crabs reach sexual maturity before commercial harvest; female Mud Crabs cannot be taken in Queensland. The status presented here for the northern Australian biological stock has been established using evidence from all three jurisdictions.

Mud Crabs are an important traditional food source for Indigenous Australians and are highly prized by recreational fishers. The only concurrent estimates of the catch by both sectors (which are now more than a decade old) suggest that their combined take accounts for around 20 per cent of the overall harvest of the northern Australian biological stock (based on Henry & Lyle¹¹, and commercial catch data from 2001). More recent angler surveys confirm the significance of the recreational harvest^{12–14}. However, a lack of regular catch estimates for recreational and Indigenous fishers means that the stock status presented here is based on data from commercial logbooks and departmental monitoring programs.

The Mud Crab Fishery (Northern Territory) accounts for around 55 per cent of the total commercial harvest of the northern Australian Giant Mud Crab biological stock. A size–age–sex monthly stock synthesis model applied to commercial catch, and fishing effort data (to December 2010)¹⁵ suggest that fishing mortality since 2001 has ranged from benign rates of 0.05/month for females and 0.15/month for males during periods of low vulnerability (the timing of which differs between sexes) to very high rates of 2.85/month for males and 3.25/month for females during periods of peak vulnerability. The monthly values, when averaged over a year, yield annual fishing mortality rates of 1.22 and 1.17 for males and females, respectively. These values approximate the estimate of annual natural mortality for Giant Mud Crabs of 1.21 (derived in 1999)⁵. A general rule in fisheries population dynamics is that fishing mortality should be constrained such that it does not exceed natural mortality (as is the case here), to avoid overfishing and prevent the stock from becoming overfished¹⁶. The above evidence indicates that the current level of fishing pressure is unlikely to cause this part of the stock to become recruitment overfished.

The stock synthesis model also produced estimates of annual recruits, and adult female abundance in January one year earlier, during the period 1984 to 2010. These estimates, when plotted against each other, showed no indication of reduced average recruitment at low spawning stock sizes—that is, there was no evidence that this part of the stock has been recruitment overfished. The spread of estimates also suggested that large numbers of female Giant Mud Crabs do not necessarily guarantee strong recruitment the following year and, conversely, that a small spawning stock can still result in good recruitment. Environmental factors such as wet seasons with lower than average rainfall appear to have a negative impact on Mud Crab recruitment and subsequent catch rates¹⁷. Poor rainfall in the western Gulf of Carpentaria—the primary fishing ground for the Northern Territory Mud Crab Fishery—during the 2012–13 wet season (and preceding wet seasons) is

considered the main reason for the suppressed catch across that area in 2013.

The Gulf of Carpentaria Mud Crab Fishery (Queensland) accounts for almost all of the remaining 45 per cent of the total commercial harvest of the northern Australian Giant Mud Crab biological stock. Annual catches by this fishery are the most stable of any commercial Mud Crab fishery in Australia, and typically vary by less than 15 per cent from one year to the next. An assessment of the Gulf of Carpentaria Mud Crab Fishery using data from 1998 to 2008 (which incorporated a 5 per cent increase in fishing efficiency each year) suggested that the fishing mortality rate for Giant Mud Crab males in 2008 was around 0.6¹⁸, 50 per cent below the estimate of natural mortality (1.21⁵).

The size-frequency distribution of the catch can often provide an indicator of the relative impacts of fishing. Where fishing effort is moderate to high, there may be a noticeable decline in the relative frequency of legal-sized animals (known as knife-edge selection). No such decline is evident in the size distribution of male Mud Crabs from the eastern Gulf of Carpentaria¹⁹, supporting the argument that fishing mortality in this part of the stock is comparatively low. This suggests that the current level of fishing pressure is unlikely to cause the western Queensland component of the stock to become recruitment overfished.

Although female Mud Crabs are not harvested by the Gulf of Carpentaria Mud Crab Fishery, they are most likely impacted by it, given that they may be handled and released many times. This can potentially result in handling damage²⁰, post-release mortality, or nonlethal effects such as reduced reproductive performance (based on observations of captive rocklobsters²¹). These impacts are considered an acceptable trade-off to maximise the number of female crabs that contribute to the next generation.

A history of comparatively light exploitation of male crabs only (as indicated by the relatively low fishing mortality rate) and the complete protection of female Giant Mud Crabs, in conjunction with the rapid growth and high fecundity of this species^{5,8}, suggests that the Queensland part of the stock is unlikely to be recruitment overfished.

The Kimberley Developing Mud Crab Fishery (Western Australia) accounts for less than 0.5 per cent of the total commercial harvest of the northern Australian Giant Mud Crab biological stock. The small commercial take in Western Australia is a result of the logistical difficulties associated with operating in, and transporting product from, the far north of that state, rather than any shortage of Mud Crabs. There are no estimates of biomass or fishing mortality rate in the Kimberley Developing Mud Crab Fishery. However, given the large area of preferred Mud Crab habitat in the Kimberley region (mangroves and mudflats), the modest and sporadic commercial catch by the fishery (which rarely exceeds 5 t per year of *S. serrata* and *S. olivacea* combined) is considered to have little impact on the resource at the current extraction rate.

The biology of Giant Mud Crab (in particular, high fecundity and dispersive capacity), combined with conservative catch controls, large unfished areas (which may buffer the effects of fishing), and low to moderate levels of fishing mortality (for one or both sexes), means that the biomass of this biological stock is unlikely to be recruitment overfished and that current catch levels are unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the entire biological stock is classified as a **sustainable stock**.

East coast biological stock

The east coast biological stock extends from the tip of Cape York to the southern limit of New South Wales. The only concurrent estimates of the recreational and Indigenous harvest of this resource (which are now more than a decade old) suggest that the combined take by these sectors equates to around 40 per cent of the overall catch of the east coast biological stock (based on Henry & Lyle¹¹, and commercial catch data from 2001). A more recent survey¹³ confirms the significance of the recreational harvest, which constitutes more than 25 per cent of the overall total. However, a lack of regular catch estimates for recreational and Indigenous fishers means that the stock status presented here is based on data from commercial logbooks and departmental monitoring programs.

The East Coast Mud Crab Fishery (Queensland) accounts for around 90 per cent of the commercial harvest of the east coast biological stock. The most recent estimate of fishing mortality in this fishery (based on commercial data to 2008) was around 1.5¹⁸, 24 per cent above the estimate of natural mortality for *S. serrata* (1.21⁵). Knife-edge selection in the size distribution of male crabs is evident in some parts of the fishery (particularly in more southern areas) but not others¹⁹, suggesting that fishing effort (by all sectors) is not evenly distributed along the coast, and that overall fishing mortality is moderate.

Although female Mud Crabs are not harvested by the East Coast Mud Crab Fishery (Queensland), they are likely to be impacted by it, given they may be handled and released many times. Some incidental damage and mortality of female crabs (as described above) is probable, but this is considered an acceptable trade-off to maximise the number of females that contribute to the next generation.

The Estuary General Fishery (New South Wales) can harvest both sexes of Giant Mud Crab and accounts for the remaining 10 per cent of the commercial take of the east coast biological stock. The fishing mortality rate of Giant Mud Crabs in New South Wales is not known.

The offshore spawning behaviour of female Mud Crabs², combined with the southward flow of the East Australian Current, suggests that recruitment success at higher latitudes may be influenced by spawning success (and larval survivorship) at lower latitudes. Hence, adult Giant Mud Crabs protected by the network of marine reserves along the coast of Queensland and northern New South Wales probably supply recruits to fished areas south of the reserves.

Giant Mud Crab density is significantly higher inside than outside marine reserves^{6,22}, and the mean size of crabs is also greater in some instances^{19,22}. Thus the reproductive output of Mud Crabs within reserves is predicted to exceed that of crabs exposed to fishing pressure²². Considering the moderate fishing mortality rate along the eastern seaboard and the protection afforded to large, fecund crabs inside marine reserves, the current level of fishing pressure is unlikely to cause the east coast Giant Mud Crab biological stock to become recruitment overfished.

There is no clear stock–recruitment relationship for Mud Crabs in the Northern Territory¹⁵, and the same may also be true in Queensland and New South Wales. Recruitment in all jurisdictions appears to be driven by environmental variables such as rainfall and water temperature¹⁷. Recent annual catches and catch rates in eastern Queensland are among the highest ever recorded and follow a series of high-rainfall years. Although other factors can also influence these catch statistics, the current high apparent productivity suggests that the east coast Giant Mud Crab biological stock is unlikely to be recruitment overfished.

On the basis of the evidence presented above, the entire biological stock is classified as a **sustainable stock**.

Table 2: Giant Mud Crab biology^{1,5,6,23,24}

<i>Longevity and maximum size</i>	3–4 years; 230 mm CW, but rarely exceeds 200 mm CW in most areas
<i>Maturity (50%)</i>	Varies by sex and location but generally 120–150 mm CW

CW = carapace width

Figure 1: Distribution of reported commercial catch of Giant Mud Crab in Australian waters, 2013 (calendar year)

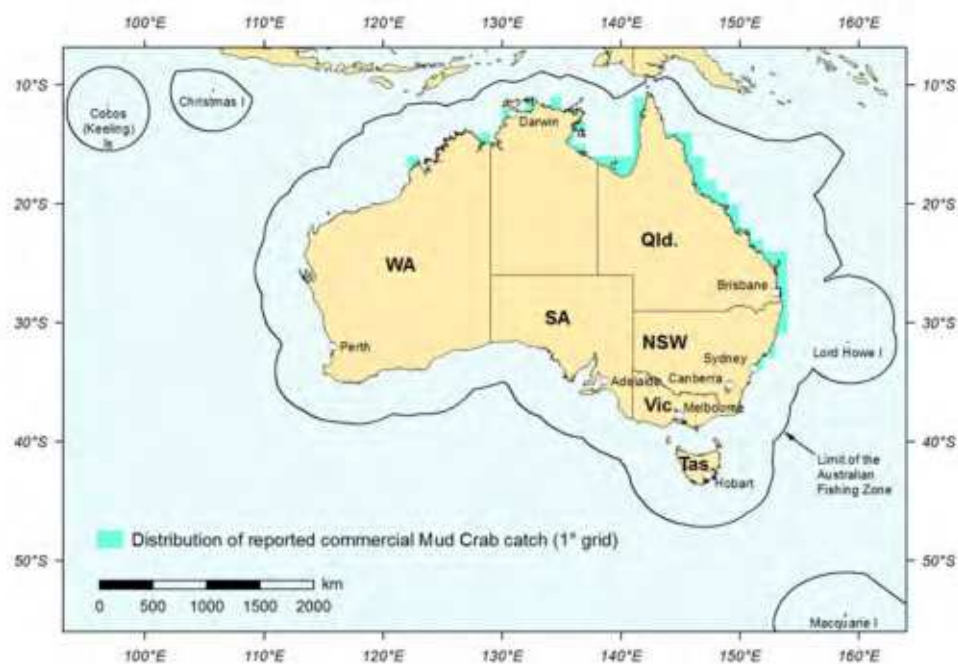


Table 3: Main features and statistics for Giant Mud Crab fisheries in Australia, 2013 (calendar year)

Jurisdiction	Western Australia	Northern Territory	Queensland	New South Wales
Fishing methods				
Commercial				
Trap	✓	✓	✓	✓
Gillnet	✓		✓	✓
Recreational				
Trap		✓	✓	✓
Rod and line	✓	✓	✓	✓
Dilly/hoop net/drop net	✓	✓	✓	✓
Inverted dilly/tangle net				✓
Scoop net	✓	✓	✓	
Cast net		✓	✓	
Beach seine net		✓	✓	
Hand collection	✓	✓	✓	✓
Spearfishing		✓	✓	
Indigenous ^{a,b}				
Trap		✓	✓	✓
Rod and line	✓	✓	✓	✓
Dilly/hoop net/drop net	✓	✓	✓	✓
Inverted dilly/tangle net				✓
Scoop net	✓	✓	✓	
Cast net		✓	✓	
Beach seine net		✓	✓	
Hand collection	✓	✓	✓	✓
Spearfishing		✓	✓	

Jurisdiction	Western Australia	Northern Territory	Queensland	New South Wales
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Spatial closures	✓	✓	✓	✓
Spatial zoning	✓	✓	✓	✓
Size limits	✓	✓	✓	✓
Effort limits	✓	✓	✓	✓
Gear restrictions	✓	✓	✓	✓
Male-only harvest			✓	
Protection of berried females	✓	✓	✓	✓
Hard shell-only harvest		✓		
Recreational				
Gear restrictions	✓	✓	✓	✓
Spatial closures	✓	✓	✓	✓
Spatial zoning	✓	✓	✓	✓
Bag limits	✓			
Possession limits		✓	✓	✓
Vessel limits	✓	✓		
Size limits	✓	✓	✓	✓
Male-only harvest			✓	
Protection of berried females	✓	✓	✓	✓
Indigenous ^{a,b}				
Gear restrictions	✓	✓	✓	✓
Spatial closures	✓	✓	✓	✓

Jurisdiction	Western Australia	Northern Territory	Queensland	New South Wales
Active licences or businesses ^c				
	3 in KDMCF ^c	49 in MCF ^c	330 in ECMCF ^c 62 in GOCMCF ^c	207 in EGF ^{†c}
Catch				
Commercial	7 t in KDMCF	227 t in MCF	1174 t in ECMCF 174 t in GOCMCF	88 t in EGF
Recreational	8 t (2011–12)	66 t (2000–01)	360 t in ECMCF (2010) 7 t in GOCMCF (2010)	30 t (2000–01)
Indigenous	12 t (2000–01)	69 t (2000–01)	13 t (2000–01)	Unknown
Markets				
Domestic	✓	✓	✓	✓
Export				

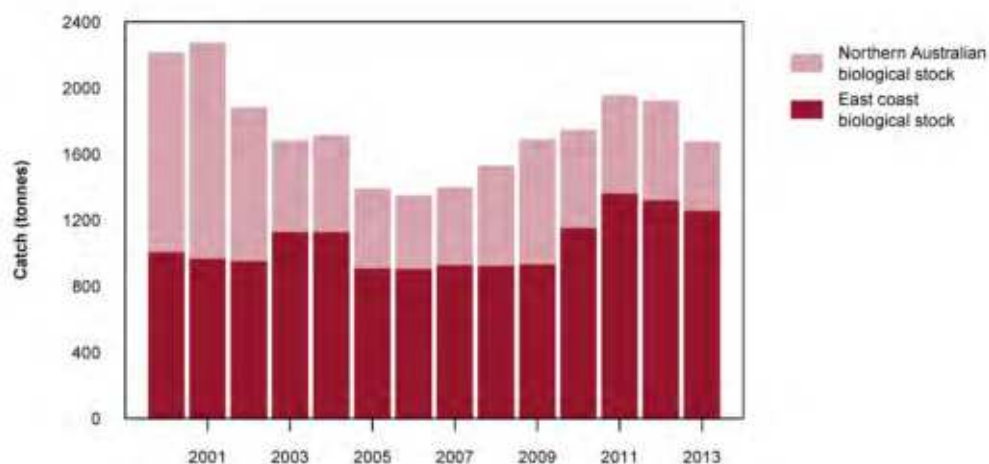
ECMCF = East Coast Mud Crab Fishery (Queensland); EGF = Estuary General Fishery (New South Wales); GOCMCF = Gulf of Carpentaria Mud Crab Fishery (Queensland); KDMCF = Kimberley Developing Mud Crab Fishery (Western Australia); MCF = Mud Crab Fishery (Northern Territory)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits. Similar customary fishing rights are recognised in equivalent legislation in Western Australia, New South Wales and the Northern Territory.

b Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

c Active licences (*) or businesses (†) are used here because the number of active vessels is not an appropriate measure of effort in Australian Mud Crab fisheries. Licensing arrangements also vary significantly between jurisdictions.

Figure 2: Commercial catch of Giant Mud Crab in Australian waters, 2000 to 2013 (calendar years)



Effects of Mud Crab fishing on the marine environment

- Entanglement of turtles in polyethylene mesh traps is a problem in eastern Queensland and New South Wales^{25,26}. To address this, both jurisdictions have released guides to responsible crabbing, which outline gear modifications and alternative fishing strategies to reduce turtle interactions, prevent trap loss and minimise ghost fishing^{27,28}.
- Discard rates of undersized Mud Crabs can be as high as 70 per cent of the total catch in some areas²⁴. Bycatch of small fishes (particularly Yellowfin Bream) is also of concern on the east coast²⁰. Recent research by the Northern Territory Department of Primary Industry and Fisheries, and the New South Wales Department of Primary Industries has demonstrated the value of escape vents in reducing the retention of undersized Mud Crabs and small teleost bycatch in a variety of Mud Crab traps^{19,29,30}. The former organisation has also developed inexpensive escape vents to fit rectangular wire mesh traps, with around 25 per cent of licensees in the Mud Crab Fishery (Northern Territory) using them on a voluntary basis. Some management agencies are currently considering the mandatory use of escape vents in Mud Crab traps.
- Giant Mud Crabs sometimes lose limbs when caught in, or removed from, traps; the injury rate is related to the style of trap used²⁰. Although limb loss appears to have little impact on the short-term survivorship of Giant Mud Crabs²⁰, repeated limb damage may potentially compromise their growth and/or reproductive success (based on observations of other crab species^{31,32}). More than 20 per cent of Giant Mud Crabs caught in monofilament tangle nets lose one or more limbs during capture and/or removal from the net²⁰. This gear also poses a significant ghost-fishing risk if lost, and is prohibited in most jurisdictions.

Environmental effects on Mud Crab

- Commercial catch rates generally show positive correlations with environmental factors such as rainfall and sea surface temperature, depending on location¹⁷. Catch rates are more strongly linked to sea surface temperatures at higher latitudes and rainfall at lower latitudes.
- Juvenile Giant Mud Crabs prefer to settle on seagrass rather than mud or sand³³. Therefore, any significant reduction in seagrass area (through human or natural disturbances, including cyclones) could affect recruitment success.

- Mud Crabs may potentially benefit from moderate climate change in some areas³⁴. Increased water temperatures at higher latitudes might increase growth rates and reproductive activity. Greater rainfall in the tropics might increase primary and secondary productivity, thereby providing more food for juvenile crabs. Any such benefits will, of course, only occur within the physiological tolerances of the particular developmental stage affected.

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12. Spanner Crab *Ranina ranina*

Jason McGilvray^a and Daniel Johnson^b



Table 1: Stock status determination for Spanner Crab

Jurisdiction	Queensland, New South Wales
Stock	East coast (OTLF, SCF)
Stock status	
	Sustainable
Indicators	Target CPUE, target fishery-independent CPUE

CPUE = catch per unit effort, OTLF = Ocean Trap and Line Fishery (New South Wales), SCF = Spanner Crab Fishery (Queensland)

Stock structure

Genetic analysis indicates that Spanner Crabs on the east coast of Australia comprise a single biological stock¹. Reporting of status is therefore undertaken at the biological stock level.

Stock status

East coast biological stock

The East Coast Spanner Crab stock is shared between Queensland and New South Wales, with Queensland accounting for the largest harvest (90 per cent, based on the reported harvest in 2013).

Total catch of Spanner Crabs has decreased significantly since 2000 (Figure 2). The reduction in catch can be attributed to large reductions in fishing effort (for Queensland, 2.7 million pot-lifts in 2000 compared with 880 000 pot-lifts in 2013), caused by changes in fishery economics, social factors, and creation of marine parks in north-east New South Wales, which led to loss of fishing area and removal of endorsements.

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The standardised catch rate of Spanner Crabs from annual fishery-independent surveys (from 2000 to 2013 in Queensland, and 2006 to 2013 in New South Wales) has increased since 2000². In 2013, the survey catch rate was above the target reference point. The survey also shows consistent numbers of small crabs (below the minimum legal size), indicating continued recruitment to the fishery². These fishery-independent indicators are positive in relation to Spanner Crab biomass.

In Queensland, the 2013 commercial fishery standardised catch rate was below the target reference point, but similar to the value calculated for 2000 to 2003². Large reductions in catch and effort between 2000 and 2013 have contributed to this result. The nominal catch rate from the New South Wales commercial fishery in the 2011–12 financial year was within historical levels².

The above evidence indicates that the biomass of both the Queensland and New South Wales parts of the stock are unlikely to be recruitment overfished.

Fishing pressure in Queensland is controlled through a total allowable commercial catch (TACC). The TACC is set biennially, using an empirical model based on fishery catch rates (Queensland) and fishery-independent catch rates (Queensland and New South Wales)³. In 2013, the pooled index (the arithmetic mean of the commercial and survey indices) recommended a reduction in the commercial quota to the base level (1631 tonnes).

In New South Wales, fishing mortality is controlled through input controls (limited entry, zoning, gear limits). Given the small number of licences, and the overall take compared with the take in Queensland, it is unlikely that fishing of the New South Wales part of the stock is having a detrimental effect on the entire east coast stock⁴.

Fishing pressure from the recreational sector is negligible. The estimated harvest by recreational fishers in Queensland and New South Wales is less than 1 per cent of reported commercial harvest in both jurisdictions (Table 3)⁵.

The spawning biomass of the east coast stock is protected through minimum size limits, which aim to allow mature individuals to spawn at least once, and temporal (spawning) closures to protect spawning animals. Egg-bearing females are rarely caught and cannot be retained. These regulations apply to both commercial and recreational fishers. Spanner Crabs are caught through entanglement, and there is evidence that limb damage during removal from the fishing gear leads to increased mortality of discarded crabs⁶, which may offset the benefits of the minimum legal size. Current fishing practices in New South Wales and Queensland aim to minimise damage to discarded crabs to limit such post-release mortality^{5,6}.

The above evidence indicates that the current levels of fishing pressure in both the Queensland and New South Wales parts of the stock are unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the entire biological stock is classified as a **sustainable stock**.

Table 2: Spanner Crab biology^{7,8}

Longevity and maximum size	10–15 years; 160 mm RCL
Maturity (50%)	Females: 70 mm RCL

RCL = rostral carapace length

Figure 1: Distribution of reported commercial catch of Spanner Crab in Australian waters, 2013 (calendar year)

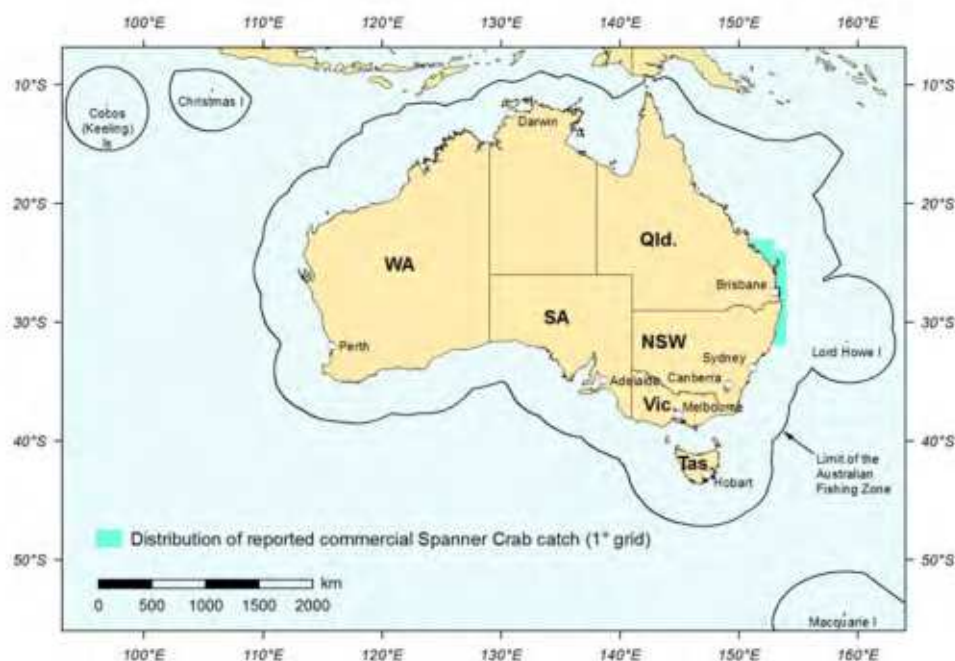


Table 3: Main features and statistics for Spanner Crab fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland	New South Wales
Fishing methods		
Commercial		
Baited dilly	✓	✓
Recreational		
Baited dilly	✓	✓
Indigenous ^{a,b}		
Management methods		
Commercial		
Limited entry	✓	✓
Size limits	✓	✓
Gear limits	✓	✓
Protection of egg-bearing females	✓	✓
Vessel restrictions	✓	✓

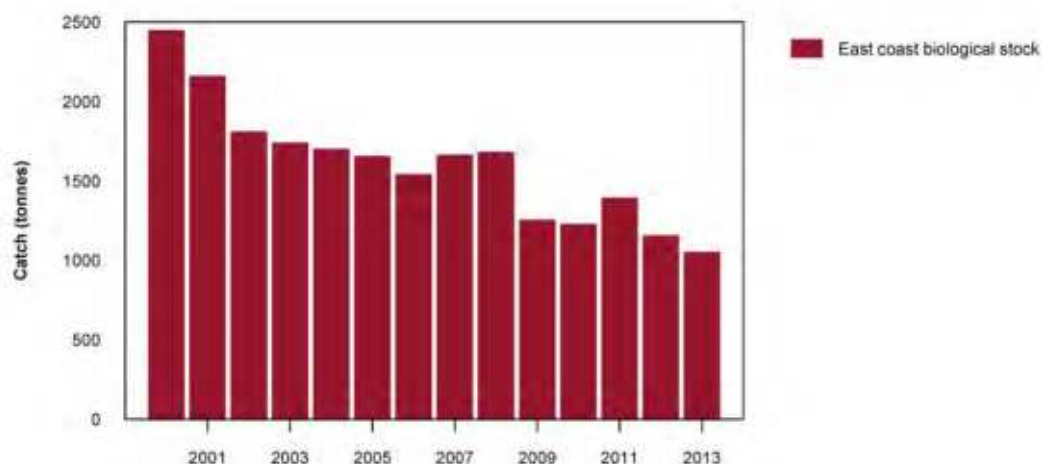
Jurisdiction	Queensland	New South Wales
Temporal closures	✓	✓
Spatial closures	✓	✓
Catch quota	✓	
Daily catch limits	✓	
Recreational		
Size limits	✓	✓
Bag limits		✓
Possession limits	✓	✓
Gear limits	✓	✓
Protection of egg-bearing females	✓	✓
Temporal closures	✓	
Spatial closures	✓	✓
Indigenous ^{a,b}		
Active vessels		
	59 in SCF	22 in OTLF
Catch		
Commercial	938 t in SCF	104 t in OTLF
Recreational	<1% of commercial ⁹	<1 t ⁴
Indigenous	<1% of recreational ⁵	None
Markets		
Domestic	✓	✓
Export	✓	

OTLF = Ocean Trap and Line Fishery (New South Wales); SCF = Spanner Crab Fishery (Queensland)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and bag limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

b In New South Wales, Indigenous fishers are able to use traditional and noncommercial apparatus to take double the recreational bag limit. Further exemptions to fishery regulations can be obtained through permits.

Figure 2: Commercial catch of Spanner Crab in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Spanner Crabs are targeted using passive gear. Bycatch is minimal, and interactions with protected species are rare⁵. Processes are in place within the management of the fisheries to deal with increases in bycatch or interactions with protected species.

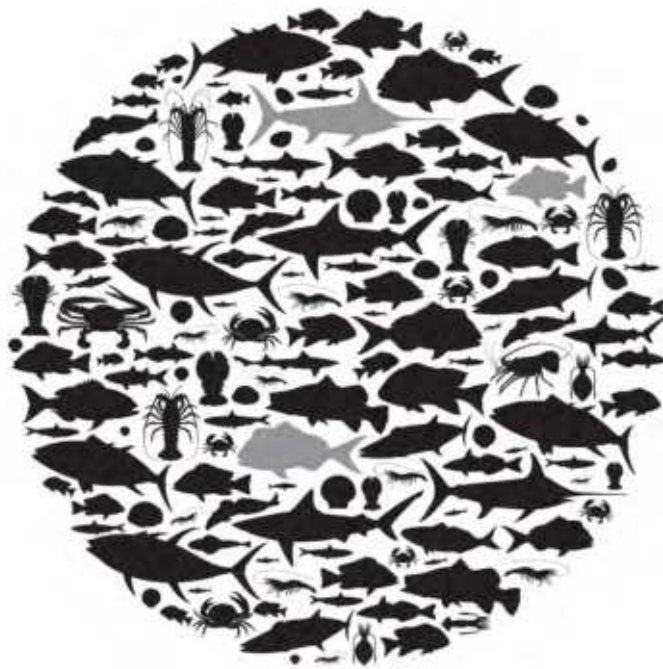
Environmental effects on Spanner Crabs

- The impact of environmental factors on Spanner Crab stocks is unknown.

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Crustaceans: *Bugs*



13. Balmain Bug *Ibacus alticrenatus*, *I. brucei*, *I. chacei*, *I. peronii*

John Stewart^a and Brad Zeller^b



True Balmain Bug (*I. peronii*)

Table 1: Stock status determination for Balmain Bug

Jurisdiction	New South Wales, Queensland	Victoria	South Australia	Western Australia
Stock	East coast (ECOTF, OTF-FS, OTF-PS)	Victorian	South Australian	Western Australian
Stock status		Negligible ^a	Negligible ^b	Negligible ^c
	Sustainable			
Indicators	Catch rates, size structure			

ECOTF = East Coast Otter Trawl Fishery (Queensland); OTF-FS = Ocean Trawl Fishery – Fish Sector (New South Wales); OTF-PS = Ocean Trawl Fishery – Prawn Sector (New South Wales)

a 'Negligible' means historically low catch; no stock status. Victorian catch ranged from 5 to 15 t between 2006–07 and 2011–12.

b 'Negligible' means historically low catch; no stock status. South Australian catch ranged from 1.1 to 8.1 t between 2001–01 and 2012–13.

c 'Negligible' means historically low catch; no stock status. Catch from the South West Trawl Managed Fishery and the South Coast Trawl Fishery in 2013 was 127 kg; in the past 10 years, the average catch from the Western Australian management unit was 106 kg.

Stock structure

The common name 'Balmain Bug' refers to four similar species of fan lobster: *Ibacus alticrenatus*, *I. brucei*, *I. chacei* and *I. peronii*¹. These species overlap in their distributions on the east coast of Australia and have

a Department of Primary Industries, New South Wales

b Department of Agriculture, Fisheries and Forestry, Queensland

evolved different life-history strategies. They are treated as a single biological stock in this report because they are rarely distinguished by fishers or fish marketers. Landings of *I. peronii* and *I. alticrenatus* in the jurisdictions of Victoria, South Australia and Western Australia are very low and the stock status is not assessed.

The true Balmain Bug (*I. peronii*) is widely distributed around the southern half of the continent, from around the Queensland – New South Wales border (latitude 28°S) to central Western Australia (latitude 29°S), including the east coast of Tasmania and Bass Strait. The true Balmain Bug is mainly found close to shore, in waters less than 80 m deep. Given the prevailing influence of the East Australian Current and a protracted (around 80 days) pelagic larval life, *I. peronii* along the east coast is thought to be a single biological stock¹. Landings in Victoria, South Australia and Western Australia are thought to be true Balmain Bugs (*I. peronii*). However, the stock structure across these jurisdictions is unknown. Consequently, the stock status for Balmain Bugs is presented on a management unit basis for these jurisdictions.

The Smooth Bug (*I. chacei*) is distributed between northern Queensland (latitude 17°S) and southern New South Wales (latitude 36°S), although it is rarely caught south of Sydney (latitude 34°S). It is most abundant on the mid-continental shelf in depths of 50–150 m. Given the prevailing influence of the East Australian Current in these depths, a pelagic larval phase and a northerly migration of older stages, Smooth Bugs are thought to be a single biological stock¹.

The Honey Bug (*I. brucei*) is distributed between central Queensland and northern New South Wales. It is most abundant on the outer continental shelf and upper slope in waters 120–300 m deep. Given the prevailing influence of the East Australian Current in these depths and a pelagic larval phase, Honey Bugs are thought to be a single biological stock¹.

The Deepwater Bug (*I. alticrenatus*) is distributed throughout southern Australian and New Zealand waters. It is most abundant at depths of 200–400 m on the upper continental slope¹.

Stock status

East Coast biological stock

This cross-jurisdictional, multispecies biological stock has components in New South Wales and Queensland. Each jurisdiction assesses the part of the biological stock that occurs in its waters. The status presented here for the entire biological stock has been established using evidence from both jurisdictions.

In New South Wales, Balmain Bugs (true Balmain Bugs and Smooth Bugs) are trawl target species, and have been assessed in terms of their commercial catch rates and length compositions in landings. Median catch rates (kg/day of trawling) have fluctuated but show no overall trends, while the size compositions in landings have remained stable for both species. The above evidence indicates that the biomass of this part of the stock is unlikely to be recruitment overfished. Current landings are at historically low levels as a result of a large reduction in fishing effort, with the number of days fished in 2013 being less than 30 per cent of those fished in 2000. This reduction in fishing effort, in combination with stable size compositions in landings, strongly suggests that fishing mortality is constrained in New South Wales waters. The above evidence indicates that the current level of fishing pressure is unlikely to cause this part of the stock to become recruitment overfished.

In Queensland, Balmain Bug fishing mortality is managed by a prohibition on taking egg-bearing females, conservative minimum legal sizes (which were updated in 2009), and mandatory use of turtle excluder devices since the early 2000s—these have been shown to reduce the incidental catch rates of scyllarid lobsters, including Balmain Bugs^{2,3}. In addition, the spawning stock is partly protected from fishing during an annual seasonal closure. Although nominal catch rates have declined since 2011, and the 2013 catch was relatively low⁴, this is likely to be an indication of the more conservative minimum legal sizes for *I. chacei* and fisher behaviour, rather than declining abundance. Fishers harvest Balmain Bug as low-value byproduct of fishing for Eastern King Prawn. Given their low value, it is suspected that Balmain Bug fishing mortality is also likely to be low.

Balmain Bugs were considered in a recent species risk assessment of the Queensland East Coast Otter Trawl Fishery, based on a qualitative method that combines biological resilience properties with fishery impact susceptibility⁵. It found a low risk of the Queensland part of the east coast Balmain Bug stock becoming recruitment overfished at the 2009 effort level south of the Great Barrier Reef Marine Park⁶, where the

majority (83 per cent, on average) of catch is taken. Fishing effort has declined in that area by 10 per cent since 2011, further reducing the risk of the stock becoming recruitment overfished. The risk of recruitment overfishing within the Great Barrier Reef Marine Park was intermediate to high⁷, based on perceived differences between this area and the area south of the Great Barrier Reef Marine Park, in terms of fishery interaction throughout the Balmain Bug life cycle, marketability and access to refugia. Fishing effort in the Great Barrier Reef Marine Park has declined by 23 per cent since 2009, also reducing risk for this part of the stock.

The above evidence indicates that the biomass of the Queensland part of the stock is unlikely to be recruitment overfished and the current level of fishing pressure is unlikely to cause this part of the stock to become recruitment overfished.

On the basis of the evidence provided above, the entire biological stock is classified as a **sustainable stock**.

Table 2: Balmain Bug biology^(1,8–12)

<i>Longevity and maximum size</i>	Balmain Bug: 15 years; 86 mm CL Smooth Bug: 5–7 years; 80 mm CL Honey Bug: longevity largely unknown; maximum CL in Queensland samples is 72 mm for females and 66 mm for males Deepwater Bug: longevity largely unknown; maximum CL in Queensland samples is 55 mm for both females and males
<i>Maturity (50%)</i>	Balmain Bug: 2 years; 50 mm CL Smooth Bug: 2 years; 55 mm CL Honey Bug: 47 mm CL Deepwater Bug: 45 mm CL

CL = carapace length (not to be confused with carapace width, which is generally used for size limits in Balmain Bugs as it is a simple and rapid measure for use by commercial and recreational fishers¹³)

Figure 1: Distribution of reported commercial catch of Balmain Bugs in Australian waters, 2013 (calendar year)

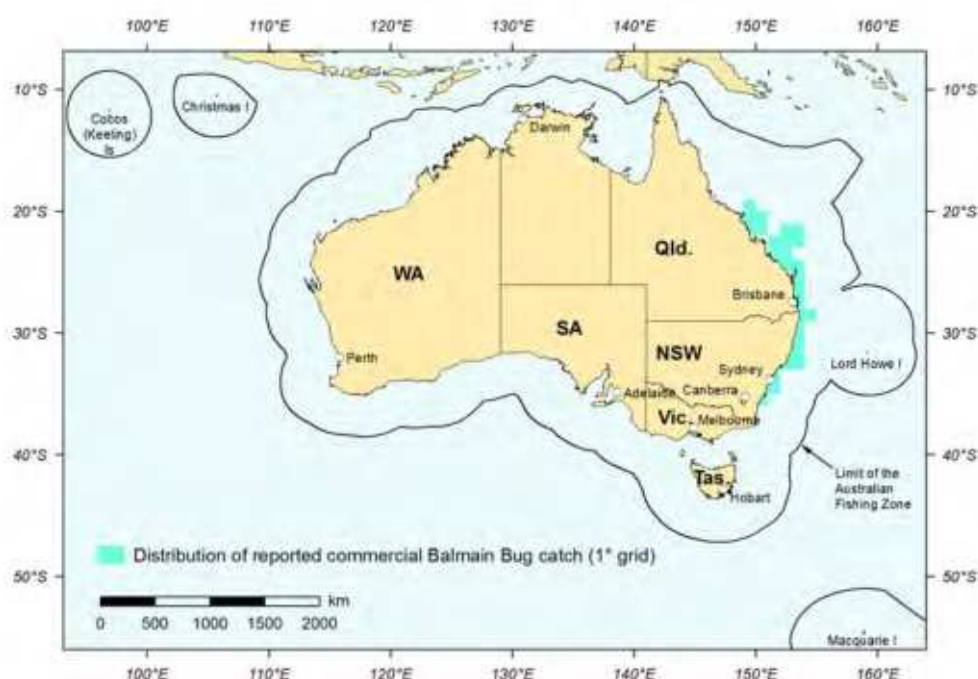


Table 3: Main features and statistics for Balmain Bug fisheries in Australia, 2013 (calendar year)

Jurisdiction	New South Wales	Queensland
Fishing methods		
Commercial		
Trawl	✓	✓
Recreational		
Diving	✓	
Indigenous		
Diving	✓	
Management methods		
Commercial		
Limited entry	✓	✓
Size limits	✓	✓
Vessel restrictions	✓	✓
Recreational		
Bag limits	✓	
Size limits	✓	
Spatial closures	✓	
Indigenous ^{a,b,c}		
Bag limits	✓	
Size limits	✓	
Spatial closures	✓	
Section 37(1)(c1), Aboriginal cultural fishing authority	✓	
Active vessels		
	22 in OTF-FS 66 in OTF-PS	150 in ECOTF

Jurisdiction	New South Wales	Queensland
Catch		
Commercial	1.5 t in OTF-FS 23.0 t in OTF-PS	65.1 t in ECOTF
Recreational	Unknown	Unknown
Indigenous	Unknown	Unknown
Markets		
Domestic	✓	✓
Export		

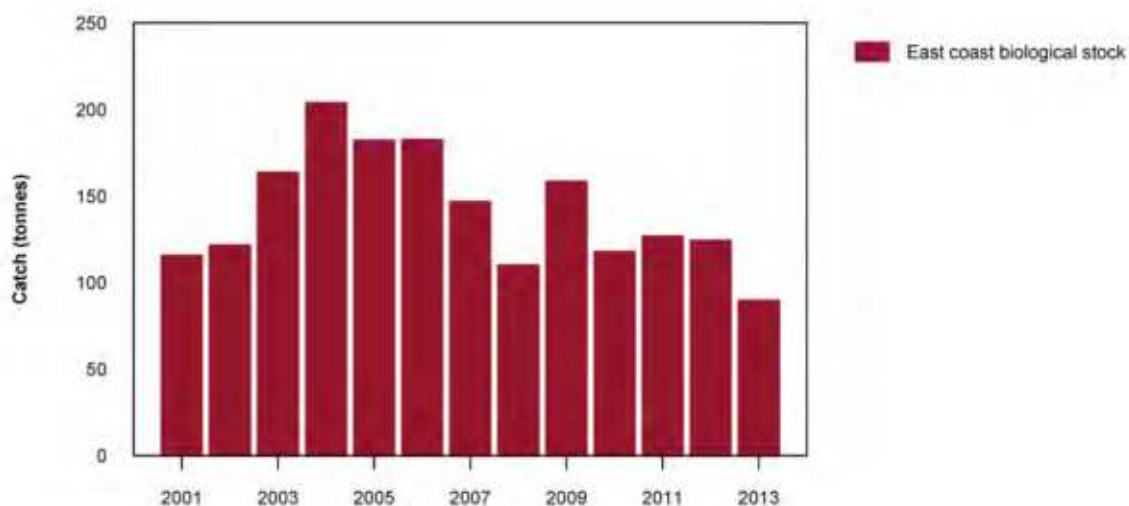
ECOTF = East Coast Otter Trawl Fishery (Queensland); OTF-FS = Ocean Trawl Fishery – Fish Sector (New South Wales); OTF-PS = Ocean Trawl Fishery – Prawn Sector (New South Wales)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland can use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

b The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

c The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Balmain Bugs in Australian waters, 2001 to 2013 (calendar years)



Effects of fishing on the marine environment

- The East Coast Otter Trawl Fishery (Queensland) interacts with a number of protected species, including turtles and sea snakes^{14,15}. Turtle excluder devices and bycatch reduction devices are deployed by all boats to reduce the amount of bycatch¹⁶. Fisher compliance with legislated design principles and best-practice use of these devices is mandatory to ensure that the devices function effectively to limit capture of turtles

and sea snakes. Interactions with these species are monitored through 'Species of Conservation Interest' logbooks¹⁷.

Environmental effects on Balmain Bugs

- The major environmental factor influencing the Balmain Bug biological stock is likely to be the southerly flow of the East Australian Current. The impact of changes in the East Australian Current on recruitment of these species is currently unknown^{1,9}. Extreme major weather events associated with the recent protracted La Niña event are thought to have modified recruitment patterns of a number of oceanic fishery species, possibly including Balmain Bug.

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14. Moreton Bay Bug *Thenus australiensis*^a, *T. parindicus*

Brad Zeller^b, Mervi Kangas^c and James Larcombe^d



Reef Bug (*Thenus australiensis*)

Table 1: Stock status determination for Moreton Bay Bug

Jurisdiction	Queensland	Western Australia	Commonwealth	
<i>Stock</i>	Queensland (ECOTF)	Western Australia (BPMF, EGPMF, KPMF, NBPMF, OPMF, PFTF, SBPMF)	NPF	TSPF
<i>Stock status</i>				
	Sustainable	Undefined	Sustainable	Sustainable
<i>Indicators</i>	Catch, CPUE	Catch	Catch	Catch

BPMF = Broome Prawn Managed Fishery (Western Australia); CPUE = catch per unit effort; ECOTF = East Coast Otter Trawl Fishery (Queensland); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); KPMF = Kimberley Prawn Managed Fishery (Western Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); NPF = Northern Prawn Fishery (Commonwealth); OPMF = Onslow Prawn Managed Fishery (Western Australia); PFTF = Pilbara Fish Trawl Fishery (Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia); TSPF = Torres Strait Prawn Fishery (Commonwealth)

Stock structure

Reef Bug (*Thenus australiensis*) and Mud Bug (*T. parindicus*) are known collectively as 'Moreton Bay Bugs'. Moreton Bay Bugs are distributed along the tropical and subtropical coast of Australia from northern New South Wales to Shark Bay in Western Australia². No studies have been carried out on the biological stock structure of Australian Moreton Bay Bugs. Given the uncertainty in biological stock structure, status is reported at the level of the management unit in Queensland and the Commonwealth, and the jurisdiction level for Western Australia. The two species have overlapping distributions, may be trawled together, are undifferentiated in the catch and are assessed together.

^a This species has previously been confused with *T. orientalis*, which is now regarded as not occurring in Australia. The species are very difficult to separate using morphological characteristics.¹

^b Department of Agriculture, Fisheries and Forestry, Queensland

^c Department of Fisheries, Western Australia

^d Australian Bureau of Agricultural and Resource Economics and Sciences

Stock status

East Coast Otter Trawl Fishery (Queensland) management unit

Moreton Bay Bugs are targeted in the East Coast Otter Trawl Fishery (Queensland) management unit. Although no formal stock assessment exists, the 2009 ecological risk assessment reported a low risk of the species being recruitment overfished in the Great Barrier Reef Marine Park (GBRMP)³, where harvesting pressure is greatest; the GBRMP catch of Moreton Bay Bugs averages 90 per cent of the East Coast Otter Trawl Fishery catch. An intermediate risk of the stock being recruitment overfished exists south of the GBRMP⁴, where about 10 per cent of the Moreton Bay Bug catch is taken. From 2009 to 2013, nominal fishing effort declined by 23 per cent in the GBRMP and 21 per cent in the East Coast Otter Trawl Fishery, implying that the risk of the stock being recruitment overfished has not increased. Long-term trends indicate decreasing fishing effort, increasing catch rate in areas where Moreton Bay Bug is in high abundance, and generally stable annual catch levels⁵. Nominal catch rate has been increasing since 2001 and is at historically high levels⁵. Since 2010, retention of berried female bugs has been allowed, which has probably contributed to the higher catch rates. The above evidence indicates that the biomass of the management unit is unlikely to be recruitment overfished.

Permanent closures in the GBRMP protect significant portions of the biomass in eastern Queensland. Research has estimated that closures included 54 per cent of the estimated GBRMP biomass of Reef Bug and 45 per cent of the estimated GBRMP biomass of Mud Bug in 2005⁶. Without evidence to the contrary, similar levels of protection from fishing mortality are assumed to have been maintained since then. In addition, a minimum legal size limit of 7.5 cm carapace width (CW), based on yield-per-recruit analysis, allows Mud Bug the opportunity to spawn before entering the fishery⁷. Individuals below this size are discarded from the retained catch. Research has found that post-capture survival is high among Moreton Bay Bugs⁸, turtle excluder devices (TEDs) lower catch rates of legal-sized Moreton Bay Bugs (greater than 7.5 cm CW),⁹ and 10 cm square-mesh codend bycatch reduction devices (BRDs) greatly lower incidental capture of undersized Reef Bug⁹ in the East Coast Otter Trawl Fishery (Queensland) management unit. In 2013, about one-third of East Coast Otter Trawl Fishery vessels used square-mesh codends. The above evidence indicates that the current level of fishing pressure is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Western Australia

No formal stock assessment exists for Moreton Bay Bugs in Western Australia. Moreton Bay Bugs are not specifically targeted in Western Australia, and current commercial catch levels are low—only 6 tonnes (t) was reported as landed in 2013 for all Western Australian fisheries combined. Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Moreton Bay Bug in Western Australia is classified as an **undefined stock**.

Northern Prawn Fishery (Commonwealth) management unit

An assessment of byproduct species in the Gulf of Carpentaria within the Northern Prawn Fishery (Commonwealth) was conducted in 2010¹⁰. This assessment estimated the annual acceptable biological catch for Moreton Bay Bugs in the fishery at 1887 t (95 per cent confidence interval: 1716 to 2057 t). Historical annual commercial catches are well below this; catch peaked at 120 t in 1998. The above evidence indicates that the biomass of the management unit is unlikely to be recruitment overfished.

Fishing mortality has been low in recent years, and ecological risk assessments¹¹ have suggested that the risk of stock depletion of Moreton Bay Bugs is low. A trigger catch limit of 100 t is also in place. If this limit is reached, additional analysis will be conducted to ensure that there are no sustainability concerns with the harvest level. Following the 2013 catch of 109 t, resources have been redirected to the collection of size-frequency distribution data for bugs for additional analysis. Fishing mortality is also reduced among the immature biomass by regulating the size at which Moreton Bay Bugs may be retained, and among the spawning biomass through prohibiting retention of egg-bearing females. Research has found that Mud Bug egg production is maintained when the minimum size limit is 7.5 cm CW⁷. Given the low level of catch in recent years, the management unit is unlikely to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Torres Strait Prawn Fishery (Commonwealth) management unit

No formal stock assessment exists for Moreton Bay Bugs in the Torres Strait Prawn Fishery (Commonwealth) management unit. A recent assessment of seabed and associated biodiversity in the Torres Strait^{12,13} estimated that, in 2007, biomass of Reef Bug was 124 t, only 19 per cent of which was located within the area exposed to prawn trawling (from the 2005 footprint of the fishery, using vessel monitoring system data). The biomass of Mud Bug was estimated to be 151 t. Again, a low percentage (18 per cent) of biomass was located in areas exposed to prawn trawling. With a decline in fishing effort in recent years, fishing mortality is also likely to have declined. Fishing mortality is also reduced among the immature biomass by regulating the size at which Moreton Bay Bugs may be retained, and among the spawning biomass through prohibiting retention of egg-bearing females. Research has found that Mud Bug egg production is maintained when the minimum size limit is 7.5 cm CW⁴. The above evidence indicates the biomass of the management unit is unlikely to be recruitment overfished.

The Torres Strait assessment of seabed and associated biodiversity¹² indicated that Moreton Bay Bugs are unlikely to have been exposed to high levels of fishing pressure in the Torres Strait Protected Zone. In 2013, a Moreton Bay Bug catch of 22 t was reported from areas open to fishing. This is less than 10 per cent of available biomass, most of which inhabits extensive areas outside the areas subject to fishing pressure. Trawl operations in the Torres Strait Prawn Fishery (Commonwealth) cover only a small proportion—approximately 20 per cent¹³—of the Torres Strait Protected Zone. Lower catch of Moreton Bay Bugs in recent years is likely a result of declining effort, accompanied by reduced spatial coverage of the fishery. The above evidence indicates that the current level of fishing pressure is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Table 2: Moreton Bay Bug biology^{14,15}

Longevity and maximum size	~7 years <i>T. australiensis</i> : males 106 mm CW, females 124 mm CW <i>T. parindicus</i> : males 87 mm CW, females 103 mm CW
Maturity (50%)	<i>T. australiensis</i> (female): 82 mm CW <i>T. parindicus</i> (female): 75 mm CW

CW = carapace width, generally used for size limits in fan and slipper lobsters as it is a simple and rapid measure for use by commercial and recreational fishers

Figure 1: Distribution of reported commercial catch of Moreton Bay Bug in Australian waters, 2013 (calendar year)

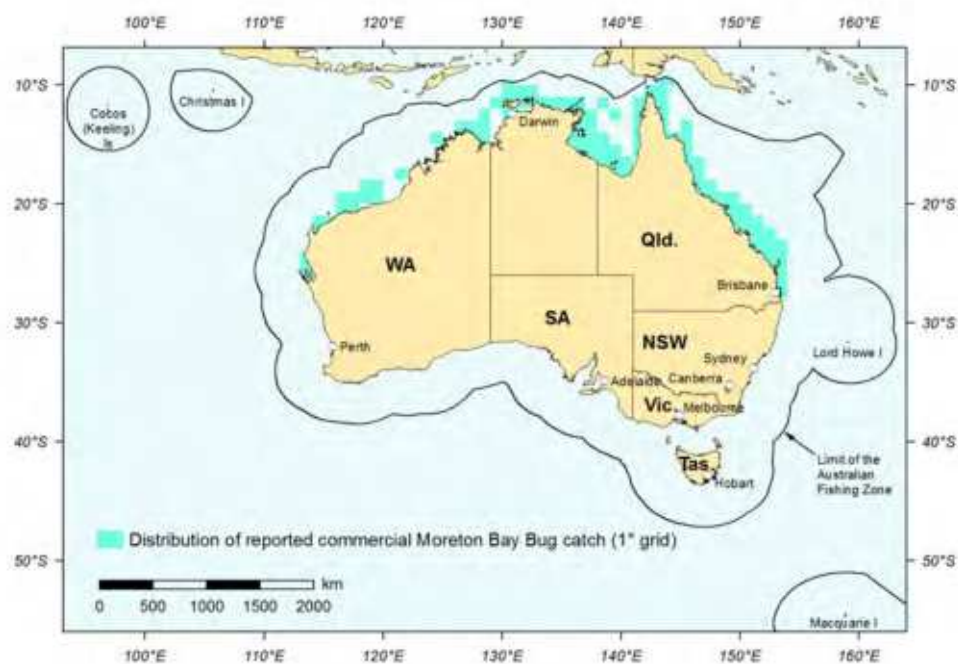


Table 3: Main features and statistics for Moreton Bay Bug fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland	Western Australia	Commonwealth
Fishing methods			
Commercial			
Demersal otter trawling	✓	✓	✓
Fish trawling		✓	
Recreational ^a			
Diving	✓		
Trap	✓		
Indigenous ^{b,c}			
		Unknown	

Jurisdiction	Queensland	Western Australia	Commonwealth
Management methods			
Commercial			
Limited entry	✓	✓	✓
Size limits	✓		✓
Prohibition on retention of females with eggs			✓
Vessel restrictions	✓	✓	✓
Effort limits	✓	✓	✓
Spatial closures	✓	✓	✓
Recreational ^a			
Size limits	✓		
Prohibition on retention of females with eggs	✓		
Indigenous ^{b,c}			
		Unknown	
Active vessels			
	219 in ECOTF	1 in BPMF 6 in EGPMF 2 in KPMF 2 in NBPMF 1 in OPMF 3 in PFTF 15 in SBPMF	50 in NPF 22 in TSPF
Catch			
Commercial	504 t in ECOTF	<1 t in BPMF <1 t in EGPMF <1 t in KPMF <1 t in NBPMF <1 t in OPMF <1 t in PFTF 3 t in SBPMF	109 t in NPF 22 t in TSPF
Recreational ^a	No catch	No catch	No catch
Indigenous ^{b,c}	No catch	No catch	No catch

Jurisdiction	Queensland	Western Australia	Commonwealth
Markets			
Domestic	✓	✓	✓
Export	✓		

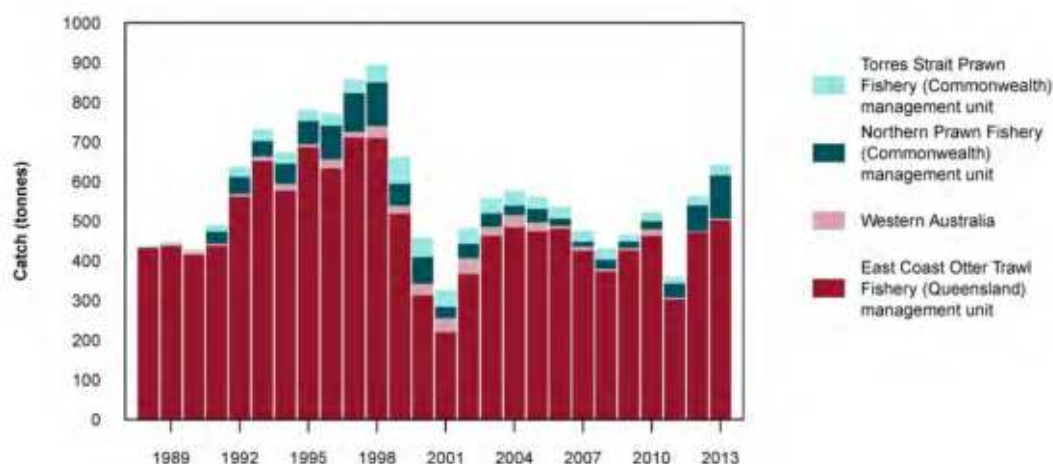
BPMF = Broome Prawn Managed Fishery (Western Australia); ECOTF = East Coast Otter Trawl Fishery (Queensland); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); KPMF = Kimberley Prawn managed Fishery (Western Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); NPF = Northern Prawn Fishery (Commonwealth); OPMF = Onslow Prawn Managed Fishery (Western Australia); PFTF = Pilbara Fish Trawl Fishery (Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia); TSPF = Torres Strait Prawn Fishery (Commonwealth)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

c Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

Figure 2: Commercial catch of Moreton Bay Bug in Australian waters, 1988 to 2013 (calendar years)



Effects of fishing on the marine environment

- The impact of trawling on habitats is managed in the Queensland and Western Australian fisheries that harvest Moreton Bay Bugs. In Queensland, the GBRMP occupies 63 per cent of the East Coast Otter Trawl Fishery¹⁶, 34 per cent of which is open to trawling⁵, but effort is highly aggregated, occurring within only a small fraction of the open area. South of the GBRMP, the fishery operates in only 10 per cent of the area open to trawling¹⁷. In Western Australia, extensive permanent and temporary closures result in the fleet operating in only 7 per cent of the Shark Bay region, less than 30 per cent of the Exmouth Gulf, and less than 3 per cent of the north-coast region. Fishing operations are restricted to areas of sand and mud, where trawling has minimal long-term physical impact¹⁸⁻²¹. The Northern Prawn Fishery (Commonwealth) uses a system of closures (spatial and seasonal) to manage the fishery, as well as other input controls (for example, limited entry, gear restrictions). A total of 2.1 per cent of the total managed area of the fishery is

subject to permanent closures, and 8.3 per cent is subject to seasonal closures²². The Torres Strait Prawn Fishery (Commonwealth) also uses spatial and temporal closures to protect small prawns, as well as important habitat areas such as breeding populations of turtles²³.

- Although the incidental capture of byproduct and bycatch species by trawling can lead to a range of indirect ecosystem effects²⁴, studies in Queensland and Western Australia found no significant difference in biodiversity or overall distribution patterns of seabed biota between trawled and nontrawled areas^{6,21}. An assessment of trawl-related risk in the GBRMP found that the East Coast Otter Trawl Fishery (Queensland) posed no more than an intermediate risk of overfishing species assemblages exposed to trawling³. Spatial contraction and/or temporal reduction in effort in these jurisdictions (see above) are likely to have mitigated the ecosystem impacts of trawling. Similarly, the Commonwealth fisheries have undergone varying levels of ecological risk assessment. In the Northern Prawn Fishery, the ecological risk management report identifies priority species at high risk. However, no target or protected species have been assessed as being at high risk because of the fishery²⁵. An ecological risk assessment conducted for the Torres Strait Prawn Fishery identified nine species for which trawling has had a negative impact on biomass²⁶.
- The use of BRDs in trawling can significantly reduce bycatch—by more than 50 per cent by weight in some fisheries²⁷. In the East Coast Otter Trawl Fishery (Queensland), the use of BRDs became mandatory in 1999, and the introduction of TEDs in 2001 largely eliminated capture of most large bycatch species, including turtles, sharks and rays²⁸. BRDs and TEDs became mandatory in the Northern Prawn Fishery (Commonwealth) in 2001. Use of TEDs in the Northern Prawn Fishery (Commonwealth) reduced turtle bycatch from 5700 individuals per year (before 2001) to approximately 30 per year (after 2001)¹¹. The introduction of TEDs in the Western Australian trawl fisheries in 2003 reduced turtle bycatch by at least 95 per cent²⁹. BRDs and TEDs have been mandatory in the Shark Bay and Exmouth Gulf prawn fisheries since 2003, and in all northern Western Australian prawn fisheries since 2005. All prawn trawlers operating in Western Australia must use TEDs and BRDs, including secondary fish exclusion devices and hoppers to increase survival of returned fish. Commitment to continuous improvement in bycatch mitigation has facilitated increased use of best-practice TEDs and BRDs in the East Coast Otter Trawl Fishery (Queensland) since 2008. Recent ecological risk assessments of the fishery^{3,4} have acknowledged the reduced impact of trawling and a general absence of high risk of overfishing bycatch species.

Environmental effects on Moreton Bay Bug

- Ocean acidification, changes in ocean current patterns (for example, strengthening of the East Australian Current), and increased intensity of tropical storms associated with climate change may affect food availability, larval survival, dispersion and settlement patterns, abundance of Moreton Bay Bugs, and the distribution and level of catches in the East Coast Otter Trawl Fishery (Queensland)³⁰. Increased rainfall and sea level rise have been identified³¹ as key impacts of climate change in the region of the Northern Prawn Fishery (Commonwealth). These impacts have the potential to modify the geographical distribution of Moreton Bay Bug stocks.

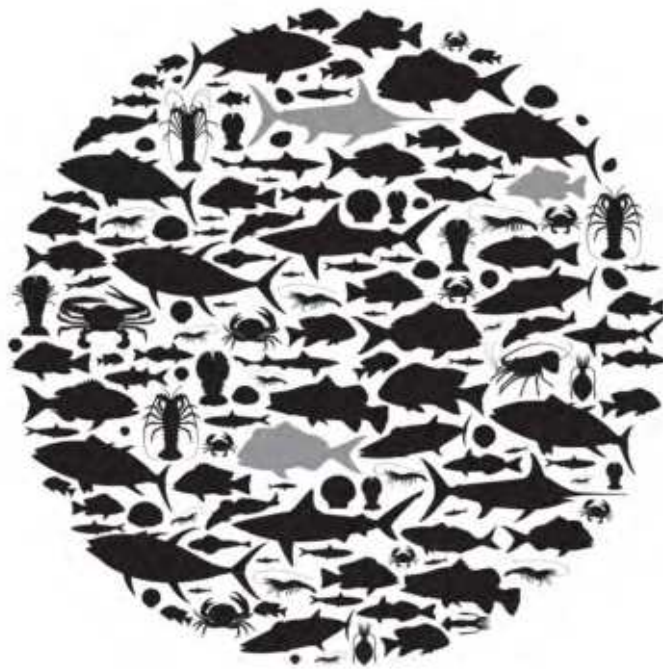
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Crustaceans: *Lobsters*



15. Eastern Rock Lobster *Sagmariasus verreauxi* (formerly *Jasus verreauxi*)¹

Geoffrey Liggins^a



Table 1: Stock status determination for Eastern Rock Lobster

Jurisdiction	New South Wales
Stock	NSWRLF
Stock status	
	Sustainable
Indicators	Biomass, CPUE, catch as percentage of TACC, spawning stock abundance (FIS-based), puerulus recruitment (FIS-based), size structure

CPUE = catch per unit effort; FIS = fishery-independent survey; NSWRLF = New South Wales Rock Lobster Fishery; TACC = total allowable commercial catch

Stock structure

Eastern Rock Lobster (*Sagmariasus verreauxi*)¹ occurs on rocky reef and sand/mud substrates in depths of less than 1 metre to about 200 metres, from southern Queensland to Port MacDonnell in South Australia, including around Tasmania. The greatest abundances and the only significant catches occur along the New South Wales coast, where Eastern Rock Lobster is taken by commercial and recreational fishers^{2,3}. The species also occurs off New Zealand, predominantly around the North Island⁴. Genetic studies have provided preliminary evidence that the stocks off Australia and New Zealand are discrete populations^{5,6}.

The spawning stock of Eastern Rock Lobster is restricted to the north coast of New South Wales. Following spawning and a 9-month larval phase (phyllosoma larvae), pueruli recruit to shallow inshore reefs along the entire New South Wales coast. This suggests a single New South Wales (Australian) biological stock. A current project, using contemporary genetic techniques, is re-examining the connectivity between Australian and New Zealand populations; and among New South Wales, Victorian and Tasmanian components of the Australian population of Eastern Rock Lobster.

Based on existing evidence of stock delineation, status is reported at the level of the single biological stock.

Stock status

New South Wales Rock Lobster Fishery biological stock

Following concerns about the sustainability of the Eastern Rock Lobster resource in the early 1990s, stock abundance has responded positively to management initiatives, including the introduction of a maximum legal length, individually numbered management tags, share management and a total allowable commercial catch (TACC)^{2,3,7-9}.

The annual TACC has effectively been taken (that is, more than 95 per cent caught) each year since 2004–05, indicating that the TACC has been limiting catch. Catch has increased from 102 tonnes (t) in 2004–05 to 150 t in 2013–14. In the 2012–13 fishing season, 139 t of catch was recorded, marginally below the 2012–13 TACC of 140 t. Catch per unit effort has been increasing since a low point in the early 1990s and is currently the highest observed during the past four decades. A fishery-independent survey in 2012–13 indicated that indices of abundance of spawning stock have been increasing since the late 1990s, and in 2012–13 were the highest observed during the 15-year time series. Based on an annual survey of puerulus abundance along the New South Wales coast, recruitment of pueruli has increased since the mid-1990s against a background of interannual fluctuations².

A length-structured model of the lobster population and the fishery provides annual estimates of stock biomass and depletion of biomass relative to pre-exploitation levels, and a prospective risk analysis of the likely consequence for biomass of alternative future TACCs. The base-case scenario of the most recent assessment² estimated that spawning biomass (SB) at the commencement of the 2013–14 season was 34 per cent (90 per cent confidence interval: 24 to 45 per cent) of the unfished (1884–85) level, having increased fourfold (median $SB_{2013-14}/SB_{1994-95} = 4.12$; 90 per cent confidence interval: 3.28 to 5.11) since 1994–95. The stock is not considered to be recruitment overfished.

Based on the prospective risk analysis of the consequences of alternative future catches, an independent Total Allowable Catch Committee⁹ sets TACCs annually to maintain the spawning biomass above the biological reference point of 25 per cent of unfished biomass. The current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Easter Rock Lobster biology^{3,10,11}

Longevity and maximum size	30+ years; 260 mm CL
Maturity (50%)	Females: 167 mm CL

CL = carapace length

Figure 1: Distribution of reported commercial catch of Eastern Rock Lobster in Australian waters, 2012–13 (fishing season)

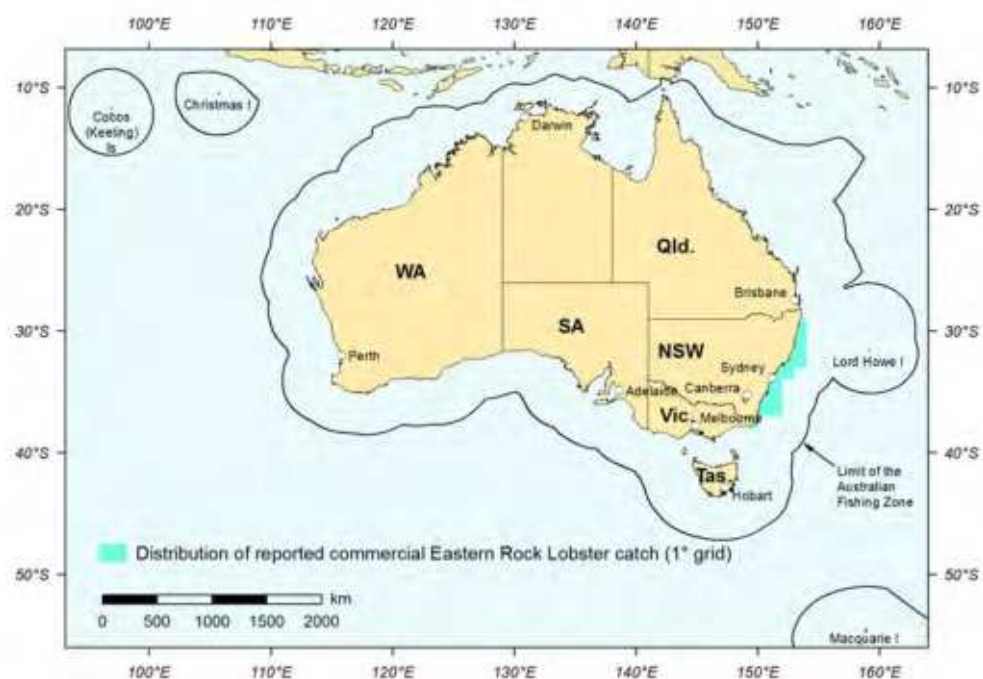


Table 3: Main features and statistics for Eastern Rock Lobster fisheries in Australia, 2012–13 (fishing season)

Jurisdiction		New South Wales
Fishing methods		
Commercial		
Lobster trap/pot		✓
Diving (free-diving)		✓
Recreational		
Lobster trap/pot		✓
Diving (free-diving)		✓
Indigenous		
Lobster trap/pot		✓
Diving (free-diving)		✓

Jurisdiction	New South Wales
Management methods	
Commercial	
Limited entry	✓
Size limits	✓
Vessel restrictions	✓
Gear restrictions	✓
Total allowable catch	✓
Spatial closures	✓
Management tags	✓
Demerit points, share confiscation	✓
Recreational	
Gear restrictions	✓
Bag limits	✓
Size limits	✓
Spatial closures	✓
Indigenous ^{a,b}	
Gear restrictions	✓
Bag limits	✓
Size limits	✓
Spatial closures	✓
Aboriginal cultural fishing authority	✓
Active vessels	
	82 in NSWRLF ^c

Jurisdiction	New South Wales
Catch	
Commercial	139 t in NSWRLF
Recreational	Unknown
Indigenous	Unknown
Markets	
Domestic	✓
Export	✓

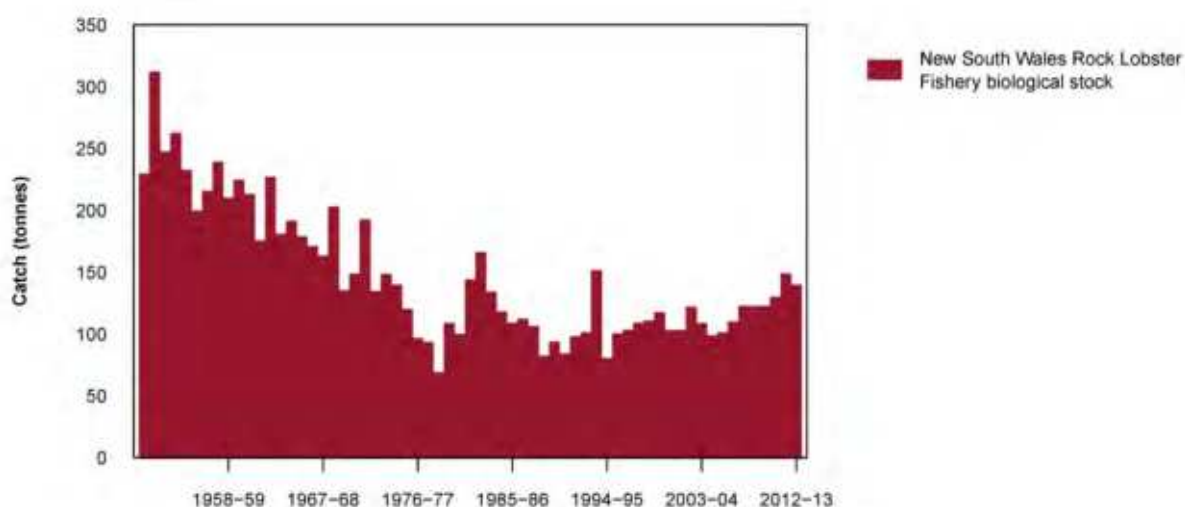
NSWRLF = New South Wales Rock Lobster Fishery

a The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

b The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

c Eighty-two fishing businesses reported catches during the 2012–13 fishing season.

Figure 2: Commercial catch of Eastern Rock Lobster in Australian waters, 1950–51 to 2012–13



Note: Data are for financial years before 2011–12, the 13-month July–July fishing year for 2011–12, and the August–July fishing year for 2012–13.

Effects of fishing on the marine environment

- Bycatch from the commercial fishery is minimal (based on data from observer surveys), and fishing with traps is likely to result in minimal physical disturbance to benthic habitats relative to the impacts of sea and swell in a high-energy coastal environment.

- Loss of traps in the deepwater component of the fishery, associated with loss of headgear, results in some ghost-fishing mortality of Rock Lobsters. This unproductive mortality is the subject of current research, and is being mitigated through the adoption of sacrificial panels in traps and acoustic release technology to provide 'at call' access to submerged headgear¹².
- Physical impacts of fish and prawn trawling on benthic habitat inhabited by lobsters (in particular, low-relief reefs on the mid-continental shelf) may have negative effects on the lobster population and subsequent catches at affected locations.

Environmental effects on Eastern Rock Lobster

- Changes in water temperature, and the spatial and temporal behaviour of the East Australian Current, due to climate change, may potentially affect the distribution of spawning stock, larval dispersal, and the strength and distribution of recruitment of pueruli. This would influence the distribution and abundance of juvenile lobsters recruiting to the fishable stock, and subsequently spatial and temporal patterns of catch in the fishery.

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16. Southern Rock Lobster *Jasus edwardsii*

Adrian Linnane^a, Caleb Gardner^b, David Reilly^c and Jason How^d



Table 1: Stock status determination for Southern Rock Lobster

Jurisdiction	South Australia, Tasmania, Victoria, Western Australia
Stock	Southern Australian (SASRLF, TRLF, VRLF, WASCCF)
Stock status	Sustainable
Indicators	Percentage of egg production relative to unfished level, proportion of spawning stock protected by minimum size limits

SASRLF = South Australian Southern Rock Lobster Fishery; TRLF = Tasmanian Rock Lobster Fishery; VRLF = Victorian Rock Lobster Fishery; WASCCF = Western Australian South Coast Crustacean Fisheries (Western Australia)

Stock structure

Southern Rock Lobster is considered to be a single biological stock across southern Australia because the species occurs in a continuous distribution across this range and has extensive larval dispersal; genetic analyses also indicate that it is a single stock¹. The larval duration is around 12–18 months. Larval release occurs across the southern continental shelf, which is a high-current area, facilitating dispersal. Oceanographic modelling has also indicated that Southern Rock Lobster dispersal occurs over large spatial scales, indicating that there is a single stock². Southern Rock Lobster is reported at the level of the biological stock.

Stock status

Southern Australian biological stock

The stock status determination for Southern Rock Lobster is based on egg production outputs from a combined stock assessment model³ for South Australia, Victoria and Tasmania. Combined outputs of the most recent assessments estimate that egg production in 2012–13 was 22 per cent of the unfished level^{4–7}. Accepting a limit reference point of 20 per cent of the unfished level, the stock is not considered to be recruitment overfished.

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^c Department of Environment and Primary Industries, Victoria

^d Department of Fisheries, Western Australia

Total allowable commercial catches have been reduced across south-eastern Australia over the past decade in response to decreases in catch rates, which reflect declines in rock lobster abundance. Current levels of fishing mortality are unlikely to cause the stock to become recruitment overfished.

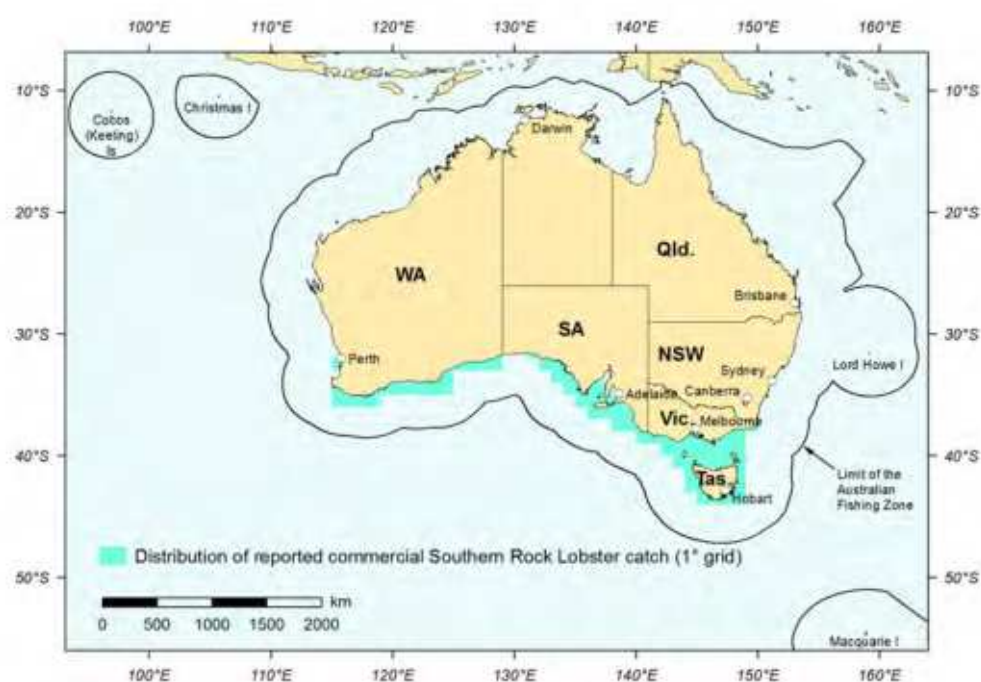
On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Southern Rock Lobster biology^{8–10}

Longevity and maximum size	20+ years; >200 mm CL
Maturity (50%)	59–122 mm CL, depending on region

CL = carapace length

Figure 1: Distribution of reported commercial catch of Southern Rock Lobster in Australian waters in 2012–13 (fishing season)



Note: Fishing seasons are October 2012 – May 2013 (South Australia), November 2012 – September 2013 (Victoria), November 2012 – September 2013 (Tasmania) and November 2012 – June 2013 (Western Australia south coast).

Table 3: Main features and statistics for Southern Rock Lobster fisheries in Australia, 2012–13 (fishing season)

Jurisdiction	South Australia	Victoria	Tasmania	Western Australia
Fishing methods				
Commercial				
Baited traps	✓	✓	✓	✓
Recreational				
Baited traps	✓		✓	✓
Hoop/drop nets	✓	✓	✓	
Diving and hand collection	✓	✓	✓	✓
Indigenous ^{a,b}				
Baited traps	✓		✓	✓
Hoop nets	✓		✓	
Diving and hand collection	✓		✓	✓
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Size limits	✓	✓	✓	✓
Total allowable catch	✓	✓	✓	
Temporal closures	✓	✓	✓	✓
Spatial closures	✓	✓	✓	
Gear restrictions	✓	✓	✓	✓
Recreational				
Bag limits	✓	✓	✓	✓
Size limits	✓	✓	✓	✓
Temporal closures	✓	✓	✓	✓
Spatial closures	✓	✓	✓	
Gear restrictions	✓	✓	✓	✓

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SOUTHERN ROCK LOBSTER

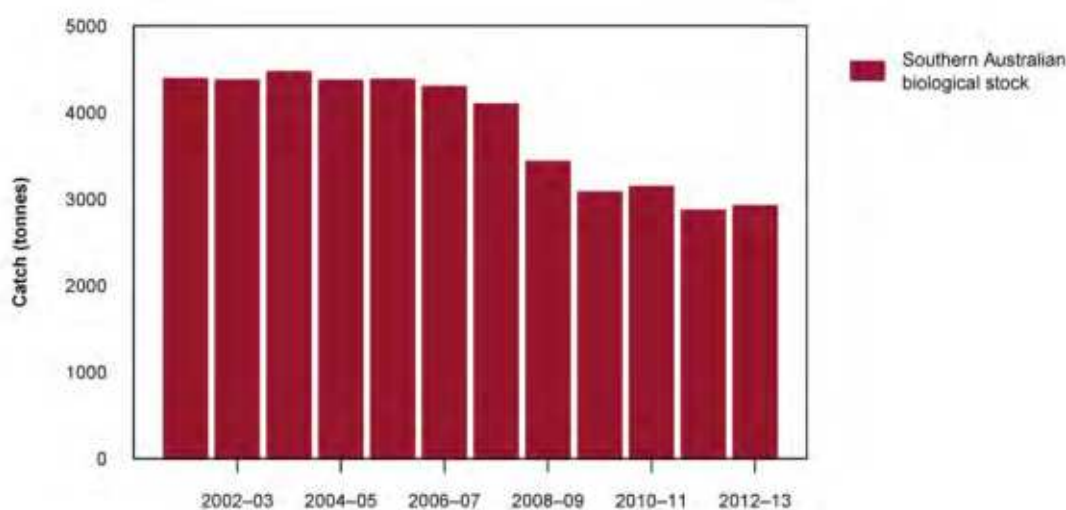
Jurisdiction	South Australia	Victoria	Tasmania	Western Australia
Indigenous ^{a,b}				
Bag limits	✓		✓	✓
Size limits	✓		✓	✓
Active vessels				
	207 in SASRLF	71 in VRLF	202 in TRLF	28 in WASCCF
Catch				
Commercial	1552 t in SASRLF	306 t in VRLF	1064 t in TRLF	45 t in WASCCF
Recreational	Unknown	Unknown	84 t	<5 t
Indigenous	Unknown	None	Unknown	Unknown
Markets				
Domestic	✓	✓	✓	
Export	✓	✓	✓	✓

SASRLF = South Australian Southern Rock Lobster Fishery; TRLF = Tasmanian Rock Lobster Fishery; VRLF = Victorian Rock Lobster Fishery; WASCCF = Western Australian South Coast Crustacean Fisheries

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (for example, different catch and size limits or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Southern Rock Lobster.

b Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catch of Southern Rock Lobster in Australian waters, 2001–02 to 2012–13 (fishing seasons)



Note: Data are based on fishing seasons, which are October 2012 – May 2013 (South Australia), November 2012 – September 2013 (Victoria), November 2012 – September 2013 (Tasmania) and November 2012 – June 2013 (Western Australia south coast).

Effects of fishing on the marine environment

- In South Australia, concern has been expressed about potential interactions with Australian Sea Lions in the fishery, specifically the risk of juvenile pups entering pots¹¹. Sea lion excluder devices are now mandatory in pots in areas where interactions are likely to occur.
- Whale entanglements are recognised as a management issue by the Victorian Southern Rock Lobster fishery management plan¹². The fishery management plan responded with a fishery code of practice to prevent and respond to whale entanglements.
- The biomass of Southern Rock Lobster is being rebuilt off eastern Tasmania to assist in the management of Long-spined Sea Urchins¹³. These urchins, which have extended their range southwards from New South Wales, can create barren patches of reef through overgrazing. Rebuilding of the Southern Rock Lobster biological stock may reduce barren formation through predation on the urchins.
- Habitat impacts of gear have been researched and assessed as negligible risk¹⁴.

Environmental effects on Southern Rock Lobster

- The potential impact of climate change on recruitment, growth and mortality has been identified as a risk across the range of the species¹⁵.
- Recruitment, catchability and growth can vary substantially from year to year as a result of environmental changes, including changes in water temperature and movement of oceanic currents¹⁶. Below-average recruitment is not necessarily associated with low egg production—it can also result from unusual oceanographic patterns, which can affect larval development and growth.

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17. Tropical Rock Lobster *Panulirus ornatus*

Matthew Flood^a and Anthony Roelofs^b

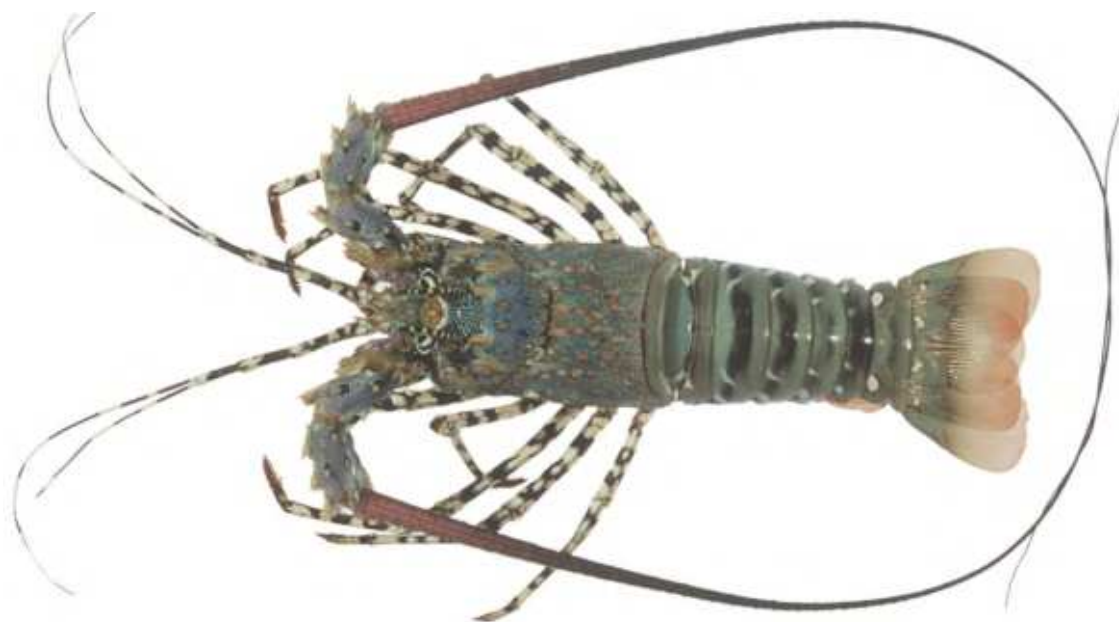


Table 1: Stock status determination for Tropical Rock Lobster

Jurisdiction	Commonwealth, Torres Strait Protected Zone Joint Authority, Queensland	Northern Territory	Western Australia
Stock	North-eastern Australian (CRF, CSF, TSTRLF)	Northern Territory	Western Australia
Stock status		Negligible ^a	Negligible ^b
	Sustainable		
Indicators	Biomass, fishing mortality		

CRF = Crayfish and Rock Lobster Fishery (Queensland); CSF = Coral Sea Fishery (Commonwealth); TSTRLF = Torres Strait Tropical Rock Lobster Fishery (Commonwealth)

a 'Negligible' means historically low catch; no stock status. No commercial catch is taken from the Northern Territory. It has been estimated that around 300 kg is taken each year by recreational fisheries.

b 'Negligible' means historically low catch; no stock status. No commercial catch is taken from Western Australia. It has been estimated that 198 ± 98 individuals were taken by boat-based recreational fishing in 2011–12.

Stock structure

Tropical Rock Lobster populations in northern Queensland (managed by Queensland), the Coral Sea (managed by the Commonwealth) and the Torres Strait (managed by the Torres Strait Protected Zone Joint Authority) are thought to comprise a single north-eastern Australian biological stock, as a result of mixing of larvae in the Coral Sea¹. Stock assessments have not been carried out for the complete biological stock, but have been conducted on the various parts of it. Stock status in this chapter is reported at the level of the single north-eastern Australian biological stock.

a Australian Bureau of Agricultural and Resource Economics and Sciences

b Department of Agriculture, Fisheries and Forestry, Queensland

Although Tropical Rock Lobster is also present in both the Northern Territory and northern Western Australia, biological stock structures in these regions have not been studied.

Stock status

North-eastern Australian biological stock

Stock status for the entire Tropical Rock Lobster biological stock has been established using evidence from the Torres Strait, Queensland and Coral Sea parts of the biological stock.

For the Torres Strait part of the biological stock, the most recent assessment² estimated that spawning stock biomass in 2013 was 114 per cent of the unfished (1973) level. This part of the stock is not considered to be recruitment overfished³. The model-generated nominal total allowable catch (TAC) for 2013 was 871 tonnes (t), and 586 t was caught. Therefore, the level of fishing mortality is unlikely to cause this part of the stock to become recruitment overfished³.

For the Queensland part of the biological stock, the most recent stock assessment⁴ estimated that biomass at the start of 2008 was 60–70 per cent of the unfished (1988) level. A TAC of 195 t was introduced for the commercial fishery in 2009. The TAC was based on a conservative 80 per cent of the estimated maximum sustainable yield for the Queensland portion of the stock. The commercial catch since 2009 has been below the TAC^{5,6}. Catch rates in 2013 were within historical limits and have shown a rising trend since 2009⁶. As a result, this part of the biological stock is not considered to be recruitment overfished⁷, and current fishing mortality is unlikely to cause this part of the biological stock to become recruitment overfished⁷.

No quantitative stock assessments have been carried out for the Coral Sea part of the biological stock, but there is only limited targeting of Tropical Rock Lobster in this area. Estimates of density on Coral Sea reefs, inferred from fishers' catch rates, suggest that lobster abundance is likely to be many times higher than would be required to support the total historical catch (less than 10 t)⁸. This part of the biological stock is not considered to be recruitment overfished. Additionally, no commercial catch was recorded in 2013. Therefore, fishing mortality is unlikely to cause this part of the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the entire biological stock is classified as a **sustainable stock**.

Table 2: Tropical Rock Lobster biology^{9–11}

Longevity and maximum size	3–5+ years; >150 mm CL
Maturity (50%)	2–3 years; ~100 mm CL

CL = carapace length

Figure 1: Distribution of reported commercial catch of Tropical Rock Lobster in Australian waters, 2013 (calendar year)

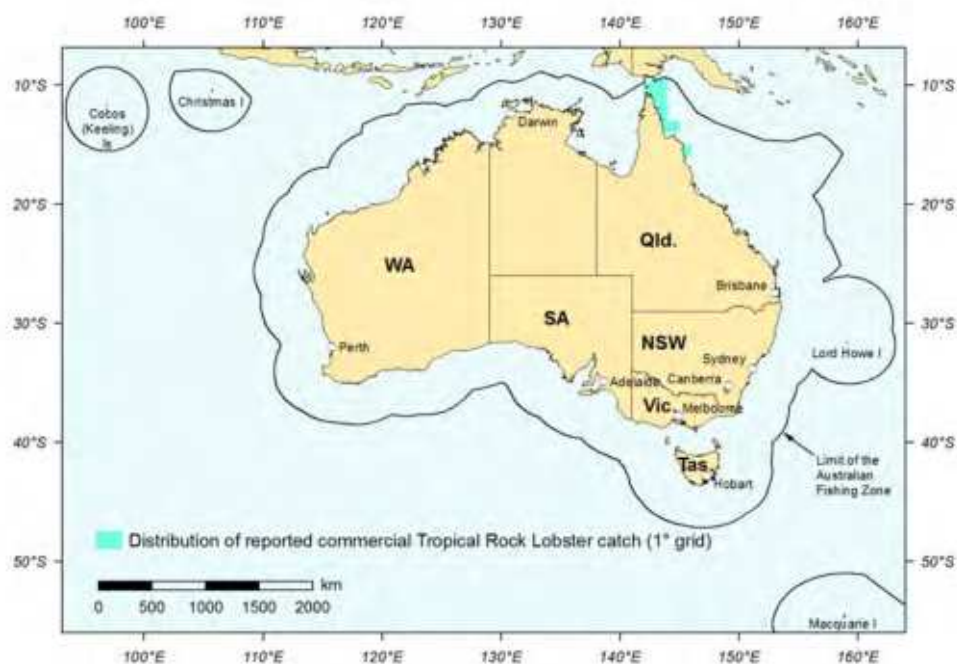


Table 3: Main features and statistics for Tropical Rock Lobster fisheries in Australia, 2013 (calendar year)

Jurisdiction	Torres Strait Protected Zone Joint Authority	Queensland	Commonwealth
Fishing methods			
Commercial			
Diving	✓	✓	✓
Recreational ^a			
Diving		✓	
Indigenous ^{b,c}			
Diving	✓	✓	

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TROPICAL ROCK LOBSTER

Jurisdiction	Torres Strait Protected Zone Joint Authority	Queensland	Commonwealth
Management methods			
Commercial			
Limited entry	✓ (non-Indigenous)	✓	✓
Size limits	✓	✓	✓
Vessel restrictions		✓	✓
Gear restrictions	✓	✓	✓
Total allowable catch	✓ (nonbinding)	✓	✓
Spatial closures		✓	✓
Seasonal closures	✓	✓	
Prohibition on take of egg-bearing and tar-spot females		✓	
Recreational ^a			
Possession limits		✓	
Size limits		✓	
Gear restrictions		✓	
Seasonal closures		✓	
Spatial closures		✓	
Prohibition on take of egg-bearing and tar-spot females		✓	
Indigenous ^{b-d}			
Bag limits	✓		
Gear restrictions		✓	
Active vessels			
	In TSTRLF: 11 non-Indigenous commercial 215 Indigenous commercial 1 cross-endorsed PNG commercial vessel.	7 in CRF	0 in CSF

Jurisdiction	Torres Strait Protected Zone Joint Authority	Queensland	Commonwealth
Catch			
Commercial	586 t in TSTRLF	181 t in CRF	0 t in CSF
Recreational ^a	Unknown	Unknown (minor)	
Indigenous ^{b,c}	Unknown	13 000 lobsters (in 2001)	
Markets			
Domestic	✓	✓	
Export	✓	✓	

CRF = Crayfish and Rock Lobster Fishery (Queensland); CSF = Coral Sea Fishery (Commonwealth); PNG = Papua New Guinea; TSTRLF = Torres Strait Tropical Rock Lobster Fishery (Commonwealth)

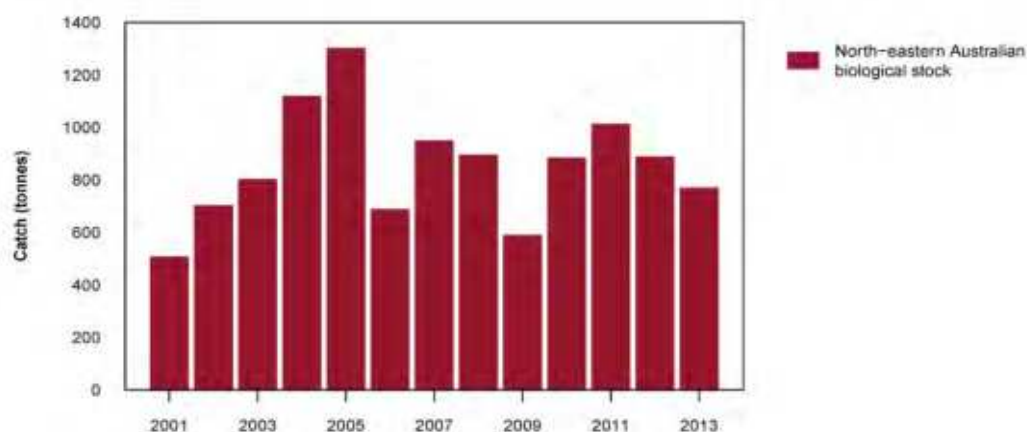
a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters. In the Torres Strait, both commercial and noncommercial Indigenous fishing is managed by the Torres Strait Protected Zone Joint Authority (PZJA) through the Australian Fisheries Management Authority (Commonwealth); the Department of Agriculture, Fisheries and Forestry (Queensland); and the Torres Strait Regional Authority. The PZJA also manages non-Indigenous commercial fishing in the Torres Strait.

c Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

d This specifically refers to noncommercial Indigenous catch. Commercial Indigenous catch in the Torres Strait is included under 'commercial'.

Figure 2: Commercial catch of Tropical Rock Lobster in Australian waters, 2001 to 2013 (calendar years)



Effects of fishing on the marine environment

- Fishing for Tropical Rock Lobster has little direct impact on the marine environment or other fish species, since hand-collection fishing methods allow careful selection of catch⁸.

Environmental effects on Tropical Rock Lobster

- The abundance of Tropical Rock Lobster is highly influenced by environmental conditions, which affect settlement and recruitment. Ocean current and wind patterns affect transport of larvae and create variability in abundance. These variations should be taken into account in setting TACs^{1,10}.

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18. Western Rock Lobster *Panulirus cygnus*

Simon de Lestang^a



Table 1: Stock status determination for Western Rock Lobster

Jurisdiction	Western Australia
Stock	WCRLF
Stock status	Sustainable
Indicators	Egg production relative to mid-1980s levels, harvest rate

WCRLF = West Coast Rock Lobster Managed Fishery (Western Australia)

Stock structure

Western Rock Lobster is a single biological stock, with a distribution along the mid- to lower west coast of Western Australia^{1,2}.

Stock status

West Coast Rock Lobster Managed Fishery (Western Australia) biological stock

The stock status for Western Rock Lobster (*Panulirus cygnus*) is determined using the egg production and harvest rate outputs from a stock assessment model that is based on a broad range of fishery data and fishery-independent monitoring³. The most recent assessment estimates that egg production in each management region in 2013 was well above the respective threshold levels. This evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

The proportion of the legal stock harvested each fishing season is currently based on maximum economic yield principles⁴ and is projected to remain below 45 per cent over the next four fishing seasons. This provides at least 75 per cent confidence that egg production levels in each management region will remain above the respective thresholds³. This indicates that the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

The stock assessments conducted on the fishery have been critically examined and reviewed on an annual

^a Department of Fisheries, Western Australia

basis since 1999 by external reviewers, as part of the fishery's continued certification by the Marine Stewardship Council (MSC). In March 2012, the fishery entered its third 5-year MSC certification period.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Western Rock Lobster biology¹

Longevity and maximum size	20+ years; >150 mm CL
Maturity (50%)	5–7 years; 65–80 mm CL, depending on location

CL = carapace length

Figure 1: Distribution of reported commercial catch of Western Rock Lobster in Australian waters, 2013 (fishing season: 15 January 2013 – 14 January 2014)

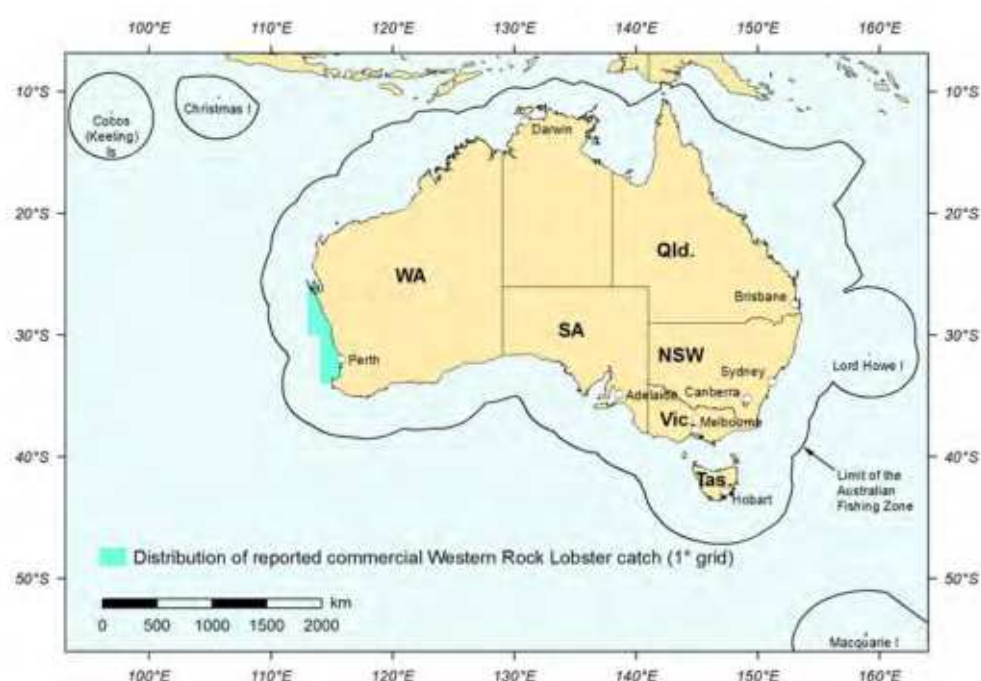


Table 3: Main features and statistics for Western Rock Lobster fisheries in Australia, 2013 (fishing season: 15 January 2013 – 14 January 2014)

Jurisdiction	Western Australia
Fishing methods	
Commercial	
Batten and beehive pots	✓
Recreational	
Batten and beehive pots	✓
Diving	✓
Indigenous ^a	

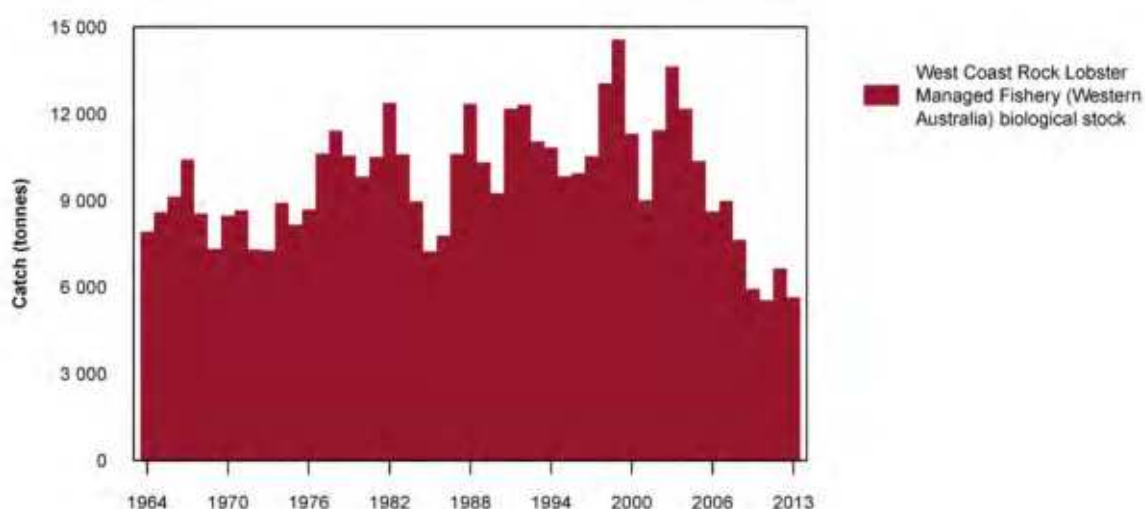
Jurisdiction	Western Australia
Batten and beehive pots	✓
Diving	✓
Management methods	
Commercial	
Limited entry	✓
Size limits	✓
Total allowable catch	✓
Gear restrictions	✓
Spatial closures	✓
Recreational	
Bag limits	✓
Size limits	✓
Gear restrictions	✓
Spatial closures	✓
Temporal closures	✓
Indigenous ^a	
Bag limits	✓
Size limits	✓
Gear restrictions	✓
Active vessels	
Commercial	251 in WCRLF
Catch	
Commercial	5641 t in WCRLF
Recreational	128 t
Indigenous	Unknown
Markets	
Domestic	✓

Jurisdiction	Western Australia
Export	✓

WCRLF = West Coast Rock Lobster Managed Fishery (Western Australia)

a Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catch of Western Rock Lobster in Australian waters, 1964 to 2013 (fishing seasons)



Note: 'Fishing season' represents a different timeframe across the data series. From 1964 to 2011, a season ran from 15 November to June or August the following year (for example, 1964 = November 1964 to August 1965). In 2011, the season was extended by changing the season start and finish dates. The 2011 season was extended to 14 months (15 November 2011 – 14 January 2013) to reschedule the start time, and the total allowable catch increased to 6900 tonnes, corresponding to the longer season. The 2013 season was the first under the new timeframe (15 January 2013 – 14 January 2014).

Effects of fishing on the marine environment

- The legislated design of rock lobster pots (batten and beehive), including the materials they are made from, prevents 'ghost fishing' problems. A study of human impacts on the marine environments of the Abrolhos Islands estimated that potting impacts less than 0.3 per cent of the surface area of fragile habitat (corals). For the coastal fishery, rock lobster fishing occurs on sand areas around robust limestone reef habitats, covered with coralline algae and macro-algae such as kelp (*Ecklonia* spp.). This type of high-energy coastal habitat is regularly subjected to swell and winter storms, and so is considered highly resistant to damage from rock lobster potting. The significant recent reductions in fishing effort will have reduced these risks even further⁵.
- The incidental capture of juvenile sea lions, recognised as a management issue by the Western Australian Department of Fisheries, has resulted in the introduction of sea lion excluder devices in high-risk areas. This has reduced captures of sea lions, and no captures were recorded in 2010–11⁵.
- Sea lions, seals and sharks have been found to be particularly susceptible to injury or death through entanglement in uncut plastic bait bands. Historically, these bands also contribute to plastic debris washed up on shorelines. In 2012, a statewide ban on the carriage of bait bands out to sea was implemented.
- Research monitoring of commercial bycatch occurs continuously across the fishery; no issues of concern have been identified⁵.

- Interactions between pot ropes/floats and migrating whales have historically remained between zero and four whales per migration season (May–November). However, a marked increase in interactions has occurred since 2011, as a result of a combination of an increase in the whale population and an expansion of the fishing season. This increase has been recognised as a management issue, and the Western Australian Department of Fisheries has implemented management changes to reduce interactions during the 2014 migration season. These include reducing pot usage (maximum of 60 pots per vessel), using negatively buoyant float lines and trialling acoustic pingers. Two Fisheries Research and Development Corporation projects have been initiated to investigate this issue.

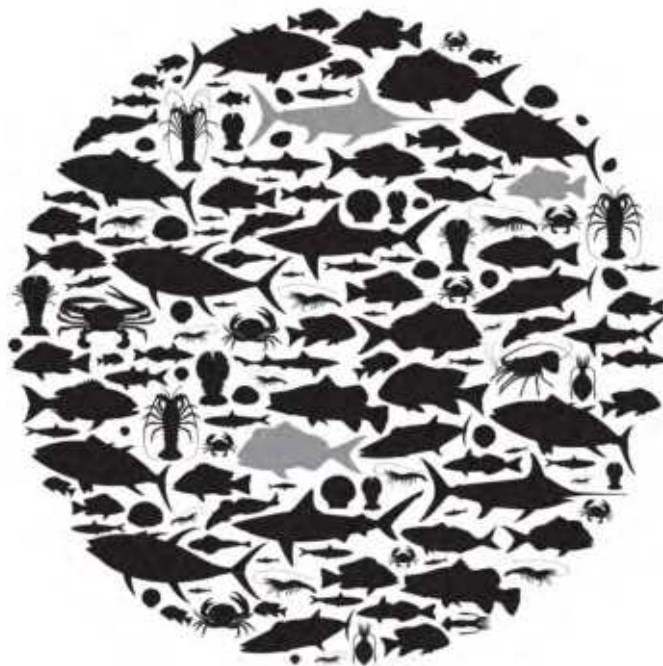
Environmental effects on Western Rock Lobster

- Annual variation in the abundance of puerulus (post-larval lobsters) has historically been associated with fluctuations in offshore water temperatures during the early larval phase; water temperatures are influenced by the strength of the Leeuwin Current and the incidence of storm fronts crossing the west coast during spring⁶. More recently, other factors, such as timing of the onset of spawning (which is affected by water temperature), have been identified as possible contributors to these variations—in particular, the 7 years of below-average settlement (2006–07 to 2012–13), including the record low settlement of 2008–09⁵.
- Many aspects of the Western Rock Lobster life history, such as growth, migration, size at maturity and catchability, appear to be sensitive to changes in water temperature^{7–9}. Increasing trends in long-term water temperature have co-occurred with declines in the size at maturity⁹ and size at migration¹⁰, and an increase in the proportion of female lobsters moulting out of setose in autumn⁸.

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Crustaceans: *Prawns*



19. Banana Prawn *Penaeus merguensis* (formerly *Fenneropenaeus merguensis*)¹, *Penaeus indicus*

James Larcombe^a, Mervi Kangas^b and Brad Zeller^c



White Banana Prawn (*P. merguensis*)

Table 1: Stock status determination for White Banana Prawn

Jurisdiction	Commonwealth	Queensland	Western Australia		
Stock	NPF	East coast (ECIFFF, ECOTF, RIBTF)	EGPMF	NBPMF	KPMF
Stock status					
	Sustainable	Sustainable	Sustainable	Sustainable	Sustainable
Indicators	Catch, CPUE, trigger limits	Catch, stock assessments	Catch, catch projections	Catch, catch projections	Catch, catch projections

CPUE = catch per unit effort; ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); ECOTF = East Coast Otter Trawl Fishery (Queensland); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); KPMF = Kimberley Prawn Managed Fishery (Western Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); NPF = Northern Prawn Fishery (Commonwealth); RIBTF = River and Inshore Beam Trawl Fishery (Queensland)

Stock structure

In Australia the standard fish name Banana Prawn is a group name which refers to *Penaeus merguensis* and *Penaeus indicus*. The current chapter only considers *Penaeus merguensis*. While it is not an agreed standard fish name *Penaeus merguensis* is commonly referred to as White Banana Prawn. The biological stock structure of White Banana Prawn is uncertain. There is some evidence that there may be separate biological stocks of White Banana Prawn in the Northern Prawn Fishery (Commonwealth); however, the boundaries of the biological stocks are unknown². Stocks within Western Australia and Queensland are unlikely to be completely independent, although it does appear that biological stocks separated by large distances are more

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independent than adjacent biological stocks³. In the absence of clear information on biological stock structure, status is reported at the management unit level.

Stock status

Northern Prawn Fishery (Commonwealth) management unit

Recruitment of White Banana Prawns in the Northern Prawn Fishery (Commonwealth) is thought to be largely determined by seasonal conditions, particularly rainfall⁴. As a result, a reliable stock–recruitment relationship has not been established. No formal stock assessment exists for this stock.

The harvest strategy for White Banana Prawns in the Northern Prawn Fishery (Commonwealth) is designed for the capture of larger prawns and to allow for sufficient escapement to ensure adequate spawning biomass (based on historical data), preventing growth and recruitment overfishing, and providing higher returns by minimising the capture of small prawns. This is achieved through season-length, the end of which is dictated by catch-rate thresholds⁵. The harvest strategy is designed to perform under conditions of substantial variation in biomass, which are largely independent of fishing. Although fishing mortality is thought to be high for White Banana Prawns in some years⁶, the species is thought to be resilient to fishing pressure.

In 2013, total reported commercial landings were 2713 tonnes (t); this is substantially below the landings in recent years and below the average catch of the preceding 10 years (2004 to 2013) of 4105 t. These catch levels indicate that a smaller than average biomass was available in 2013. Effort expended on White Banana Prawns in the Northern Prawn Fishery (Commonwealth) in 2013 was 2192 vessel-days, less than the 10-year average (2002 to 2012) of approximately 2858 vessel-days.

The recent history of commercial catches of White Banana Prawns, which have been harvested in accordance with the harvest strategy and with a substantially reduced fishing fleet (compared with historical levels), indicates that the management unit is unlikely to be recruitment overfished⁷. The comparatively low effort indicates that fishing mortality is unlikely to cause the management unit to become recruitment overfished⁷.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

East coast (Queensland) management unit

The most recent quantitative assessment of the east coast (Queensland) management unit was based on catch-and-effort data from 1988 to 2004, and estimated an average annual maximum sustainable yield (MSY) of 802 t³. Although there appears to be no long-term trend in total annual catch in relation to the MSY, there is evidence that the size of year-to-year variations may be increasing (for example, record high total catch in 2011, record low total catch in 2012 and the second highest total catch in 2013)⁸. From 2009 to 2013, annual catches have been variable in substocks where the majority (95 per cent) of the catch was taken⁸. The above evidence indicates the biomass of the management unit is unlikely to be recruitment overfished.

Although fishing mortality is likely to be at or near the upper sustainable limit for some substocks, recent ecological risk assessments found that there was a low risk of the management unit becoming recruitment overfished at 2009 effort levels^{9,10}. Since 2009, there has been a 16 per cent decrease in effort directed at White Banana Prawn (days when White Banana Prawn was caught), indicating that, despite an increase in fishing power in the East Coast Otter Trawl Fishery fleet (0.4 to 3.1 per cent per year)¹¹, fishing pressure on the management unit is not increasing. The above evidence indicates that the current level of fishing pressure is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Exmouth Gulf Prawn Managed Fishery (Western Australia) management unit

Banana Prawn landings are generally low (or zero) in this fishery, but in 2013 landings (74 t) were the highest recorded since the fishery started. This is likely to be attributable to favourable environmental conditions for White Banana Prawn (moderate rainfall in December–March for 3 years and warmer than average water temperatures). In 2012, a total of 33 t of White Banana Prawn was landed, indicating a higher than average abundance of spawning stock in that year. This is likely to have resulted in improved recruitment in 2013. The management unit is not considered to be recruitment overfished, and the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Nickol Bay Prawn Managed Fishery (Western Australia) management unit

Historical commercial catch levels from 1989 to 1998 have been used as the basis for calculating target catch ranges. The target catch range is 40–220 t¹². Annual commercial catch projections for the fishing season are based on wet-season rainfall (December–March). The commercial catch projection for the 2013 fishing season was 120–180 t. Total commercial catch for 2013 was 106 t, which is within the target catch range but slightly below the 2013 projected catch range. Six boats fished in 2013, for a total effort of 178 vessel-days.

On the basis of annual trends in landings and effort since 1980 and, more recently, annual catch rates and the outputs of stock production models and a biomass dynamics model (unpublished work by the Western Australian Department of Fisheries), the White Banana Prawn stock in Nickol Bay is currently being fished at a sustainable level. Key evidence to support this is as follows:

- There has been no marked declining trend in overall landings across the entire time series, despite very marked reductions in effort in recent years. Catches have typically fluctuated within the lower half of the catch target range.
- Although catches have declined somewhat in recent years, the level of reduction is consistent with the level of effort reduction, according to the outputs of stock production models.
- There has been no decline in peak catch rates in recent years in the two main fishing grounds.
- There has been a declining trend in fishing mortality due to low fishing levels, as estimated by a biomass dynamics model.
- In recent years, the levels of spawning biomass have been high relative to the estimated unfished level, as determined from the biomass dynamics model.

Therefore, the management unit is not considered to be recruitment overfished, and the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Kimberley Prawn Managed Fishery (Western Australia) management unit

Historical commercial catch levels from 1989 to 1998 have been used as the basis for calculating target catch ranges. The range in the Kimberley Prawn Managed Fishery (Western Australia) is 200–450 t¹². Annual commercial catch projections for the fishing season are based on January and February rainfall levels in Kalumburu and Derby, and the annual total landings¹². The commercial catch projection for the 2013 fishing season was 230–350 t. Total commercial catch for 2013 was 144 t, which is well below the target catch range and projected catch range. The management unit operates under an upper-limit effort cap of 1500 vessel-days (based on historical effort levels); only 314 vessel-days were fished in 2013.

On the basis of annual trends in landings and effort since 1980 and, more recently, catch rates, the White Banana Prawn stock is currently being fished at a sustainable level. Key evidence to support this is as follows:

- There has been no marked declining trend in landings across the entire time series.
- Landings have been maintained at relatively low levels of effort compared with historical levels.
- Fishing effort (vessel-days) in the past 5 years has been well below the levels that provided the highest catches in the history of the fishery.
- In recent years, estimated levels of stock biomass have been high, and estimated levels of fishing mortality have been low, as determined from a preliminary biomass dynamic model.
- There has been a marked increase in annual mean catch rates, apparently associated with a change in the economics of fishing since about 2005, which led to a marked reduction in the number of fishers harvesting the available stock.

The management unit is not considered to be recruitment overfished, and the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

In the current economic conditions, fishers are aiming to optimise returns by maximising their efficiency (with the majority fishing only when catch rates are high), and targeting larger and higher-quality prawns (by fishing later in the year). These conditions are conducive to conservative harvesting of the resource. Permanent

closures have been introduced in all the major rainfall catchments, as well as temporal closures in two of the catchment areas (known as 'size management fish grounds') to protect smaller prawns and their habitats.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Table 2: White Banana Prawn biology^{2,3,12}

Longevity and maximum size	1–2 years; >240 mm TL
Maturity (50%)	~6 months; 120–150 mm CL

CL = carapace length; TL = total length

Figure 1: Distribution of reported commercial catch of White Banana Prawn in Australian waters, 2013 (calendar year)

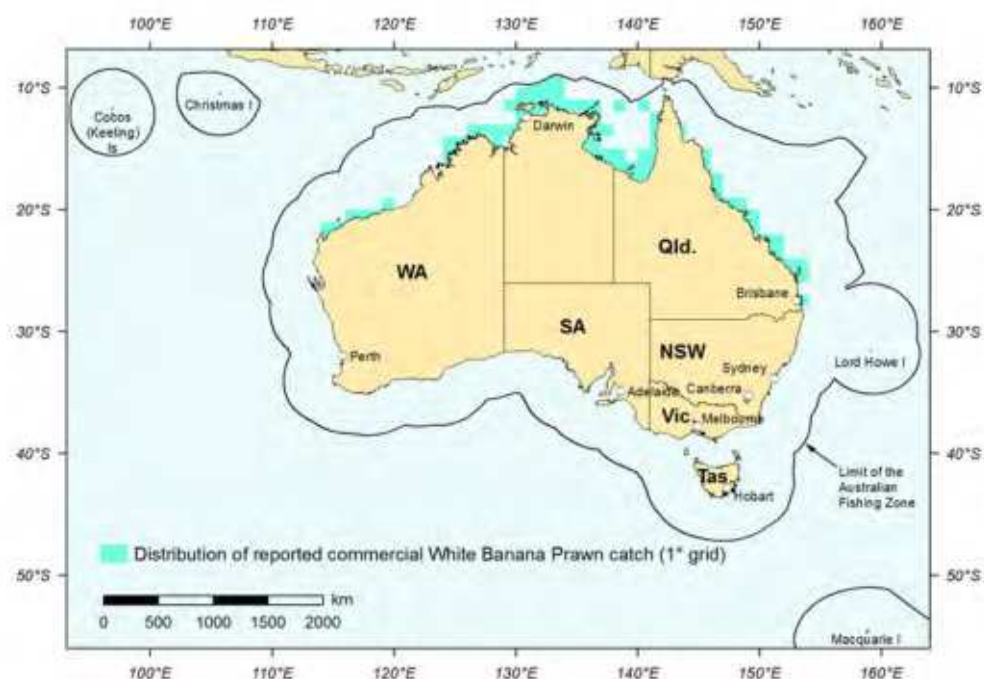


Table 3: Main features and statistics for White Banana Prawn fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth	Queensland	Western Australia
Fishing methods			
Commercial			
Otter trawl	✓	✓	✓
Beam trawl		✓	
Mesh net		✓	
Recreational ^a			
Cast netting		✓	

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Jurisdiction	Commonwealth	Queensland	Western Australia
Indigenous ^b			
Cast netting		✓	
Management methods			
Commercial			
Limited entry	✓	✓	✓
Vessel restrictions	✓	✓	
Gear restrictions	✓	✓	✓
Effort limits	✓		
Spatial closures	✓	✓	✓
Temporal closures	✓	✓	✓
Recreational ^a			
Licence			✓
Bag limits			✓
Possession limits		✓	
Indigenous ^{b,c}			
Gear restrictions		✓	
Active vessels			
	52 in NPF	25 in ECIFFF 134 in ECOTF 45 in RIBTF	6 in EGPMF 12 in KPMF 6 in NBPMF
Catch			
Commercial	2713 t in NPF	35 t in ECIFFF 1022 t in ECOTF 89 t in RIBTF	74 t in EGPMF 144 t in KPMF 106 t in NBPMF
Recreational ^a		Unknown	Unknown
Indigenous ^{b,c}		Unknown	Unknown

Jurisdiction	Commonwealth	Queensland	Western Australia
Markets			
Domestic	✓	✓	✓
Export	✓		✓

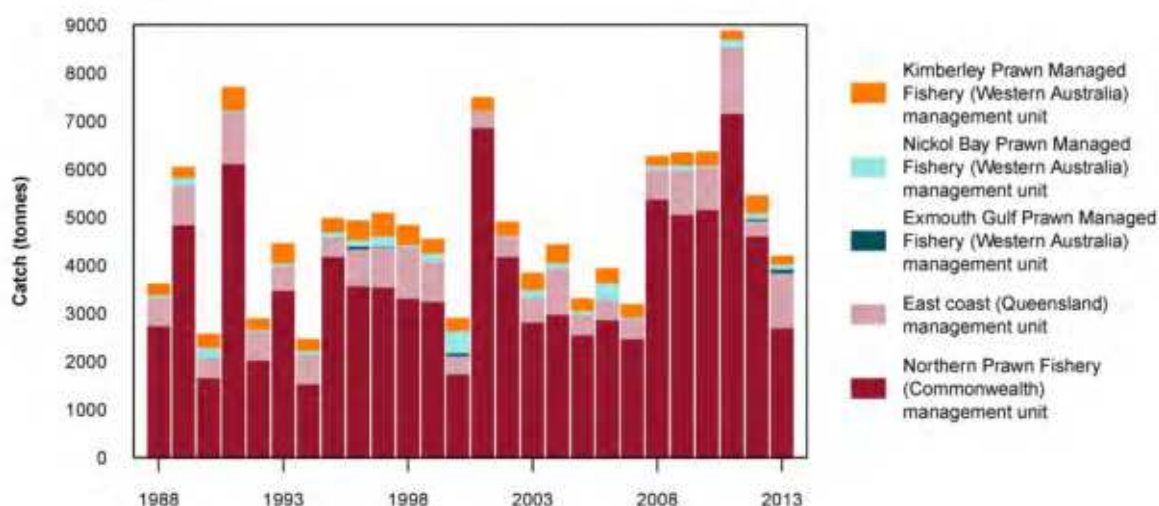
ECIFFF = East Coast Inshore Fin Fish Fishery; ECOTF = East Coast Otter Trawl Fishery (Queensland); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); KPMF = Kimberley Prawn Managed Fishery (Western Australia); NBPMPF = Nickol Bay Prawn Managed Fishery (Western Australia); NPF = Northern Prawn Fishery (Commonwealth); RIBTF = River and Inshore Beam Trawl Fishery (Queensland)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

c Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

Figure 2: Commercial catch of White Banana Prawn in Australian waters, 1988 to 2013 (calendar years)



Effects of fishing on the marine environment

- The impact of trawling on habitats is managed in all jurisdictions. In Queensland, the Great Barrier Reef Marine Park occupies 63 per cent of the East Coast Otter Trawl Fishery¹³, 34 per cent of which is open to trawling⁸, but effort is highly aggregated, occurring within only a small fraction of the open area. South of the Great Barrier Reef Marine Park, the fishery operates in only 10 per cent of the area open to trawling¹⁴. In Western Australia, extensive permanent and temporary closures result in the fleet operating in less than 30 per cent of the Exmouth Gulf, and less than 3 per cent of the north coast region. Fishing operations are restricted to areas of sand and mud, where trawling has minimal long-term physical impact^{15–18}. The Northern Prawn Fishery (Commonwealth) also uses a system of closures (spatial and seasonal) to manage the fishery, as well as other input controls (for example, limited entry, gear restrictions). A total of 2.1 per cent of the total managed area of the fishery is subject to permanent closures, and 8.3 per cent is subject to seasonal closures¹⁹.

- Although the incidental capture of byproduct and bycatch species by trawling can lead to a range of indirect ecosystem effects²⁰, studies in Queensland and Western Australia found no significant difference in biodiversity or overall distribution patterns of seabed biota between trawled and nontrawled areas^{18,21}. An assessment of trawl-related risk in the Great Barrier Reef Marine Park found that the East Coast Otter Trawl Fishery (Queensland) posed no more than an intermediate risk of overfishing species assemblages exposed to trawling⁹. Spatial contraction and/or temporal reduction in effort in these jurisdictions (see above) are likely to have mitigated the ecosystem impacts of trawling. Similarly, in the Northern Prawn Fishery (Commonwealth), the ecological risk management report identifies priority species at high risk. However, no target or protected species have been assessed as high risk because of the fishery²².
- The use of bycatch reduction devices (BRDs) in trawling can significantly reduce bycatch—by more than 50 per cent by weight in some fisheries²³. In the East Coast Otter Trawl Fishery (Queensland), the use of BRDs became mandatory in 1999, and the introduction of turtle excluder devices (TEDs) in 2001 largely eliminated capture of most large bycatch species, including turtles, sharks and rays²⁴. BRDs and TEDs became mandatory in the Northern Prawn Fishery (Commonwealth) in 2001. Use of TEDs in the Northern Prawn Fishery reduced turtle bycatch from 5700 individuals per year (before 2001) to approximately 30 per year (after 2001)¹³. The introduction of TEDs in the Western Australian trawl fisheries in 2003 reduced turtle bycatch by at least 95 per cent²⁵. BRDs and TEDs have been mandatory in the Exmouth Gulf Prawn Managed Fishery (Western Australia) since 2003 and in all northern Western Australian prawn fisheries since 2005. All prawn trawlers operating in Western Australia must use TEDs and BRDs, including secondary fish exclusion devices and hoppers to increase survival of returned fish. Commitment to continuous improvement in bycatch mitigation has facilitated increased use of best-practice TEDs and BRDs in the East Coast Otter Trawl Fishery (Queensland) since 2008. Recent ecological risk assessments of the fishery have acknowledged the reduced impact of trawling and a general absence of high risk of overfishing bycatch species^{8,9}.

Environmental effects on White Banana Prawn

- The abundance of prawns can be highly variable. It is influenced by environmental factors, including water temperatures, cyclones and broadscale oceanographic features⁴. For example, in Western Australia, cyclones can have either a positive or a negative impact on prawn biomass and availability. Early-season (December–January) cyclones can increase mortality of small prawns through the scouring of nursery areas, which destroys seagrass and algal habitat. Conversely, prawn mortality can decrease when water becomes turbid because predation is reduced²³.
- River flow as a result of rainfall is highly correlated with offshore commercial catches of banana prawns^{3,4}. In the south-eastern Gulf of Carpentaria, it has been suggested that increased river flow has different effects on different stages of the White Banana Prawn life cycle: high flows can increase emigration of juveniles from estuaries; increased flows can prevent immigration, settlement and survival of post-larvae; and rainfall run-off may increase overall productivity, through the contribution of increased nutrient input to increased growth and survival rates³.
- The 2013 catch was the second highest on record in the east coast (Queensland) management unit, almost all (98 per cent) of which was taken south of Mackay⁹. Clustering of high catches among neighbouring regional substocks is believed to be in response to major flooding of central and southern Queensland streams, following record rainfall associated with Tropical Cyclone Oswald in January 2013²⁶.

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20. Eastern King Prawn *Melicertus plebejus*

Andrew Prosser^a and Faith Doyle^b



Table 1: Stock status determination for Eastern King Prawn

Jurisdiction	New South Wales, Queensland
Stock	Eastern Australian (ECOTF, EGF, EPTF, OTF-PS)
Stock status	Sustainable
Indicators	Biomass; catch, effort and CPUE relative to MSY reference points; fishery-independent index of recruit abundance

CPUE = catch per unit effort; ECOTF = East Coast Otter Trawl Fishery (Queensland); EGF = Estuary General Fishery (New South Wales); EPTF = Estuary Prawn Trawl Fishery (New South Wales); MSY = maximum sustainable yield; OTF-PS = Ocean Trawl Fishery–Prawn Sector (New South Wales)

Stock structure

Eastern King Prawn (*Melicertus plebejus*) is endemic to Australia. It is one of two Australian species (the other being Western King Prawn: *M. latisulcatus*) recognised by the standard fish name 'King Prawn'¹. Eastern King Prawns are harvested in Queensland and New South Wales fisheries and are considered a single multi-jurisdictional biological stock^{2,3}. There are two contiguous management units for the stock: one from 22 to 28°S in Queensland, and another along the whole New South Wales coast (28 to 37.5°S). A comprehensive stock assessment of the eastern Australian biological stock has recently been completed^{3,4}. Status determination is made on the basis of the single biological stock.

Stock status

Eastern Australian biological stock

The most recent quantitative stock assessment undertaken on the biological stock estimated that the biomass in 2010 was 60–80 per cent of 1958 levels³. Maximum sustainable yield (MSY) was estimated at 3100 tonnes (t) (95 per cent confidence interval: 2454 to 3612 t)⁴. The 2013 catch was 3355 t (2786 t in Queensland, 569 t in New South Wales), which is above the mean estimate of MSY, but below the 95 per cent confidence interval of the estimate (3612 t). The average catch from 2011 to 2013 was 2937 t, which is below the mean estimate

^a Department of Agriculture, Fisheries and Forestry, Queensland
^b Department of Primary Industries, New South Wales

of MSY. For the Queensland component of the stock, standardised catch rates were mostly above MSY reference points between 2009 and 2013⁵, indicating that the level of biomass was sufficient to sustain catches at MSY. For the New South Wales component of the stock, median nominal commercial catch rates were relatively stable between 2009 and 2013, and slightly greater than catch rates between 2004 and 2008⁶. Fishery-independent surveys of recruit abundance show variable recruitment to the fishery. The above evidence indicates that the stock is unlikely to be recruitment overfished.

The most recent quantitative stock assessment estimated effort (E) at MSY (E_{MSY}), standardised to the number of boat-days in 2010, as 38 002 boat-days (95 per cent confidence interval: 27 035 to 50 754 boat-days), assuming no increase in fishing power or costs. An alternative estimate of 28 300 boat-days (95 per cent confidence interval: 20 110 to 37 663 boat-days) accounts for a 3 per cent per year increase in fishing power and costs from 2010 levels⁴. Effort in 2013 was 19 619 boat-days (13 277 boat-days in Queensland⁵, 6342 boat-days in New South Wales⁶), which was well below both estimates of E_{MSY} and the peak effort of around 30 000 boat-days in 2000, but similar to levels in 2010. The decline in effort since 2000 has been offset by increases in fishing power⁷, resulting in increased catch rates and recent record harvests in Queensland. The number of boats accessing the fishery has substantially declined in Queensland and New South Wales since 2010, probably as a result of economic factors³. The above evidence indicates that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Eastern King Prawn biology^{8–10}

Longevity and maximum size	<3 years; males 52 mm CL, females 73 mm CL
Maturity (50%)	Females 42 mm CL

CL = carapace length

Figure 1: Distribution of reported commercial catch of Eastern King Prawn in Australian waters, 2013 (calendar year)

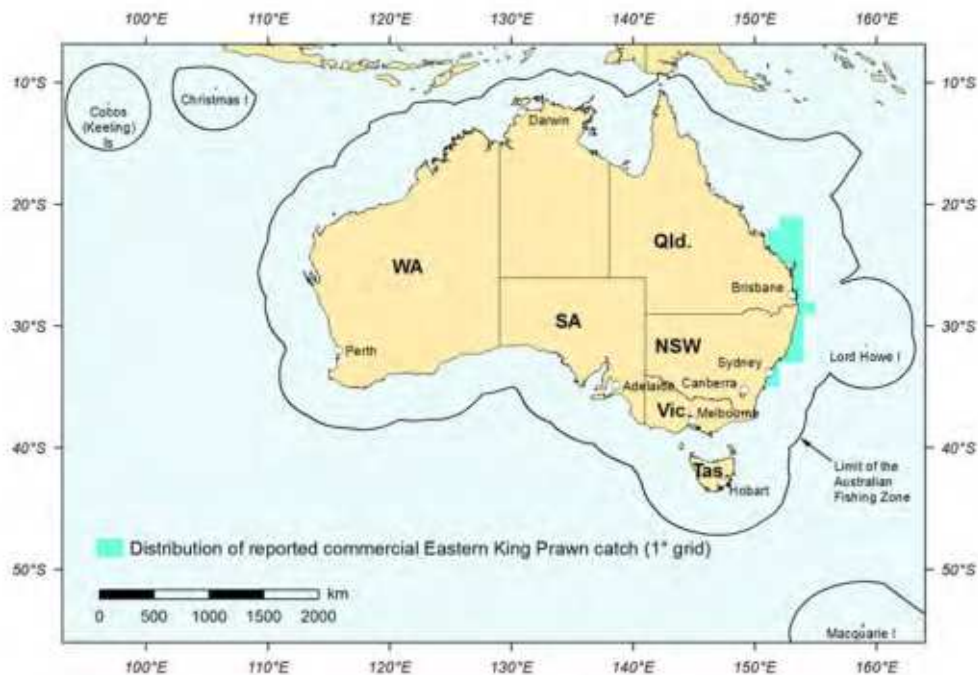


Table 3: Main features and statistics for Eastern King Prawn fisheries in Australia, 2013 (calendar year)

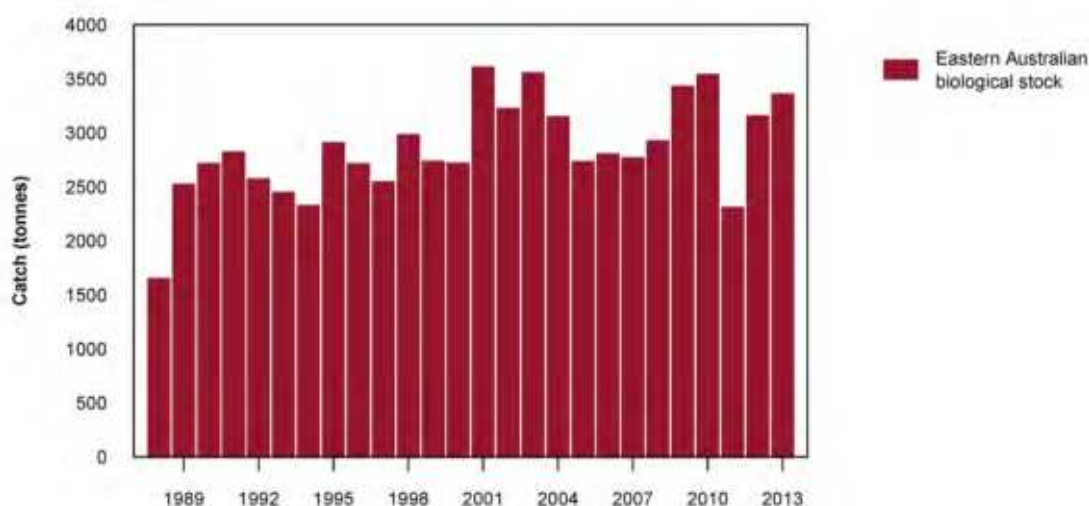
Jurisdiction	New South Wales	Queensland
Fishing methods		
Commercial		
Otter trawl	✓	✓
Beam trawl	✓	
Set pocket netting	✓	
Recreational		
Scoop netting	✓	
Indigenous		
	Unknown	Unknown
Management methods		
Commercial		
Limited entry	✓	✓
Vessel restrictions	✓	✓
Effort limits	✓	✓
Temporal closures	✓	✓
Spatial closures	✓	✓
Gear restrictions	✓	✓
Recreational		
Recreational fishing licence	✓	
Bag limits	✓	
Possession limits		✓
Indigenous ^a		
Section 37(1)(c1), Aboriginal cultural fishing authority	✓	
Active vessels		
	56 in EGF 15 in EPTF 79 in OTF-PS	148 in ECOTF

Jurisdiction	New South Wales	Queensland
Catch		
Commercial	29 t in EGF 14 t in EPTF 526 t in OTF-PS	2786 t in ECOTF
Recreational	<110 t ¹¹	Negligible
Indigenous	Negligible	Negligible
Markets		
Domestic	✓	✓
Export		✓

ECOTF = East Coast Otter Trawl Fishery (Queensland); EGF = Estuary General Fishery (New South Wales); EPTF = Estuary Prawn Trawl Fishery (New South Wales); OTF-PS = Ocean Trawl Fishery–Prawn Sector (New South Wales)

a The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Eastern King Prawn in Australian waters from 1988 to 2013 (calendar years)



Effects of fishing on the marine environment

- Trawling involves interactions with the benthic environment¹², but can only occur over sandy or muddy substrates. Recent research shows that trawling in Queensland has no significant effect on biodiversity or distribution patterns of benthic species¹³. In Queensland, although trawling is permitted in 34 per cent of the area inside the Great Barrier Reef Marine Park⁵, it only occurs in suitable areas within the permitted area and poses only an intermediate risk of overfishing species assemblages¹⁴. South of the Great Barrier Reef Marine Park, trawling occurs in 10 per cent of the available area¹⁵.

- Improvements in technology, and the mandatory uptake of bycatch reduction and turtle excluder devices, combined with lower numbers of boats accessing the fishery, are likely to have reduced the overall amount of bycatch in the fishery^{16–20}. Interactions with species of conservation interest, including turtles, sea snakes and large elasmobranchs, have also been reduced¹⁸. A reduction in bycatch per trawl probably improves the survival of discards and the quality of retained product¹⁹.

Environmental effects on Eastern King Prawn

- Extreme weather events associated with a strong La Niña episode²¹ in 2011 may have influenced recruitment patterns and access to fishing grounds, resulting in depressed catches of Eastern King Prawn (Figure 2).
- Climate change is likely to have a significant long-term effect on the distribution of this species. Under a scenario of increasing sea surface temperatures, the distribution of Eastern King Prawn may shift southwards, potentially affecting recruitment and the timing of migration^{22,23}. A study of Moreton Bay²⁴ indicated that recruitment in the Eastern King Prawn fishery tends to decline in years associated with warmer winters, suggesting that recruitment is likely to decline in south-east Queensland as coastal water temperatures rise. Destruction of seagrass beds and alteration of water flows in estuaries could affect the area of nursery grounds available to recruiting prawns, and the size of the biological stock available for capture²³.

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21. Endeavour Prawns *Metapenaeus endeavouri*, *M. ensis*

Michelle Winning^a, Mervi Kangas^b and James Larcombe^c



Red Endeavour Prawn (*M. ensis*)

Table 1: Stock status determination for Endeavour Prawns

Jurisdiction	Commonwealth			Queensland
Stock	NPF	NPF	TSPF	ECOTF
Stock status	Blue Endeavour Prawn	Red Endeavour Prawn	Blue Endeavour Prawn	Blue and Red Endeavour Prawn
	Sustainable	Undefined	Sustainable	Sustainable
Indicators	Spawning biomass, fishing mortality, catch	None	Biomass, effort, catch	Catch, effort

ECOTF = East Coast Otter Trawl Fishery (Queensland); NPF = Northern Prawn Fishery (Commonwealth); TSPF = Torres Strait Prawn Fishery (Commonwealth)

Table 1 continued

Jurisdiction	Western Australia		
Stock	EGPMF	SBPMF	NCPMF
Stock status	Blue Endeavour Prawn	Blue Endeavour Prawn	Blue Endeavour Prawn
	Sustainable	Undefined	Undefined
Indicators	Catch, survey catch rate	Catch	Catch

EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); NCPMF = North Coast Prawn Managed Fisheries (Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia)

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^b Department of Fisheries, Western Australia

^c Australian Bureau of Agricultural and Resource Economics and Sciences

Stock structure

Endeavour Prawn fisheries are located in Shark Bay, in Exmouth Gulf, on the north coast of Western Australia, in the Gulf of Carpentaria, in the Torres Strait and on the east coast of Queensland. Little is known about the biological stock structure of the populations of Blue and Red Endeavour Prawns that make up these fisheries. Hence, status is reported at the management unit level. The majority of catch reported in this chapter is Blue Endeavour Prawn. Red Endeavour Prawn is represented in the East Coast Otter Trawl Fishery (Queensland), where it constitutes less than 20 per cent of the endeavour prawn catch¹, and in the Northern Prawn Fishery (Commonwealth), where it constitutes 20–40 per cent of the annual endeavour prawn harvest.

Stock status

Northern Prawn Fishery (Commonwealth) Blue Endeavour Prawn management unit

Blue Endeavour Prawn is assessed as part of the integrated bioeconomic model constructed for the Northern Prawn Fishery (Commonwealth) Tiger Prawn sector². Commercial catch of Endeavour Prawn is disaggregated into separate species using a model incorporating historical fishery-independent survey data³. Blue Endeavour Prawn is assessed using a biomass dynamic model that estimated the spawner stock size at the end of 2012 to be 88.5 per cent of the spawner stock size (S) that would be required for maximum sustainable yield (S_{MSY})². This is above the limit reference point of 50 per cent ($0.5S_{MSY}$). As a result, the management unit is not considered to be recruitment overfished⁴. The commercial catch in 2012 (approximately 343 tonnes [t]) was below the estimate of maximum sustainable yield (base case 836 t). This level of effort is unlikely to cause the management unit to become recruitment overfished⁴.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Northern Prawn Fishery (Commonwealth) Red Endeavour Prawn management unit

Although stock assessments have been attempted for Red Endeavour Prawn, there is currently no reliable assessment to confidently classify the status of this stock⁴. Catches over 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 (Red Endeavour Prawn is a byproduct species from effort directed at Tiger Prawn), rather than any indication of a fall in Red Endeavour Prawn biomass. Insufficient information is available to confidently classify the status of this stock⁴.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Torres Strait Prawn Fishery (Commonwealth) Blue Endeavour Prawn management unit

The most recent assessment⁵ for Blue Endeavour Prawn in the Torres Strait Prawn Fishery (Commonwealth) estimated that biomass in 2007 ranged from 71 to 85 per cent of the unfished (1967) level. Maximum sustainable yield was estimated at approximately 1100 t, and recent annual catches have been well below this level: catch in 2013 was 103 t, and catches since 2007 have been below 500 t. As a result, the management unit is not considered to be recruitment overfished⁶. Catch and effort levels, which have been well below maximum sustainable yield and maximum sustainable effort estimates for more than 10 years, are unlikely to cause the management unit to become recruitment overfished⁶.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

East Coast Otter Trawl Fishery (Queensland) Red and Blue Endeavour Prawn management unit

Since 1998, there has been a general upward trend in the nominal catch rate⁷ for Endeavour Prawns (species combined, as they are not differentiated in commercial logbooks) in the East Coast Otter Trawl Fishery (Queensland). Effort in this fishery stabilised in 2007 following management changes, marine park closures and the economic impact of rising operational costs. The average annual catch rate for the past 5 years (2009 to 2013) was 69 kg per day, which is 55 per cent higher than the long-term average (1990 to 2006). Current harvest levels are significantly lower than levels in 2001, when an assessment concluded that Endeavour Prawns were fully exploited⁸. The above evidence indicates that the biomass of the management unit is unlikely to be recruitment overfished. The average annual commercial harvest of Endeavour Prawns in the

past 5 years (2009 to 2013) was 540 t, which is half the long-term average of 1112 t for the years 1990 to 2006. The fishing effort associated with the 2013 catch (7924 days) was only 30 per cent of the long-term average of 25 939 fishing days. This level of fishing pressure (catch and effort) is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Exmouth Gulf Prawn Managed Fishery (Western Australia) Blue Endeavour Prawn management unit

The Exmouth Gulf Prawn Managed Fishery (Western Australia) contributes the majority of the commercial landings of Blue Endeavour Prawns in Western Australia. There is no formal assessment for Blue Endeavour Prawn, which is a byproduct species whose distribution partly overlaps that of both Brown Tiger Prawn (*Penaeus esculentus*) and Western King Prawn (*Melicertus latisulcatus*); Blue Endeavour Prawns are caught when fishers are targeting these two species. Fishery-independent recruitment surveys of Brown Tiger Prawns and Western King Prawns (at standardised sites on separate key fishing grounds for the two species) also record the abundance of Endeavour Prawns on these grounds, providing an annual recruitment abundance index for this species. In 2013, the mean abundance index (catch rate) for Blue Endeavour Prawns on the Brown Tiger Prawn grounds of 9 kg/hour was below the 15-year mean (13 kg/hour), but within the range observed during these years (6–35 kg/hour). On the Western King Prawn grounds, the mean abundance index for Blue Endeavour Prawns of 7 kg/hour was also below the 6-year (2007 to 2012) mean of 14 kg/hour, but within the range observed during those years (2–38 kg/hour). There has been no declining trend in the fishery-independent survey catch rates over the periods sampled in either of these fishing grounds. As a result, the biomass of the management unit is not considered to be recruitment overfished.

With respect to fishing mortality, a target catch range is set at 120–300 t, based on historical catches between 1989 and 1998. Total catch in 2013 (85 t) was below the target catch range and below the average catch over the past 15 years (201 t)⁹. Low overall effort was expended in this fishery in 2013 (33 per cent less effort than the mean annual effort recorded between 2007 and 2011) due to low Brown Tiger Prawn stock abundance. The level of fishing effort on the Brown Tiger Prawn fishing grounds is normally around 60 per cent of the total annual effort; in 2013, it was only 25 per cent of total effort, and this reduced effort translated to a lower-than-average effort on Blue Endeavour Prawns. In the Exmouth Gulf Prawn Managed Fishery (Western Australia) management unit, the breeding biomass of Blue Endeavour Prawns is considered to be adequate because a significant portion of the breeding biomass is protected by the Brown Tiger Prawn spawning closures. As well, an additional portion of the Blue Endeavour Prawn biomass occurs inshore of the key fishing grounds for Brown Tiger Prawns, which are permanently closed. Hence, the current level of effort is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Shark Bay Prawn Managed Fishery (Western Australia) Blue Endeavour Prawn management unit

Blue Endeavour Prawns are landed in low numbers in the Shark Bay Prawn Managed Fishery (Western Australia), since they are not the target species. Therefore, catch-and-effort data cannot be used to determine the status of the species in this fishery. In 2013, 15 t were reported as landed, compared with a mean landing during the past 15 years of 9 t. Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

North Coast Prawn Managed Fisheries (Western Australia) Blue Endeavour Prawn management unit

Blue Endeavour Prawns are landed in low numbers in the North Coast Prawn Managed Fisheries (Western Australia), since they are not the target species. Therefore, catch-and-effort data cannot be used to determine

the status of the species in these fisheries. Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Table 2: Blue and Red Endeavour Prawn biology^{10–14}

Longevity and maximum size	1–2 years; Blue Endeavour Prawn: 200 mm TL Red Endeavour Prawn: 180 mm TL
Maturity (50%)	~6 months; females 24–26 mm CL, males ~18 mm CL

CL = carapace length; TL = total length

Figure 1: Distribution of reported commercial catch of Blue and Red Endeavour Prawns in Australian waters, 2013 (calendar year)

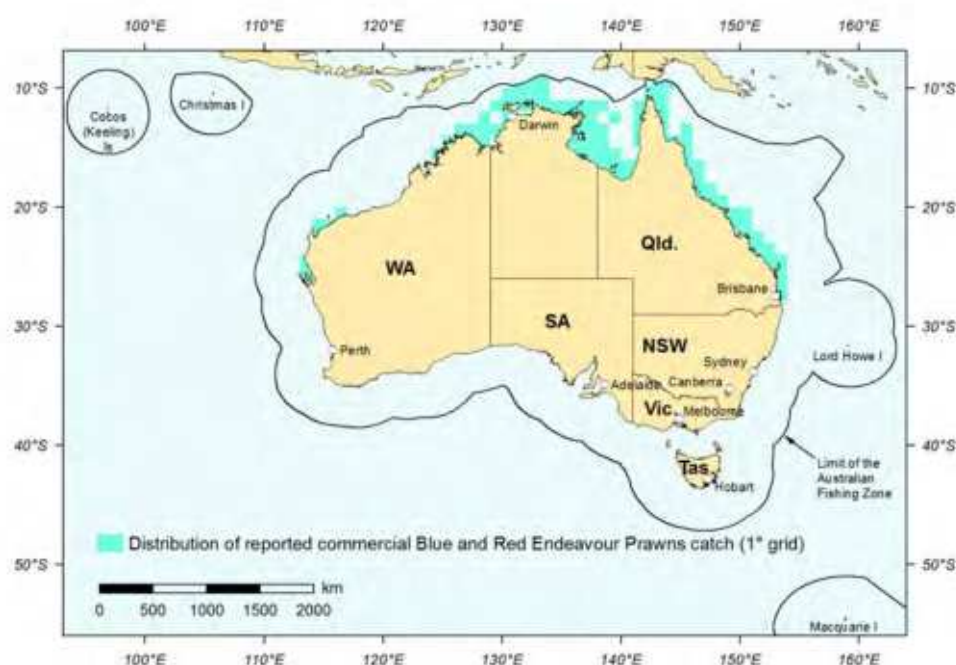


Table 3: Main features and statistics for Blue and Red Endeavour Prawn fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth	Queensland	Western Australia
Fishing methods			
Commercial			
Demersal otter trawling	✓	✓	✓
Recreational ^{a,b}			
Cast net		✓	None

Jurisdiction	Commonwealth	Queensland	Western Australia
Indigenous ^c			
Cast net		✓	None
Management methods			
Commercial			
Limited entry	✓	✓	✓
Vessel restrictions	✓	✓	✓
Gear restrictions	✓	✓	✓
Effort limits	✓	✓	✓
Spatial closures	✓	✓	✓
Temporal closures	✓	✓	✓
Recreational ^{a,b}			
Possession limits		✓	None
Indigenous ^c			
Possession limits		✓	None
Active vessels			
	52 in NPF 21 in TSPF	155 in ECOTF	6 in EGPMF 7 in NCPMF 18 in SBPMF
Catch			
Commercial	507 t in NPF 103 t in TSPF	506 t in ECOTF	85 t in EGPMF 4 t in NCPMF 15 t in SBPMF
Recreational ^d		Negligible	0 t
Indigenous		Negligible	0 t
Markets			
Domestic	✓	✓	✓
Export	✓		

ECOTF = East Coast Otter Trawl Fishery (Queensland); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); NCPMF = North Coast Prawn Managed Fisheries (Western Australia); NPF = Northern Prawn Fishery (Commonwealth); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia); TSPF = Torres Strait Prawn Fishery (Commonwealth)

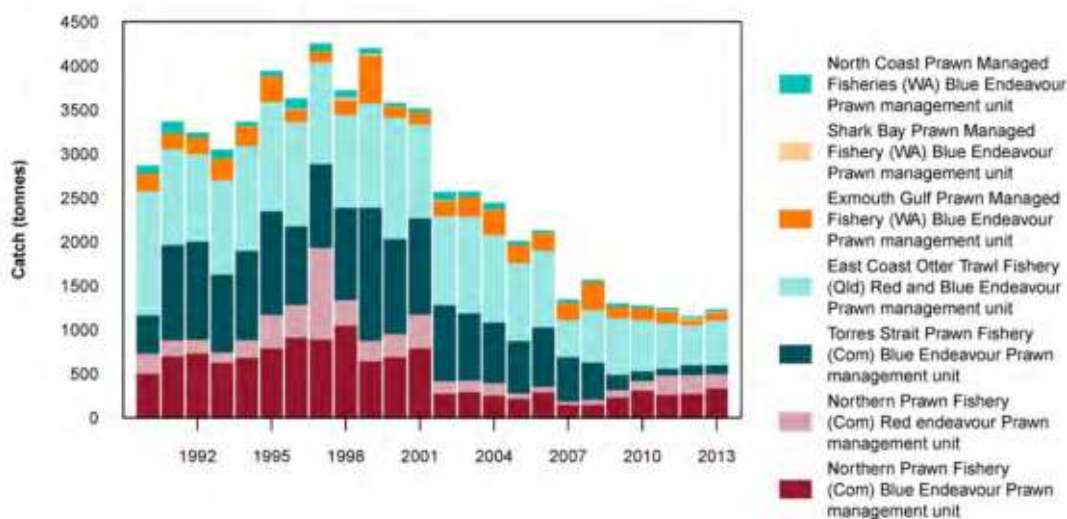
a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

b The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

c The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters (with the exception of the Torres Strait). In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters. In the Torres Strait, both commercial and noncommercial Indigenous fishing is managed by the Torres Strait Protected Zone Joint Authority (PZJA) through the Australian Fisheries Management Authority (Commonwealth); the Department of Agriculture, Fisheries and Forestry (Queensland); and the Torres Strait Regional Authority. The PZJA also manages non-Indigenous commercial fishing in the Torres Strait.

d In Queensland recreational fishers are permitted to catch Endeavour Prawns, but are unlikely to catch them in large amounts because of the distribution of this species group.

Figure 2: Commercial catch of Blue and Red Endeavour Prawns in Australian waters, 1990 to 2013 (calendar years)



Effects of fishing on the marine environment

- There is typically a high proportion of bycatch, relative to retained product, in otter trawl fisheries. Post-release survival of bycatch species is variable¹⁵.
- The use of bycatch reduction devices is mandatory in all Australian tropical prawn trawl fisheries. Use of turtle excluder devices in the Northern Prawn Fishery (Commonwealth) reduced turtle bycatch from 5700 individuals per year before 2001 to approximately 30 per year after 2001¹⁶. The introduction of turtle excluder devices in the Western Australia prawn trawl fisheries in 2003 reduced turtle bycatch by at least 95 per cent¹⁷.
- Spatial closures afford some protection to the marine environment from the physical effects of trawling. In Queensland, the Great Barrier Reef Marine Park occupies 63 per cent of the East Coast Otter Trawl Fishery¹⁸, 34 per cent of which is open to trawling⁷. However, effort is highly aggregated, occurring within only a small fraction of the open area. In Western Australia, extensive permanent and temporary closures result in the fleet operating in only 7 per cent of the Shark Bay region, less than 30 per cent of the Exmouth Gulf, and less than 3 per cent of the north coast region. Fishing operations are restricted to areas of sand and mud, where trawling has minimal long-term physical impact¹⁹⁻²². The Northern Prawn Fishery (Commonwealth) uses a system of closures (spatial and seasonal) to manage the fishery, as well as other input controls (for example, limited entry, gear restrictions). A total of 2.1 per cent of the total managed area of the fishery is subject to permanent closures, while 8.3 per cent is subject to seasonal closures²³.

The Torres Strait Prawn Fishery (Commonwealth) also employs spatial and temporal closures to protect small prawns and important habitat areas, such as for breeding populations of turtles²⁴.

- An assessment of trawl-related risk in the Great Barrier Reef Marine Park found that the East Coast Otter Trawl Fishery (Queensland) posed no more than an intermediate risk of overfishing some species assemblages exposed to trawling²⁵.
- Interactions with species protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), such as sea snakes and seabirds, are routinely monitored.
- The Northern Prawn Fishery (Commonwealth) has been certified by the Marine Stewardship Council since November 2012.

Environmental effects on Blue and Red Endeavour Prawns

- Nursery grounds (such as seagrass beds) are important for maintaining Endeavour Prawn stocks in the Northern Prawn Fishery (Commonwealth). Management strategies therefore involve the closure of significant nursery areas to trawling to protect stocks²⁶.
- Prawn distribution can be driven by environmental factors. For example, in a study on the distribution of Endeavour Prawns in the Gulf of Carpentaria, Blue Endeavour Prawns were found to be most abundant in the south-eastern gulf and shallower parts of the western gulf, where sediments were either sand or muddy sand. The highest abundance of Red Endeavour Prawns was in the north-eastern gulf and deeper areas of the western gulf, where sediments were more than 60 per cent mud²⁷. However in the Torres Strait, Blue Endeavour Prawns were equally abundant on all substrate types¹³.

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22. School Prawn *Metapenaeus macleayi*

Faith Ochwada-Doyle^a, Brad Zeller^b and James Andrews^c

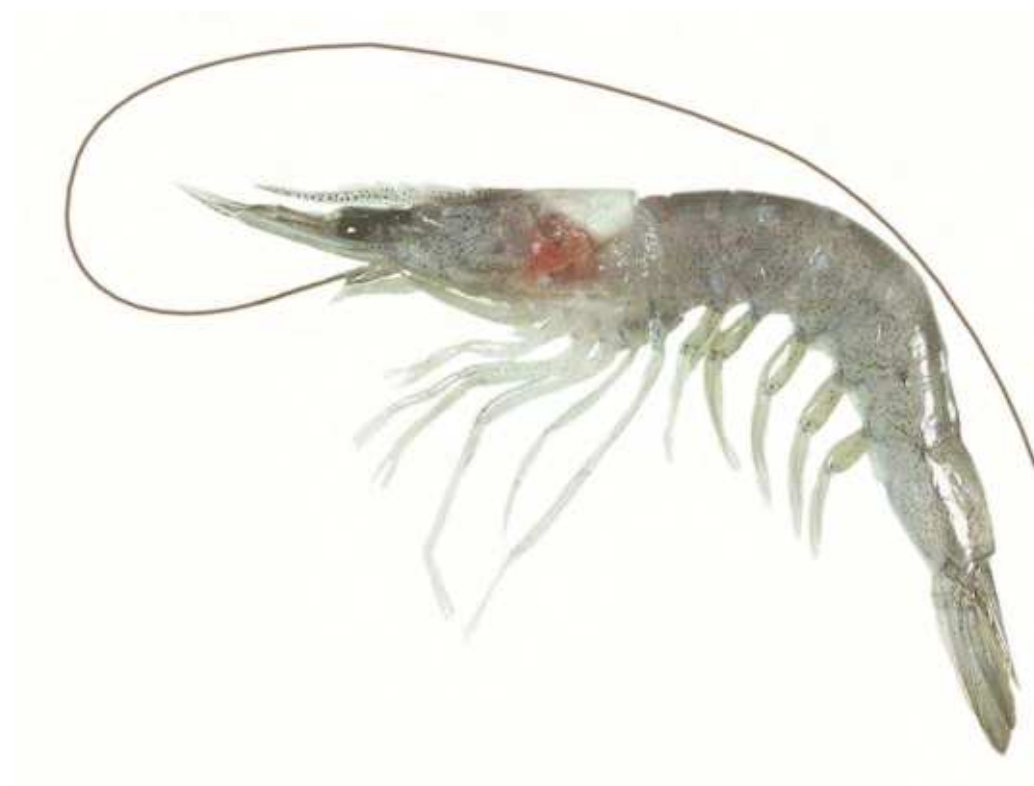


Table 1: Stock status determination for School Prawn

Jurisdiction	New South Wales	Victoria	Queensland
<i>Stock</i>	New South Wales (EGF, EPTF, OTF-PS)	Victoria (ITF)	Queensland (ECTF)
<i>Stock status</i>			
	Sustainable	Undefined	Undefined
<i>Indicators</i>	Catch, CPUE, environmental models, length frequencies	Catch	Catch, CPUE

CPUE = catch per unit effort; ECTF = East Coast Trawl Fishery (Queensland); EGF = Estuary General Fishery (New South Wales); EPTF = Estuary Prawn Trawl Fishery (New South Wales); ITF = Inshore Trawl Fishery (Victoria); OTF-PS = Ocean Trawl Fishery–Prawn Sector (New South Wales)

Stock structure

School Prawn fisheries occur in New South Wales, Victoria and Queensland. Although recent genetic work on the biological stock structure of this species is limited, genetic differentiation has been reported between populations from southern Queensland (from the Noosa River and Tweed River) and populations from different estuaries in New South Wales (all of which were genetically homogeneous)¹. Comparable genetic information for Victorian populations is limited. Since the biological stock structure of School Prawns remains largely unknown throughout their distribution, and a sample from any one location cannot always be

^a Department of Primary Industries, New South Wales

^b Department of Agriculture, Fisheries and Forestry, Queensland

^c Department of Environment and Primary Industries, Victoria

considered as genetically representative of the species, stock status classifications for this species are reported at the jurisdictional level.

Stock status

New South Wales

Despite a peak in median ocean prawn trawling catch rates during 2010–11, the median commercial catch rates of School Prawn in New South Wales have been relatively steady for the past 5 years (especially for the Estuary Prawn Trawl Fishery) and greater than in the previous 5 years (Figure 1). This species is commercially fished throughout most of its geographic range in New South Wales, although there has been limited harvest between latitudes 35 and 36°S in recent years.

Landings in New South Wales in 2013 (731.3 tonnes [t]) were similar to the long-term annual average (788.2 t) (Figure 1). The reported number of fisher days in 2013 in the Ocean Trawl Fishery–Prawn Sector (approximately 1389 days), the Estuary Prawn Trawl Fishery (approximately 3856 days) and the Estuary General Fishery (3562 days, summed across methods) were some of the lowest levels observed historically. Typical size compositions in landings in 2012–13 suggest little change in the stock. Although slightly fewer large prawns have been caught in the past 2 years, this shift is likely related to interannual changes in environmental conditions. Recent research and modelling have established that environmental factors (river flows) influence School Prawn landings². The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished and that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, School Prawn in New South Wales is classified as a **sustainable stock**.

Victoria

Since 2000, the total annual catch of School Prawn in Victoria has usually been between 5 and 15 t. Catches were relatively high (approximately 50 t) during 2011 and 2012, but returned to more average levels (16.7 t) in 2013 (Figure 1). Nearly all the catch is landed by vessels belonging to the Inshore Trawl Fishery, and, since 2008, a maximum of 10 vessels have participated in the fishery. The relatively low but variable levels of catch, and the absence of reliable estimates for current biomass and sustainable yield mean that there is insufficient information to confidently classify the status of this stock.

On the basis of the evidence provided above, School Prawn in Victoria is classified as an **undefined stock**.

Queensland

Long-term catch levels are variable (Figure 1), and nominal catch rates are fairly stable. There have been occasional very high catch and catch-rate years (for example, 2009)³. A recent ecological risk assessment found that School Prawn was at low risk of being overfished at 2009 effort levels⁴. Although the species appears to be resilient (that is, it has a high capacity to recover from a decline in abundance)⁴ and fishing pressure is low in most years⁴, catches have been at or near historical lows since 2009, when a record catch of 305 t was taken (more than three times the long-term average). Without a reliable estimate of current biomass or sustainable yield, there is insufficient information to confidently classify the status of this stock.

On the basis of the evidence provided above, School Prawn in Queensland is classified as an **undefined stock**.

Table 2: School Prawn biology^{5,6}

Longevity and maximum size	Female: 32 months; 39.4 mm CL Male: 32 months; 31.8 mm CL
Maturity (50%)	~11.7 cm CL

CL = carapace length

Figure 1: Distribution of reported commercial catch of School Prawns in Australian waters, 2013 (calendar year)

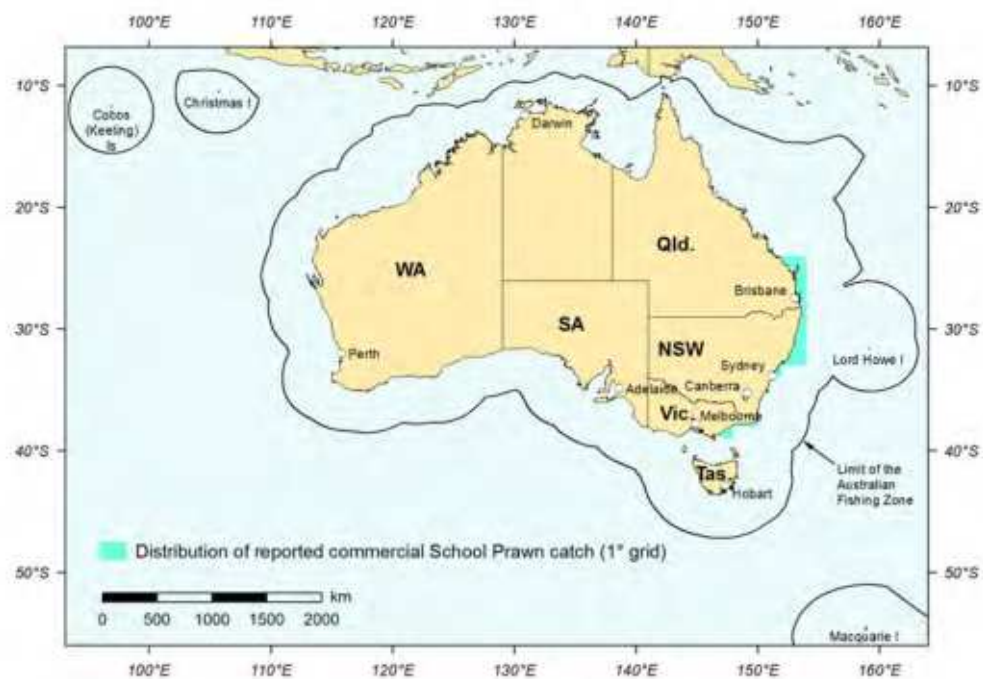


Table 3: Main features and statistics for School Prawn fisheries in Australia, 2013 (calendar year)

Jurisdiction	New South Wales	Victoria	Queensland
Fishing methods			
Commercial			
Set pocket nets	✓		
Dip nets	✓		
Prawn stake nets		✓	
Prawn trawl	✓	✓	✓
Recreational			
Hand-held nets	✓	✓	
Cast nets			✓
Seine nets	✓		✓
Bait nets		✓	
Indigenous ^a			
Hand-held nets	✓		
Cast nets			✓
Seine nets	✓		✓
Management methods			
Commercial			
Limited entry	✓	✓	✓
Gear restrictions	✓	✓	✓
Vessel number restrictions	✓	✓	✓
Temporal closures	✓		✓
Spatial closures	✓	✓	✓
Bycatch reduction devices	✓		✓
CPUE limits	✓		

Jurisdiction	New South Wales	Victoria	Queensland
Recreational			
Bag limits	✓	✓	
Possession limits			✓
Indigenous ^{a-d}			
Bag limits	✓		
Section 37(1)(c1), Aboriginal cultural fishing authority	✓		
Active vessels			
	166 in EGF 80 in EPTF 69 in OTF-PS	9 in ITF	33 in ECTF
Catch			
Commercial	243.1 t in EGF 308.9 t in EPTF 179.3 t in OTF-PS	16.7 t in ITF	16.7 t in ECTF
Recreational	<30 t (2000–01)	Unknown	Unknown
Indigenous	Unknown	Unknown	Unknown
Markets			
Domestic	✓	✓	✓
Export			

CPUE = catch per unit effort; ECTF = East Coast Trawl Fishery (Queensland); EGF = Estuary General Fishery (New South Wales); EPTF = Estuary Prawn Trawl Fishery (New South Wales); ITF = Inshore Trawl Fishery (Victoria); OTF-PS = Ocean Trawl Fishery–Prawn Sector (New South Wales)

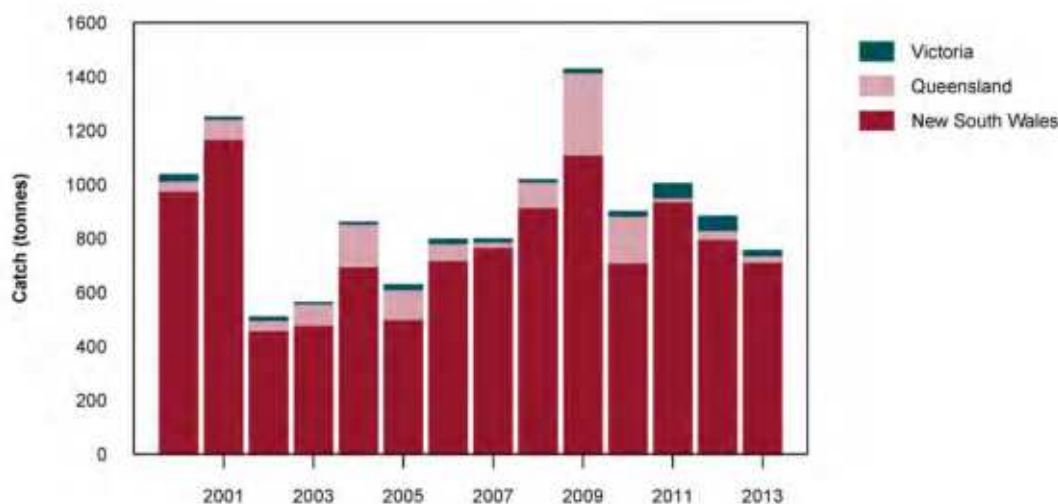
a In Victoria, management of fishing activities by Indigenous people is grouped with the recreational fishing sector in terms of collecting data, undertaking stock assessments and implementing management responses. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (for example, different catch and size limits or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2013, there were no applications for customary fishing permits to access School Prawn.

b The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

c The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

d Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

Figure 2: Commercial catch of School Prawns in Australian waters, 2001 to 2013 (calendar years)



Effects of fishing on the marine environment

- Species caught incidentally by trawl nets are discarded because they either have low market value or are not permitted to be retained. Bycatch consists mainly of small fish, crabs, other penaeid prawns and numerous other bottom-dwelling invertebrate species, including sponges, sea stars and gastropod shellfish. Improvements in technology and the mandatory use of bycatch reduction devices has been shown to reduce bycatch in the trawl fisheries in New South Wales^{7,8}.
- Fishing methods used for school prawns pose a risk to habitats because repeated trawling can lead to depletion of sedentary species, such as sponges, that are habitat forming⁹. However, recent research has shown that trawling in Queensland does not have a significant effect on the biodiversity or distribution of benthic species relative to nontrawled areas¹⁰.

Environmental effects on School Prawns

- Climate change may have a significant effect on the distribution of School Prawns. Under a scenario of increasing sea surface temperatures and a strengthening East Australian Current, the distribution of School Prawns may shift southwards, potentially affecting the timing of their spawning and migration, and decreasing variability in their recruitment¹¹. As well, recent environmental models indicate that the growth and movement of School Prawns are affected by rates of river discharge. If climate change results in lower river discharges for some New South Wales estuaries, as some of the literature suggests¹², lower catches and a lower stock biomass of this species may be a consequence².

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23. Tiger Prawns *Penaeus esculentus*, *P. semisulcatus*

James Larcombe^a, Faith Doyle^b, Mervi Kangas^c and Brad Zeller^d



Brown Tiger Prawn (*Penaeus esculentus*)



Grooved Tiger Prawn (*P. semisulcatus*)

Table 1: Stock status determinations for Brown and Grooved Tiger Prawn

Jurisdiction	Commonwealth			New South Wales
Stock	NPF	NPF	TSPF	New South Wales (EGF, EPTF, OTF)
Stock status	Brown Tiger Prawn	Grooved Tiger Prawn	Brown Tiger Prawn	Negligible ^a
	Sustainable	Sustainable	Sustainable	
Indicators	Spawning stock size, effort	Spawning stock size, effort	Biomass estimate, catch, effort	

EGF = Estuary General Fishery (New South Wales); EPTF = Estuary Prawn Trawl Fishery (New South Wales); NPF = Northern Prawn Fishery (Commonwealth); OTF = Ocean Trawl Fishery (New South Wales); TSPF = Torres Strait Prawn Fishery (Commonwealth)

^a 'Negligible' means historically low catch, no stock status. Catch from New South Wales in 2013 was 2 t; in the past 10 years, average catch from New South Wales was 5 t.

^a Australian Bureau of Agricultural and Resource Economics and Sciences

^b Department of Primary Industries, New South Wales

^c Department of Fisheries, Western Australia

^d Department of Agriculture, Fisheries and Forestry, Queensland

Table 1 continued

Jurisdiction	Queensland	Western Australia		
Stock	ECOTF ^b	SBPMF	EGPMF	North Coast Prawn Managed Fisheries (KPMF, NBPMF, OPMF)
Stock status	Brown and Grooved Tiger Prawns	Brown Tiger Prawn	Brown Tiger Prawn	Brown Tiger Prawn
	Sustainable	Sustainable	Sustainable	Sustainable
Indicators	Biomass, spawning stock size, catch, effort	Survey of stock biomass	Survey of stock biomass	Catch

ECOTF = East Coast Otter Trawl Fishery (Queensland); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); KPMF = Kimberley Prawn Managed Fishery (Western Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); OPMF = Onslow Prawn Managed Fishery (Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia)

^b In Queensland, Grooved and Brown Tiger Prawns are not differentiated in commercial logbooks

Stock structure

The standard name 'Tiger Prawn' refers to the species *Penaeus esculentus*, *P. semisulcatus* and *P. japonicus*. Only *P. esculentus* (Brown Tiger Prawn) and *P. semisulcatus* (Grooved Tiger Prawn) are considered in this chapter; *P. japonicus* is not caught commercially in Australian waters.

Brown Tiger Prawns are endemic to tropical and subtropical waters of Australia, while Grooved Tiger Prawns have a wider Indo–West Pacific distribution. There is some genetic evidence of separation of Brown Tiger Prawn stocks from the east and west coasts of Australia¹. Since biological stock structure for these species is uncertain, stock status classifications are undertaken at the management unit level for fisheries in the Commonwealth, Queensland and Western Australia, and at the jurisdiction level for New South Wales.

Stock status

Northern Prawn Fishery (Commonwealth) Brown Tiger Prawn management unit

Brown and Grooved Tiger Prawn stocks are assessed as part of an integrated bioeconomic model undertaken for the Northern Prawn Fishery (Commonwealth)². The base-case estimate of the size of the Brown Tiger Prawn spawner stock at the end of 2012 as a percentage of spawner stock size (*S*) at maximum sustainable yield (MSY; S_{2012}/S_{MSY}) was 104.1 per cent². On this basis, the management unit is not considered to be recruitment overfished³.

In 2010, fishing effort (*E*) was well below the level that would achieve MSY (E_{2012}/E_{MSY} was 28.8 per cent)². This level of effort is unlikely to cause the management unit to become recruitment overfished³.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Northern Prawn Fishery (Commonwealth) Grooved Tiger Prawn management unit

The base-case estimate of the size of the Grooved Tiger Prawn spawner stock at the end of 2012 as a percentage of spawner stock size at MSY (S_{2012}/S_{MSY}) was 108.6 per cent². On this basis, the management unit is not considered to be recruitment overfished³.

In 2010, fishing effort on Grooved Tiger Prawns was well below the level that would achieve MSY (E_{2012}/E_{MSY} was 38.8 per cent)². This level of effort is unlikely to cause the management unit to become recruitment overfished³.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Torres Strait Prawn Fishery (Commonwealth) Brown Tiger Prawn management unit

The most recent assessment of Brown Tiger Prawn in the Torres Strait Prawn Fishery (Commonwealth) used two separate modelling approaches, producing two separate estimates of MSY and effort at MSY⁴. Commercial catch of this stock has been below the mean estimates of MSY (606 tonnes [t] and 676 t) for the past eight seasons (2006 to 2013), and effort has been below the estimates of E_{MSY} (8245 and 9197 fishing nights) for the past 10 seasons (2004 to 2013). This level of catch and effort is unlikely to cause the management unit to become recruitment overfished⁵.

Some components of the assessment were updated in 2007⁶; this indicated that biomass in 2006 was 60–80 per cent of the unfished (1980) level. This was considerably higher than biomass that supports MSY (B_{MSY}), estimated to be around 28–38 per cent of the unfished level^{4,6}. As a result of the 2006 biomass estimate, and low levels of catch and effort since that estimate, the management unit is not considered to be recruitment overfished⁵.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

East Coast Otter Trawl Fishery (Queensland) Brown and Grooved Tiger Prawn management unit

Recent modelling of the combined Brown and Grooved Tiger Prawn resource in the East Coast Otter Trawl Fishery (Queensland) suggests that fishing mortality may have been excessive before 2000, causing the spawning stock to be depleted to less than the level that would achieve MSY (S_{MSY})⁷. The spawning stock has since recovered to a level well above S_{MSY} ⁷. Regional nominal catch rates have all increased and are at historical high levels^{8,9}. A key indicator of risk from trawling is the percentage of combined Brown and Grooved Tiger Prawn biomass in areas closed to trawling. Research estimated that, in 2005, 38 per cent of the Brown Tiger Prawn biomass and 26 per cent of the Grooved Tiger Prawn biomass within the Great Barrier Reef Marine Park (GBRMP) was unavailable to trawl capture as a result of permanent closures¹⁰. These closures remain in place. The above evidence indicates that the biomass of the management unit is unlikely to be recruitment overfished.

From 2000 to 2013, total catch showed a decreasing trend, but this coincided with a significant decline in fishing effort, currently at a historical low level⁹. At 966 t, the 2013 catch is well below the MSY estimate of 1239 t¹¹ and the more recent initial estimate of 1706–1907 t⁷. The most recent assessment of combined Brown and Grooved Tiger Prawn fishing effort¹¹ in 2004 estimated E_{MSY} at 19 618 fishing days. From 2007 to 2013, effort has been well below E_{MSY} ⁹. Recent semiquantitative risk assessment of individual Tiger Prawn species found that the risk of their becoming recruitment overfished at the level of fishing pressure exerted on the management unit in 2009 was low for Brown Tiger Prawn^{12,13}, low for Grooved Tiger Prawn south of the GBRMP¹³ and intermediate for Grooved Tiger Prawn within the GBRMP¹². Although fishing power for Tiger Prawn is increasing at a rate of 1.5–3 per cent per year⁷, since 2009 the number of trawl days in the GBRMP has declined by 23 per cent⁹. Effective fishing effort in the GBRMP is therefore unlikely to be increasing. The above evidence indicates that the current level of fishing pressure is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Shark Bay Prawn Managed Fishery (Western Australia) Brown Tiger Prawn management unit

Standardised catch-per-unit-effort data (also referred to as catch rate) are used as an indicator of abundance in the Shark Bay Prawn Managed Fishery (Western Australia) Brown Tiger Prawn management unit, and can be used to monitor changes in stock levels from year to year. The average commercial catch and catch rate are compared with a 10-year (1989 to 1998) reference point¹⁴.

This management unit is also assessed each year using fishery-independent recruitment and spawning stock surveys. These methods are the primary means for assessing stock status. Recruitment surveys provide an index of annual recruitment and are also the basis of an annual Brown Tiger Prawn catch prediction.

A spawning stock–recruitment relationship exists for Brown Tiger Prawns^{15–17}, and the maintenance of adequate spawning stock (using a target catch rate) is the key management objective. Brown Tiger Prawns are managed to reference levels (catch rates) and accompanying control rules. A mandatory closure of the Brown Tiger Prawn spawning area is enforced, either to a catch-rate target or on a set date (around June–July),

whichever is sooner, to protect the spawning stock. The fishery operates on a real-time management basis: commercial catch rates are monitored nightly to ensure that the Brown Tiger Prawn spawning areas are closed at the appropriate time. As fishing ceases in an area, fishery-independent surveys are conducted to verify catch rates in the spawning area.

The July 2013 spawning stock survey showed a mean standardised catch rate of 20.2 kg/hour in the Brown Tiger Prawn spawning area. This is below the target level of 25 kg/hour¹⁸, but above the threshold level (10 kg/hour). It is therefore considered that the biomass of this management unit is unlikely to be recruitment overfished, and it appears that, overall, there was an adequate spawning stock during the key spawning period in 2013.

With respect to fishing mortality, the assessment sets an annual target catch range for the 2013 season of 400–700 t. In addition, the Brown Tiger Prawn catch prediction (based on fishery-independent recruitment surveys) was 400–600 t. The total catch (660 t) was slightly above the prediction, but within the target catch range and above the average catch over the past 15 years (504 t)¹⁸. The level of fishing effort since 2007, when all boats adopted quad gear (four standardised nets), has remained between 33 000 and 41 000 trawl hours (standardised to twin nets); fishing effort in 2013 was 36 000 trawl hours. This evidence indicates that the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Exmouth Gulf Prawn Managed Fishery (Western Australia) Brown Tiger Prawn management unit

Stock assessments for the Exmouth Gulf Prawn Managed Fishery (Western Australia) Brown Tiger Prawn management unit are undertaken using similar methods to those used in the Shark Bay Prawn Managed Fishery (Western Australia). The management objective is to maintain the spawning biomass above the historically determined biological reference points; the current target is 25 kg/hour, with a limit of 10 kg/hour, in the *spawning* stock surveys. Three standardised Brown Tiger Prawn spawning stock surveys were carried out from August to October 2013, with an average catch rate of 22.6 kg/hour, slightly below the target level but above the limit reference point. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

The stock in 2012 had been reduced to a level at which there was a significant risk of recruitment failure. This was despite the spawning stock abundance in the previous year (2011) being as high as ever recorded (60–100 kg/hour) throughout the key spawning period, and well above the target of 25 kg/hour. The 2013 *recruitment* surveys indicated continued low recruitment levels (32 kg/hour, which was above the limit but below the *recruitment survey* target of 40 kg/hour), but an improvement on 2012 recruitment (21.5 kg/hour). This was also reflected in slightly higher catches in the fishery. The recruitment surveys are used to predict the annual catch. The predicted low annual landings for both years resulted in modifications to the harvest strategy, including a later season opening, conservative fishing on Brown Tiger Prawns (47 t landed in 2012 and 95 t landed in 2013¹⁸, compared with the long-term target catch range of 250–550 t) and daily monitoring of catch rates to ensure cessation of fishing at an adequate catch rate. This evidence indicates that the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

There is evidence of a link between declines in Tiger Prawn biomass and a heatwave in 2010–11 that was followed by continued higher-than-average water temperatures in the Exmouth Gulf in the summers of 2011–12 and 2012–13¹⁹. The declines appear to be partly associated with the loss of structured habitat (as a result of continued higher-than-average temperatures) in inshore Tiger Prawn nursery areas, which could impact survival of juveniles²⁰ and cause low recruitment. Given the monitoring and management frameworks in place to control fishing pressure, it is unlikely that the low levels of recruitment have been due to overfishing or lack of appropriate fisheries management. There is confidence that recruitment levels will build under existing management, assuming that the habitat improves and no major negative environmental perturbations occur.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

North Coast Prawn Managed Fisheries (Western Australia) Brown Tiger Prawn management unit

Small quantities of Brown Tiger Prawns have been landed from the North Coast Prawn Managed Fisheries (Western Australia) in recent years, with Brown Tiger Prawn being a key target species in only the Onslow Prawn Managed Fishery. These fisheries use annual catch in reference to a target catch range as an indicator of acceptable performance and whether the stock is subject to overfishing. If the annual catch falls outside the range, this needs to be adequately explained or additional investigations undertaken. In 2013, the Kimberley Prawn Managed Fishery landed 6 t¹⁸ (target catch range 15–60 t), and the Onslow (target catch range 10–120 t) and Nickol Bay (target catch range 2–40 t) Prawn Managed Fisheries each reported landings of less than 0.5 t. These low landings reflect the very low effort expended in these fisheries, particularly for Brown Tiger Prawn. Only one boat operated, for four nights in total, in the Onslow Prawn Managed Fishery in 2013. The fishing effort in the Kimberley Prawn Managed Fishery in 2013 was the second lowest on record (effort was lower in 2011). The fishing effort in the Nickol Bay Prawn Managed Fishery is primarily directed at White Banana Prawns, and hence overall effort is related to White Banana Prawn abundance. However, the overall annual mean fleet effort in this fishery has decreased since 2007 to around 160 boats-days, compared with 700 boat-days between 1990 and 2005. Therefore, the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished, and, given the recent history of low annual catches, the biomass of this stock is unlikely to be recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Table 2: Brown and Grooved Tiger Prawn biology^{18,21,22}

Longevity and maximum size	1–2 years; 55 mm CL
Maturity (50%)	East coast: ~6 months; 32–39 mm CL West coast: ~6 months; 27–35 mm CL Northern Australia: ~6 months; 32–39 mm CL

CL = carapace length

Figure 1: Distribution of reported commercial catch of Tiger Prawns in Australian waters, 2013 (calendar year)

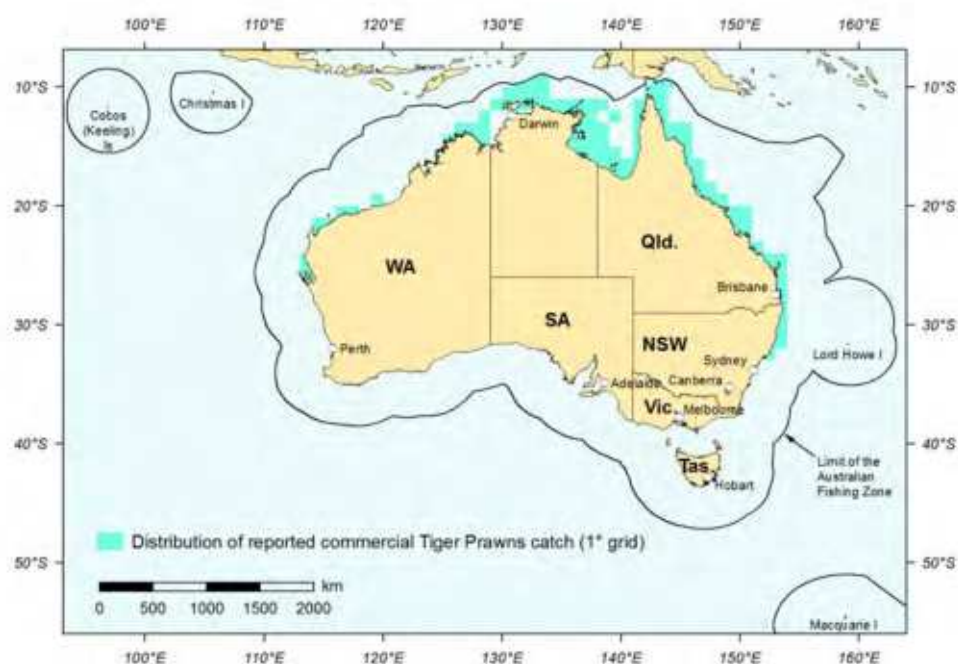


Table 3: Main features and statistics for Tiger Prawn fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth	Queensland	Western Australia
Fishing methods			
Commercial			
Otter trawl	✓	✓	✓
Recreational ^a			
Cast net		✓	
Indigenous ^{b,c}			
			None
Management methods			
Commercial			
Limited entry	✓	✓	✓
Vessel restrictions	✓	✓	
Gear restrictions	✓	✓	✓
Effort limits	✓	✓	✓
Spatial closures	✓	✓	✓

Jurisdiction	Commonwealth	Queensland	Western Australia
Temporal closures	✓	✓	✓
Recreational ^a			
Possession limits		✓	
Indigenous ^{b,c}			
			None
Active vessels			
	52 in NPF 21 in TSPF	199 in ECOTF	18 in SBPMF 6 in EGPMF 4 in KPMF 4 in NBPMF 1 in OPMF
Catch			
Commercial	2201 t in NPF 418 t in TSPF	966 t in ECOTF	661 t in SBPMF 95 t in EGPMF 6 t in KPMF <1 t in NBPMF <1 t in OPMF
Recreational ^a		Unknown	None
Indigenous ^{b,c}		Unknown	None
Markets			
Domestic	✓	✓	✓
Export	✓	✓	✓

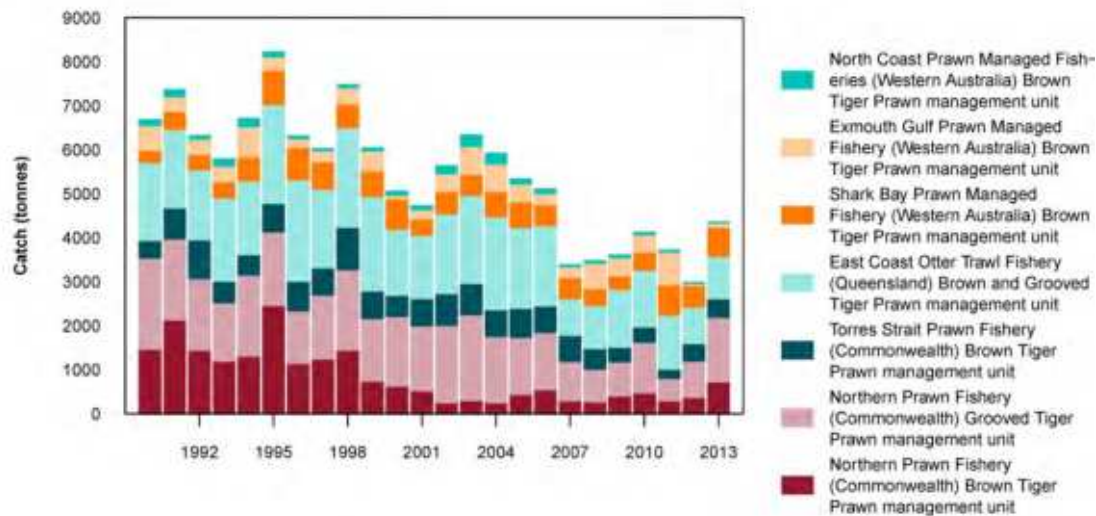
ECOTF = East Coast Otter Trawl Fishery (Queensland); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); KPMF = Kimberley Prawn Managed Fishery (Western Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); NPF = Northern Prawn Fishery (Commonwealth); OPMF = Onslow Prawn Managed Fishery (Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia); TSPF = Torres Strait Prawn Fishery (Commonwealth)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters. In the Torres Strait, both commercial and noncommercial Indigenous fishing is managed by the Torres Strait Protected Zone Joint Authority (PZJA) through the Australian Fisheries Management Authority (Commonwealth); the Department of Agriculture, Fisheries and Forestry (Queensland); and the Torres Strait Regional Authority. The PZJA also manages non-Indigenous commercial fishing in the Torres Strait.

c Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

Figure 2: Commercial catch of Tiger Prawns in Australian waters, 1990 to 2013 (calendar years)



Effects of fishing on the marine environment

- Management is in place to reduce the impact of trawling on habitats. In Queensland, the GBRMP occupies 63 per cent of the East Coast Otter Trawl Fishery²³, 34 per cent of which is open to trawling⁹, but effort is highly aggregated, occurring within only a small fraction of the open area. South of the GBRMP, the fishery operates in only 10 per cent of the area open to trawling²⁴. In Western Australia, extensive permanent and temporary closures result in the fleet operating in less than 30 per cent of the Exmouth Gulf, and less than 3 per cent of the north coast region. Fishing operations are restricted to areas of sand and mud, where trawling has minimal long-term physical impact^{14,25–27}. The Northern Prawn Fishery (Commonwealth) also uses a system of closures (spatial and seasonal) to manage the fishery, as well as other input controls (for example, limited entry, gear restrictions). A total of 2.1 per cent of the total managed area of the fishery is subject to permanent closures, while 8.3 per cent is subject to seasonal closures²⁸.
- Although the incidental capture of byproduct and bycatch species by trawling can lead to a range of indirect ecosystem effects²⁹, studies in Queensland and Western Australia found no significant difference in biodiversity or overall distribution patterns of seabed biota between trawled and nontrawled areas^{10,26}. An assessment of trawl-related risk in the GBRMP found that the East Coast Otter Trawl Fishery (Queensland) posed no more than an intermediate risk of overfishing species assemblages exposed to trawling¹². Spatial contraction and/or temporal reduction in effort in these jurisdictions (see above) are likely to have mitigated the ecosystem impacts of trawling. Similarly, in the Northern Prawn Fishery (Commonwealth), the ecological risk management report identifies priority species at high risk. However, no target or protected species have been assessed as high risk because of the fishery³⁰.
- The use of bycatch reduction devices is mandatory in all Australian tropical prawn trawl fisheries. The use of bycatch reduction devices (BRDs) in trawling can significantly reduce bycatch—by more than 50 per cent by weight in some fisheries³¹. In the East Coast Otter Trawl Fishery (Queensland), the use of BRDs became mandatory in 1999, and the introduction of turtle excluder devices (TEDs) in 2001 largely eliminated capture of most large bycatch species, including turtles, sharks and rays³². BRDs and TEDs became mandatory in the Northern Prawn Fishery (Commonwealth) in 2001. Use of TEDs in the Northern Prawn Fishery reduced turtle bycatch from 5700 individuals per year (before 2001) to approximately 30 per year (after 2001)²³. The introduction of TEDs in the Western Australian trawl fisheries in 2003 reduced turtle bycatch by at least 95 per cent³³. BRDs and TEDs have been mandatory in the Exmouth Gulf Prawn Managed Fishery (Western Australia) since 2003 and in all northern Western Australian prawn fisheries since 2005. All prawn trawlers operating in Western Australia must now use TEDs and BRDs, including secondary fish exclusion devices and hoppers to increase survival of returned fish. Commitment to continuous improvement in bycatch mitigation has facilitated increased use of best-practice TEDs and

BRDs in the East Coast Otter Trawl Fishery (Queensland) since 2008. Recent ecological risk assessments of the fishery have acknowledged reduced impact of trawling and a general absence of high risk of overfishing bycatch species^{8,12}.

Environmental effects on Tiger Prawns

- Biomass of prawns can be highly variable and affected by environmental factors such as water temperatures, cyclones and broadscale oceanographic features^{34,35}. Cyclones can have either a positive or a negative impact on prawn biomass and availability. Early-season (December–January) cyclones can increase mortality of small prawns through the scouring of nursery areas, destroying seagrass and algal habitats. Conversely, mortality can decrease when water becomes turbid, because predation decreases¹⁸. A marine heatwave during the summers of 2010–11 and 2012–13, with water temperatures reaching record high levels in 2012–13, may have affected the structured nursery habitat of Tiger Prawns in the Exmouth Gulf, resulting in very low recruitment.

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24. Western King Prawn *Melicertus latisulcatus*

Craig Noell^a, Mervi Kangas^b and Brad Zeller^c



Table 1: Stock status determination for Western King Prawn

Jurisdiction	Western Australia				Queensland
<i>Stock</i>	SBPMF	EGPMF	North Coast Prawn Managed Fisheries (BPMF, KPMF, NBPMF, OPMF)	SWTMF	ECOTF
<i>Stock status</i>					
	Sustainable	Sustainable	Sustainable	Sustainable	Sustainable
<i>Indicators</i>	Survey catch rates, catch	Survey catch rates, catch	Catch	Catch	Catch

BPMF = Broome Prawn Managed Fishery (Western Australia); ECOTF = East Coast Otter Trawl Fishery (Queensland); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); KPMF = Kimberley Prawn Managed Fishery (Western Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); OPMF = Onslow Prawn Managed Fishery (Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia); SWTMF = South West Trawl Managed Fishery (Western Australia)

Table 1 continued

Jurisdiction	South Australia		
<i>Stock</i>	SGPF	GSVPF	WCPF
<i>Stock status</i>		↓	
	Sustainable	Transitional-depleting	Sustainable
<i>Indicators</i>	Survey catch rates	Survey catch rates	Survey catch rates, catch

GSVPF = Gulf St Vincent Prawn Fishery (South Australia); SGPF = Spencer Gulf Prawn Fishery (South Australia); WCPF = West Coast Prawn Fishery (South Australia)

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b Department of Fisheries, Western Australia
c Department of Agriculture, Fisheries and Forestry, Queensland

Stock structure

Western King Prawn is distributed throughout the Indo–West Pacific¹. No research has been conducted on Western King Prawn biological stock structure in Western Australia or Queensland, and status in these states is therefore reported at the management unit level. In South Australia, one study of the genetic structure of Western King Prawn found no differences between the three fisheries²; however, each fishery functions as an independent population, with distinct adult and juvenile habitats, and independent variations in recruitment and abundance. Each fishery in South Australia is therefore assessed and managed as a separate management unit.

Stock status

Shark Bay Prawn Managed Fishery (Western Australia) management unit

Western King Prawns and Brown Tiger Prawns (the other key target species) overlap in their spatial distribution within Shark Bay. Western King Prawns are more resilient to fishing than Brown Tiger Prawns because they are less catchable (they are strongly nocturnal and readily bury) and have a protracted spawning period^{3,4}. Therefore the rates of fishing that maintain the spawning biomass of Tiger Prawn are well below the rates that could result in Western King Prawn becoming recruitment overfished⁵. More than 40 years of catch-and-effort data support the assumption that this stock has never been reduced to levels considered to be recruitment overfished⁶, and current effort levels are below the level of effort previously applied to the stock. Analysis of catch-and-effort data from the 1970s to the 1990s provided no evidence of a stock–recruitment relationship for Western King Prawns⁵, suggesting that the spawning stock was never reduced to levels where this would become evident. Consequently, at the levels of effort exerted during that period (which covered most environmental variations that are likely to be encountered, including the Leeuwin Current, La Niña and El Niño), sufficient breeding stock will be available to ensure ongoing recruitment levels.

In addition, there is no significant correlation between spawning stock and recruitment indices derived from fishery-independent surveys of Western King Prawn for the range of spawning stocks observed since 2001. This is believed to reflect the maintenance of the spawning stock above levels that would result in recruitment overfishing (noting that there has never been a collapse of the Western King Prawn stock in Shark Bay). Similarly, there is no evidence of a declining trend in recruitment in fishery-independent survey indices since 2000 (unpublished data from the Department of Fisheries, Western Australia); the annual recruitment indices have been well above the target reference level each year (unpublished data from the Department of Fisheries, Western Australia), indicating that most of the recruitment variability is driven by environmental factors. The introduction of closures related to season, moon phase and area since the early 1990s provides further restrictions on the overall fishing effort, which increases protection for the breeding stocks of Western King Prawn⁵.

The fishery-independent recruitment surveys undertaken each year assess prawn abundance and size structure, and are used for catch predictions and management decisions, such as spatial–temporal opening of fishing areas.

Historical catch and catch rates from 1989 to 1998, when it was known that recruitment was not affected by fishing effort, were used as the basis for calculating the target catch range (950–1350 tonnes [t]) and mean target catch rate (21 kg per hour; range 16–29 kg per hour) for this stock⁷. The total commercial catch of 1139 t in 2013 was within the target catch range, and an overall mean catch rate of 31.7 kg/hr was slightly above the target. The above evidence indicates that the biomass of the management unit is unlikely to be recruitment overfished and that the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Exmouth Gulf Prawn Managed Fishery (Western Australia) management unit

For the Exmouth Gulf management unit, maintaining catches within historical ranges is also used to ensure that spawning stock and fishing mortality are kept at appropriate levels⁸. Production levels from the 1970s to the 1990s provide no evidence of a stock–recruitment relationship for Western King Prawn⁶. In 1983, the effort on Western King Prawn increased significantly as a result of the requirement to reduce effort on Tiger Prawn. The annual production of Western King Prawn increased on average by around 40 per cent as a result

of this increased effort. Although it is assumed that this increased production would have decreased the overall spawning stock, it did not result in any decrease in production other than the normal variations seen in recruitment strength due to environmental factors; this suggests that the stock has never been reduced to levels at which this stock–recruitment relationship would become evident. The current effort levels are below this and therefore considered adequate to maintain breeding stocks. This indicates that, at current effort levels and with variations in environmental conditions, sufficient breeding stock will be available to ensure sufficient recruitment in the future.

Fishery-independent recruitment surveys are undertaken each year to assess the abundance and size structure of the stock, and are used for catch predictions and management decisions, such as spatial–temporal opening of fishing areas. In 2013, the Western King Prawn fishery-independent recruitment index was 60.5 kg/hr, which was well above the target (30 kg/hr).

Catch and catch rate levels from 1989 to 1998 have been used as the basis for calculating a target catch range of 350–500 t⁷ and a target catch rate of 12 kg/hr (range 8–14 kg/hr). The target catch range is being reviewed, following a decline in the level of effort for the fishery as a result of shifts in markets and targeting of larger prawns. The commercial catch for 2013 of 331 t was just below the target range, although the catch rate (19.3 kg/hr) was well above the target range. The above evidence indicates that the biomass of the management unit is unlikely to be recruitment overfished and that the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

North Coast Prawn Managed Fisheries (Western Australia) management unit

The North Coast Prawn Managed Fisheries management unit is made up of four separate fisheries (see Table 1) but reported as one unit because of its minimal take. Western King Prawn forms part of total prawn landings in these multispecies prawn fisheries. Only in the Broome Prawn Managed Fishery is Western King Prawn the key target species. Current commercial catch compared with historical ranges is therefore used to assess the level of fishing mortality for these minor North Coast Prawn Managed Fisheries. Historical catch levels from periods when it is known that recruitment was not affected by fishing effort (1991 to 1998) have been used as the basis for calculating target catch ranges; collectively, the range is 65–295 t⁷ for the North Coast Prawn Managed Fisheries. Total commercial catch for 2013 was only 2 t, with the majority taken in the Broome Prawn Managed Fishery. The low catches are attributed to very low effort expended on this species in these fisheries because of the current low market value and high costs of fishing. The above evidence indicates that the biomass of the management unit is unlikely to be recruitment overfished and that the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

South West Trawl Managed Fishery (Western Australia) management unit

Historical catch and catch rate ranges are used to assess spawning stock and fishing mortality for the small prawn fisheries in the south-west region of Western Australia. Historical catch levels from periods when it is known that recruitment was not affected by fishing effort (1990 to 1999) have been used as the basis for calculating target catch ranges and catch rates. The target catch range is 10–40 t, and the target catch rate 14–52 kg per day fished. Total commercial catch for 2013 was only 4 t⁷, which is below the target catch range and well below the long-term (20 years) average catch of 18 t. The 2013 catch rate of 47 kg per day was within the historical catch range, with the low landings reflecting low effort. The above evidence indicates that the biomass of the stock is unlikely to be recruitment overfished and that the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

East Coast Otter Trawl Fishery (Queensland) management unit

A recent ecological risk assessment of the East Coast Otter Trawl Fishery (Queensland) found a low risk of Western King Prawn becoming recruitment overfished as a result of 2009 fishing pressure levels^{9,10}. Nominal fishing effort in the Great Barrier Reef Marine Park has declined by 23 per cent since 2009¹¹, suggesting that the risk of the management unit becoming recruitment overfished has not increased. The long-term catch rate is stable¹¹. Catch declined steadily from 2004 to 2006, following the introduction of new closures in the Great Barrier Reef Marine Park, where more than 90 per cent of the Western King Prawn catch is taken¹¹. From 2007

to 2013, catch was variable, but the 2011 catch was the lowest on record¹¹. A key indicator of risk from trawling is the percentage of available biomass closed to trawling. Research estimated that, in 2005, a large proportion of the Western King Prawn biomass (41 per cent) within the Great Barrier Reef Marine Park was unavailable to trawl capture as a result of permanent closures⁹. These closures remain in place, isolating a large part of the biomass from fishing pressure. The above evidence indicates that the biomass of this management unit is unlikely to be recruitment overfished and that the current level of fishing pressure is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Spencer Gulf Prawn Fishery (South Australia) management unit

The primary measures for stock status in Spencer Gulf are the average catch rates obtained during fishery-independent surveys conducted yearly in February, April and November, which are used as indices of relative biomass. Mean catch rates for surveys conducted in February, April and November 2010 were 100 kg/hr, 171 kg/hr and 113 kg/hr, respectively¹². The February mean catch rate was below the lower threshold of 120 kg/hr; the April mean catch rate was above the lower threshold of 160 kg/hr; and the November mean catch rate was above the lower threshold of 95 kg/hr. Fleet catch cap decision rules resulted in a 450 t pre-Christmas catch cap (fished in November and December)¹³. The lower thresholds for relative biomass aim to maintain survey catch rates within historical ranges¹³, rather than providing a reference below which the stock is considered to be recruitment overfished. Therefore, although the February mean catch rate was below the lower threshold, it is assumed to be above sustainable limits¹². On balance, the mean catch rates across all three surveys indicate that the biomass is unlikely to be recruitment overfished. Combined with the fishery maintaining a long and stable history of recruitment and commercial catches¹⁴ (generally between 1600 and 2400 t), the above evidence indicates that the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Gulf St Vincent Prawn Fishery (South Australia) management unit

The primary measures for stock status in Gulf St Vincent are the average catch rates obtained during fishery-independent surveys, which are used as indices of relative biomass. Traditionally, four surveys were conducted each fishing year, in December, March, April and May; however, the number of surveys was reduced to two (April and May) in 2011–12. The fishery was closed in 2012–13 and 2013–14, primarily for economic reasons and, secondarily, reflecting concerns about biological sustainability; therefore, no survey results were available for 2013. The most recent surveys were conducted in 2012, when mean catch rates in April and May were 42 kg/hr and 43 kg/hr, respectively (unpublished data from the South Australian Research and Development Institute). Despite being among the lowest on record, these survey catch rates were similar to those from 2004 to 2006, which were followed by increases in survey catch rate and commercial catch. Because of a combination of poor economic performance, low mean survey catch rates in 2012, and consecutive declines in annual catch to the lowest since the fishery was closed in 1991–92 and 1992–93, the fishery was closed in November 2012. This evidence indicates that, although the biomass was not considered to be recruitment overfished, fishing pressure was moving the stock in the direction of becoming recruitment overfished. Management arrangements are currently being developed to address the economic and biological concerns associated with reopening of the fishery.

On the basis of the evidence provided above, the management unit is classified as a **transitional–depleting stock**.

West Coast Prawn Fishery (South Australia) management unit

The West Coast Prawn Fishery harvests from an oceanic stock that experiences large fluctuations in recruitment and commercial catch¹⁵. The primary measures for stock status on the west coast are the total commercial catch and the annual average catch rate from fishery-independent surveys (conducted yearly in February, June and November), which are used as an indicator of relative biomass. The fishery suffered a prolonged period of stock collapse from 2002 to 2007¹⁵.

Comparisons of mean commercial catch and survey catch rates during this period provide the basis for assessment of status. The 2013 commercial catch of 148 t was higher than in the previous 5 years (2008 to 2012; mean = 125 t), more than nine times higher than during the period of collapse (2002 to 2007; mean = 16 t) and marginally higher than in the previous period of stable catches (1995 to 2001; mean = 145 t)¹⁶. The

mean survey catch rate in 2013 of 57 kg/hr was higher than the annual mean of the previous 5 years (2008 to 2012; mean = 52 kg/hr) and almost double the annual mean during the period of collapse (2002 to 2007; mean = 30 kg/hr)^{15,16}, suggesting that the stock has fully recovered. The above evidence indicates that the biomass is unlikely to be recruitment overfished and that the current level of fishing pressure is unlikely to cause the management unit to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Table 2: Western King Prawn biology^{5,8,12}

<i>Longevity and maximum size</i>	2–3 years, maximum 4 years Western Australia: males 48 mm CL, females 63 mm CL South Australia: males 47 mm CL, females 65 mm CL
<i>Maturity (50%)</i>	6–8 months; 23–27 mm CL

CL = carapace length

Figure 1: Distribution of reported commercial catch of Western King Prawn in Australian waters, 2013 (calendar year)

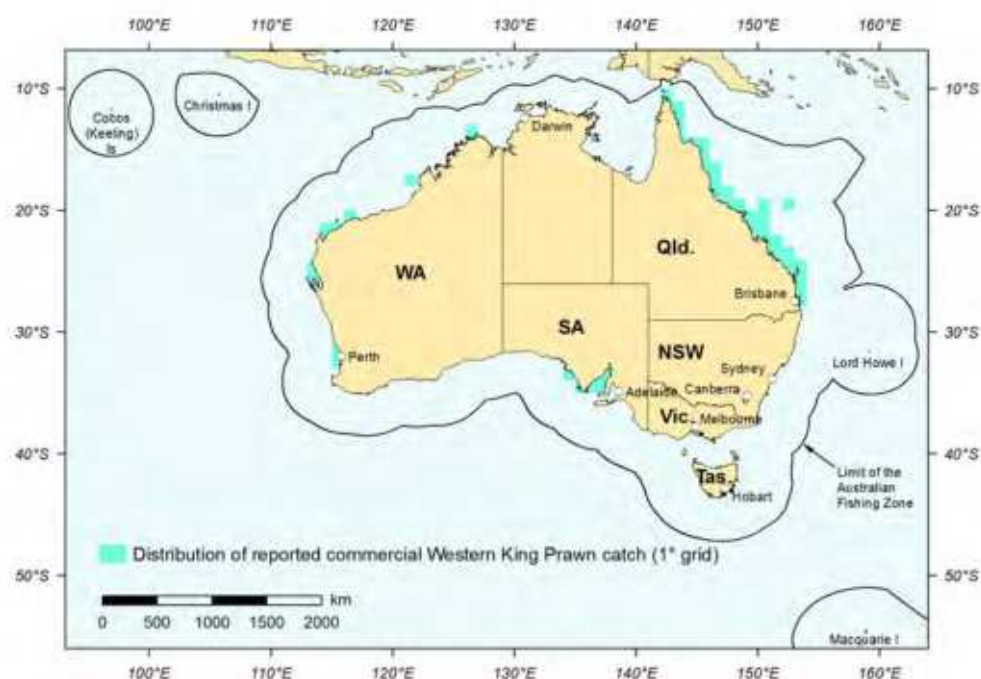


Table 3: Main features and statistics for Western King Prawn fisheries in Australia, 2013 (calendar year)

Jurisdiction	Western Australia	Queensland	South Australia
Fishing methods			
Commercial			
Demersal otter trawling	✓	✓	✓
Recreational			
Hand dip	✓		
Hand scoop	✓		
Dive scoop	✓		
Hand trawl	✓		
Charter			
Hand dip	✓		
Hand scoop	✓		
Indigenous ^a			
	Unknown	Unknown	Unknown
Management methods			
Commercial			
Limited entry	✓	✓	✓
Vessel restrictions	✓	✓	✓
Catch limits			✓
Effort limits	✓	✓	✓
Spatial closures	✓	✓	✓
Recreational			
Recreational licensing	✓		
Gear restrictions	✓		
Bag limits	✓	✓	
Possession limits		✓	

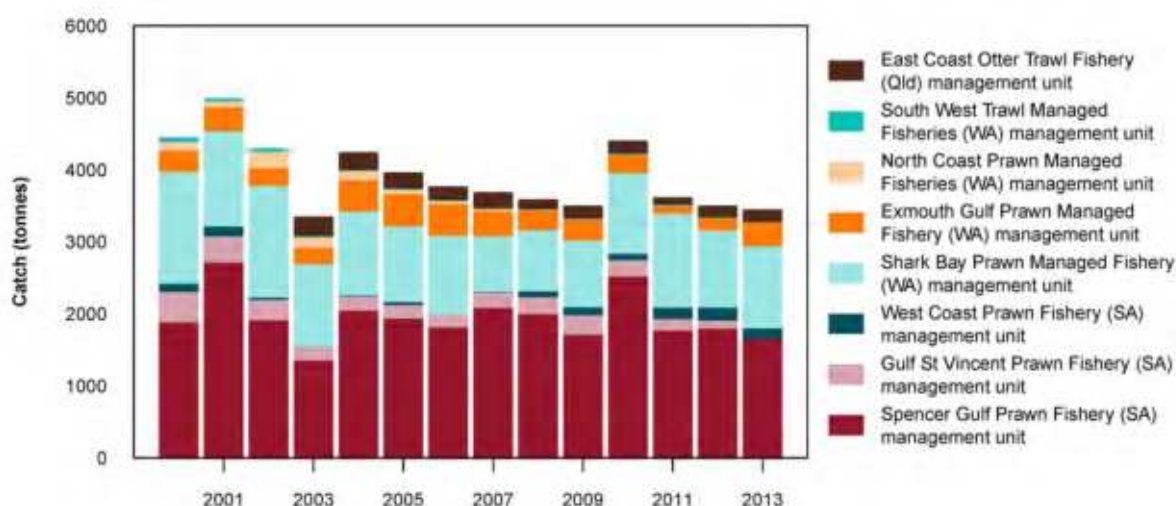
Jurisdiction	Western Australia	Queensland	South Australia
Charter			
Charter licensing	✓		
Limited entry	✓		
Spatial zoning	✓		
Passenger restrictions	✓		
Bag limits	✓		
Possession limits		✓	
Indigenous ^a			
	Unknown	Unknown	Unknown
Active vessels			
	1 in BPFM 6 in EGPMF 1 in KPMF 1 in NBPMF 1 in OPMF 18 in SBPMF 2 in SWTMF	95 in ECOTF	0 in GSVPF 39 in SGPF 3 in WCPF
Catch			
Commercial	2 t in BPFM 331 t in EGPMF <1 t in KPMF <1 t in NBPMF <1 t in OPMF 1139 t in SBPMF 4 t in SWTMF	144 t in ECOTF	0 t in GSVPF 1665 t in SGPF 148 t in WCPF
Recreational	Unknown	No catch	No catch
Indigenous	Unknown	No catch	Unknown
Markets			
Domestic	✓	✓	✓
Export	✓		✓

BPMF = Broome Prawn Managed Fishery (Western Australia); ECOTF = East Coast Otter Trawl Fishery (Queensland); EGPMF = Exmouth Gulf Prawn Managed Fishery (Western Australia); GSVPF = Gulf St Vincent Prawn Fishery (South Australia); KPMF = Kimberley Prawn Managed Fishery (Western Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); OPMF = Onslow Prawn Managed Fishery

(Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia); SGPF = Spencer Gulf Prawn Fishery (South Australia); SWTMF = South West Trawl Managed Fishery (Western Australia); WCPF = West Coast Prawn Fishery (South Australia)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

Figure 2: Commercial catch of Western King Prawn in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- In 2011, the Spencer Gulf Prawn Fishery (South Australia) became the first prawn fishery in the South Pacific to become accredited by the Marine Stewardship Council (MSC). Accreditation by the MSC has been maintained since.
- Fishing for Western King Prawns in Western Australia, Queensland and South Australia is considered to be of low risk to the trophic structures in the ecosystems in which the fisheries operate. Although harvest rates may be relatively high, Western King Prawns have very high natural mortality rates and make up only a small proportion of the total biomass on the trawl grounds. Predators of prawns need to be opportunistic because of the natural variations in prawn populations. Consequently, given the small areas and short periods now fished, it is considered unlikely that the commercial take of prawns impacts significantly on other trophic levels^{5,8}. An assessment of trawl-related risk to trophic structures was not explicitly assessed for the East Coast Otter Trawl Fishery (Queensland), but, in the Great Barrier Reef Marine Park, there is no more than an intermediate risk of overfishing species assemblages exposed to trawling⁹.
- Although trawling can impact on habitats, these effects are managed in the Western King Prawn fisheries in Western Australia, Queensland and South Australia. In Western Australia, extensive permanent and temporary closures result in the fleet operating in only 7 per cent of the Shark Bay region, less than 30 per cent of the Exmouth Gulf and less than 3 per cent of the north coast region. Fishing operations are restricted to areas of sand and mud, where trawling has minimal long-term physical impact^{5,8,17,18}. In Queensland, the Great Barrier Reef Marine Park occupies 63 per cent of the East Coast Otter Trawl Fishery¹⁹, 34 per cent of which is open to trawling¹¹, but effort is highly aggregated, occurring within only a small fraction of the open area. South of the Great Barrier Reef Marine Park, the fishery operates in only 10 per cent of the area open to trawling²⁰. In South Australia, trawl effort has decreased by more than 60 per cent from its historical peaks in all fisheries. Since the inception of the South Australian fisheries,

permanent closures have included all waters less than 10 m deep to ensure protection of seagrass habitats¹¹.

- Although the incidental capture of byproduct and bycatch species by trawling can lead to a range of indirect ecosystem effects²¹, studies in Western Australia, Queensland and South Australia found no significant difference in biodiversity or overall distribution patterns of seabed biota between trawled and nontrawled areas^{17,22,23}. Spatial contraction and/or temporal reduction in effort in all three jurisdictions (see above) are likely to have mitigated the ecosystem impacts of trawling.
- The use of bycatch reduction devices (BRDs) in prawn trawling can significantly reduce bycatch—by more than 50 per cent by weight in some fisheries²⁴. All prawn trawlers operating in Western Australia must use turtle excluder devices (TEDs) and BRDs, including secondary fish exclusion devices and hoppers to increase survival of returned fish. The introduction of TEDs in the Western Australian prawn trawl fisheries in 2003 reduced turtle bycatch by at least 95 per cent²⁵. In the East Coast Trawl Fishery (Queensland), the use of BRDs became mandatory in 1999, and the introduction of TEDs in 2001 largely eliminated capture of most large bycatch species, including turtles, sharks and rays²⁶. More recently, commitment to continuous improvement in bycatch mitigation has facilitated increased use of best-practice TEDs and BRDs in the East Coast Otter Trawl Fishery (Queensland). Recent ecological risk assessments of the fishery have acknowledged the reduced impact of trawling and a general absence of high risk of overfishing bycatch species^{9,10}. In South Australia, all vessels use crab bags, and 49 of the 52 vessels use hopper systems to ensure rapid return of bycatch to the water. The Spencer Gulf MSC certification includes assessment of broad environmental impacts and is important evidence for the low risk of trawling impacts. In the Gulf St Vincent Prawn Fishery (South Australia), all 10 vessels recently adopted specialised mesh codends with rigid grids that substantially reduce bycatch volumes²⁷.

Environmental effects on Western King Prawn

- Major extreme weather events associated with the recent protracted La Niña episode²⁸ are thought to have influenced recent recruitment patterns and depressed catches of a number of oceanic fishery species in Queensland, including Western King Prawn in 2011 (Figure 2). Management of Western King Prawn and other species in the East Coast Otter Trawl Fishery (Queensland) management unit will benefit from knowledge gained from current research into the interrelationships among physical oceanographic features (for example, sea surface temperature anomalies), catch rates, biological parameters and the spatial distribution of Saucer Scallop, a co-occurring species in Queensland and Western Australian trawl fisheries.
- Water temperature has been shown to affect the recruitment of Western King Prawns in Western Australia²⁹.
- In South Australia, there is some evidence to suggest that strong El Niño conditions result in unfavourable upwelling in critical spawning grounds, which may result in recruitment failure, particularly in the West Coast Prawn Fishery (South Australia) management unit³⁰.

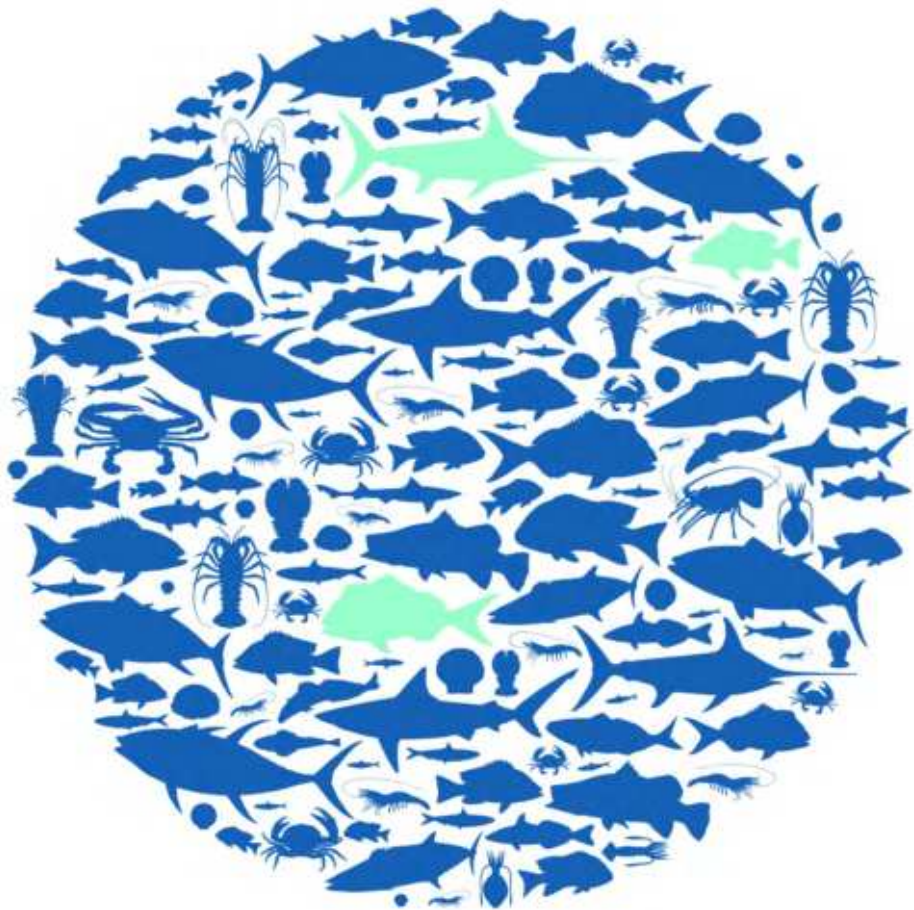
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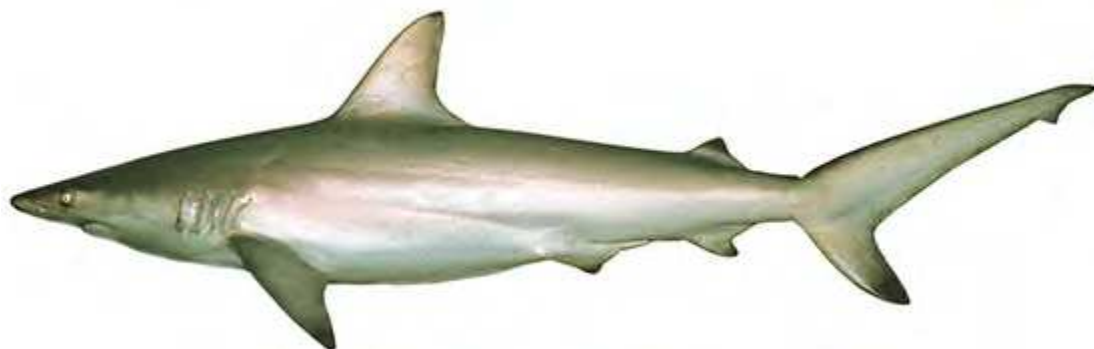
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Sharks



25. Blacktip Shark *Carcharhinus tilstoni*, *C. limbatus*, *C. sorrah*

Grant Johnson^a, Rory McAuley^b, Vic Peddemors^c and Anthony Roelofs^d



Australian Blacktip Shark (*Carcharhinus tilstoni*)

Table 1: Stock status determination for Blacktip Shark

Jurisdiction	New South Wales, Queensland	Northern Territory, Queensland	Northern Territory, Western Australia
Stock	East coast (ECIFFF, OTLF)	Gulf of Carpentaria (GOCIFFF, GOCLF, ONLF)	North and west coast (JANSF, KGBF, NCSF, ONLF)
Stock status			
	Undefined	Undefined	Sustainable
Indicators	Catch	Catch	Catch, mark recapture, CPUE, pup production

CPUE = catch per unit effort; ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); GOCIFFF = Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); JANSF = Joint Authority Northern Shark Fishery (Western Australia); KGBF = Kimberley Gillnet and Barramundi Fishery (Western Australia); NCSF = North Coast Shark Fishery (Western Australia); ONLF = Offshore Net and Line Fishery (Northern Territory); OTLF = Ocean Trap and Line Fishery (New South Wales)

Stock structure

In the context of Australian fisheries, the Blacktip Shark species complex, part of the family Carcharhinidae (whaler sharks), comprises three species: *Carcharhinus tilstoni*, *C. limbatus* and *C. sorrah*. Whereas *C. tilstoni* and *C. sorrah* are distributed within Australian and Indo–West Pacific waters, respectively, *C. limbatus* is globally distributed in tropical and warm temperate waters. In Australian waters, genetic studies have identified two biological stocks of *C. tilstoni* (a western stock extending from the western Northern Territory into northern Western Australia, and an eastern stock extending from the Gulf of Carpentaria to the east coast of Queensland and New South Wales), three biological stocks of *C. limbatus* (one across Western Australia and the Northern Territory, one in the Gulf of Carpentaria, and one on the east coast of Queensland and New South Wales) and a single biological stock of *C. sorrah* across northern Australia¹. Specific stock boundaries between the western biological stocks of *C. tilstoni* and *C. limbatus* and those in the Gulf of Carpentaria are uncertain.

Currently, commercially caught size classes of *C. limbatus* and *C. tilstoni* can only be taxonomically differentiated by genetic analyses or precaudal vertebral counts (although recent evidence of these species' hybridisation may affect the accuracy of these techniques^{2,3}). Thus, reliable species differentiation is not practical during fishing operations. Although *C. sorrah* can be clearly distinguished from *C. tilstoni* and

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C. limbatus, it has only relatively recently been reported separately in commercial catch records from Northern Territory, Queensland and Western Australian fisheries. Because a suite of three species is grouped together for this assessment, all with differing stock structures, stocks have been assessed on the finest known scale—that is, the three biological stock areas identified for *C. limbatus*.

Stock status

East coast biological stocks

Blacktip Shark species are an important component of shark fisheries in New South Wales⁴ and Queensland⁵. In 2009, Queensland introduced a precautionary annual quota of 600 tonnes (t) for all shark and ray species (combined) for the Queensland east coast. This is less than 50 per cent of the highest reported historical annual commercial catch, which occurred in 2003. Although there have not yet been any stock assessments by either New South Wales or Queensland, genetic analysis techniques are currently being used to estimate the effective population size for the east coast stock of *C. limbatus*. Queensland is currently undertaking a stock assessment for major commercial shark species, including the Blacktip Shark species complex, and expects results to be available in late 2014. Until this assessment is complete, stock status cannot be assigned to these biological stocks.

On the basis of the evidence provided above, the biological stocks are classified as **undefined stocks**.

Gulf of Carpentaria biological stocks

Substantial Blacktip Shark catches are harvested from the Gulf of Carpentaria. However, since species identification of sharks has only been undertaken in the Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland) from 2006, it has been difficult to obtain enough data specific to catches of Blacktip Sharks for stock assessment purposes. Consequently, the impact of current catch levels on these biological stocks is unknown, and there is insufficient information to confidently classify their status.

On the basis of the evidence provided above, the biological stocks are classified as **undefined stocks**.

North and west coast biological stocks

The north and west coast biological stocks straddle two management jurisdictions: the Northern Territory, west of the Wessel Islands – Western Australian border; and Western Australia.

The most recent assessment for these biological stocks estimated that the harvest rates for all species within the complex are currently well within sustainable limits, and current pup production is approximately 80 per cent of unfished levels⁶. A mark-recapture study in the Northern Territory for all species of Blacktip Sharks supports the stock assessment results⁷.

Although there is uncertainty in the species composition and magnitude of historical Blacktip Shark catches from Western Australia, these species are not currently harvested in this jurisdiction. Evidence from both jurisdictions indicates that the biomass of this biological stock is unlikely to be recruitment overfished and that current catch levels are unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stocks are classified as **sustainable stocks**.

Table 2: Blacktip Shark biology^{2,8–10}

Longevity and maximum size	<i>C. tilstoni</i>: females 15 years, males 13 years; 2000 mm TL^a <i>C. limbatus</i>: maximum age unknown; 2500 mm TL^a <i>C. sorrah</i>: females 14 years, males 9 years; 1600 mm TL
Maturity (50%)	<i>C. tilstoni</i>: 5–6 years; females 1350–1400 mm TL, males 1200 mm TL^a <i>C. limbatus</i>: males 1800 mm, females unknown^a <i>C. sorrah</i>: 2–3 years; both sexes 900–950 mm TL

TL = total length

^a These biological estimates do not account for hybridisation between *C. tilstoni* and *C. limbatus*.

Figure 1: Distribution of reported commercial catch of Blacktip Sharks in Australian waters, 2013 (calendar year)

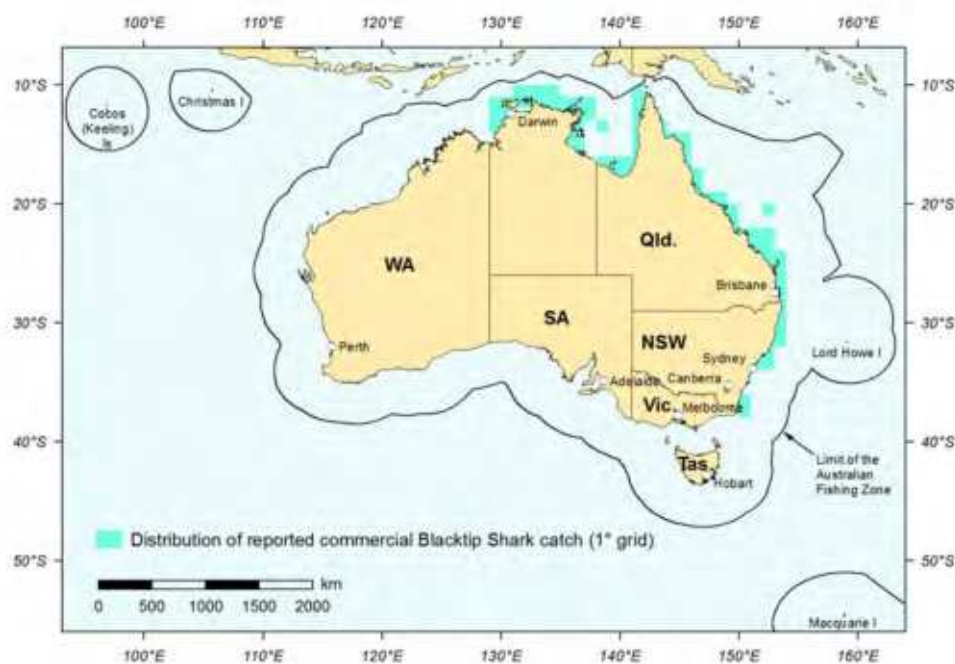


Table 3: Main features and statistics for Blacktip Shark fisheries in Australia, 2013 (calendar year)^{5,11–15}

Jurisdiction	Northern Territory	Western Australia	Queensland	New South Wales
Fishing methods				
Commercial				
Pelagic gillnet	✓		✓	
Demersal gillnet		✓	✓	✓
Anchored longline	✓			✓
Recreational				
Rod and line	✓	✓	✓	✓
Hand line		✓		
Indigenous ^a				
Hand line	✓	Unknown	✓	
Spearfishing	✓	Unknown		
Management methods				
Commercial				
Limited entry	✓		✓	✓
Vessel restrictions	✓		✓	✓
Total allowable effort	✓			✓
Total allowable catch			✓	
Spatial closures	✓	✓		✓
Gear restrictions	✓	✓	✓	✓
Commercial protection		✓		

Jurisdiction	Northern Territory	Western Australia	Queensland	New South Wales
Recreational				
Licences		✓		✓
Bag limits		✓	✓	✓
Possession limits	✓			
Size limits			✓	
Gear restrictions	✓	✓	✓	✓
Spatial closures	✓	✓	✓	✓
Charter				
Licences	✓	✓	✓	✓
Bag limits		✓	✓	✓
Possession limits	✓			
Size limits			✓	
Gear restrictions	✓	✓	✓	
Spatial closures	✓	✓	✓	✓
Indigenous ^{a,b}				
No limits on customary catch	✓	✓		✓
Active vessels				
	7 in ONLF	0 in JANSF 1 in KGBF 0 in NCSF	78 in ECIFFF 27 in GOCIFFF 1 in GOCLF	52 in OTLF
Catch				
Commercial	111 t in ONLF	0 t in JANSF 0.1 t in KGBF 0 in NCSF	144 t in ECIFFF 184 t in GOCIFFF 0.1 t in GOCLF	3.6 t in OTLF
Recreational	Unknown	Unknown	Unknown	Unknown
Charter	Unknown	Unknown	Unknown	Unknown

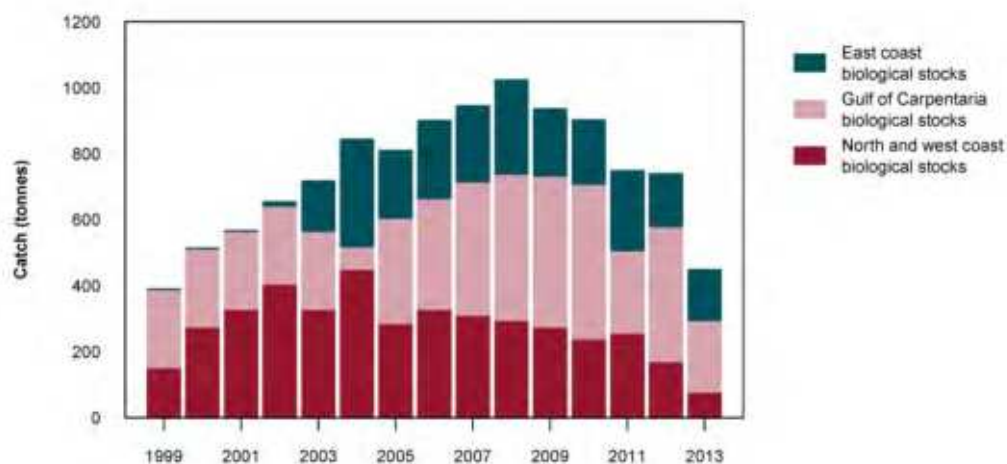
Jurisdiction	Northern Territory	Western Australia	Queensland	New South Wales
Indigenous	Unknown	Unknown	Unknown	Unknown
Markets				
Domestic	✓	n/a	✓	✓
Export	✓	n/a	✓	✓

ECIFFF = East Coast Inshore Fin Fish Fishery; GOCIFF = Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); JANSF = Joint Authority Northern Shark Fishery (Western Australia); KGBF = Kimberley Gillnet and Barramundi Fishery (Western Australia); n/a = not available; NCSF = North Coast Shark Fishery (Western Australia); ONLF = Offshore Net and Line Fishery (Northern Territory); OTLF = Ocean Trap and Line Fishery (New South Wales)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and bag limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

b Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catch of Blacktip Sharks in Australian waters, 1999 to 2013 (calendar years)



Effects of fishing on the marine environment

- Pelagic gillnets and longlines are not intended to come into contact with the seabed, and, under normal circumstances, they have no impact on benthic habitats. Demersal gillnets contact the seabed but are generally set away from any benthic structures (for example, reefs, sponges or mangroves) that could be damaged by them, or cause damage to them. The physical characteristics of these gears and the way in which they are fished are also selective for the target species and size classes.
- However, these fishing methods do interact with threatened, endangered and protected (TEP) species. Although reported interactions are low, the impact on the populations of most TEP species is either unknown^{5,12–14,16,17} or assessed as negligible to low¹². Longline fishing on the east coast has been shown to have the potential to threaten the long-term viability of the east coast population of Grey Nurse Shark (*Carcharias taurus*)¹⁸.

Environmental effects on Blacktip Shark

- The impact of environmental factors on biological stocks of Blacktip Shark is unknown. These species are adapted to a range of environmental conditions and are therefore likely to be resilient to environmental changes.

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26. Dusky Shark *Carcharhinus obscurus*^a

Rory McAuley^b, Vic Peddemors^c, Anthony Fowler^d and Scott Hansen^e



Table 1: Stock status determination for Dusky Shark

Jurisdiction	Commonwealth, South Australia, Western Australia	Commonwealth, New South Wales
Stock	Western Australian (JASDGLF, MSF, SESSF, WCDGLF, WTBF)	Eastern Australian (CSF, ETBF, OTLF)
Stock status	↑	
	Transitional–recovering	Undefined
Indicators	Catch, CPUE, direct estimates of fishing mortality	Catch

CPUE = catch per unit effort; CSF = Coral Sea Fishery (Commonwealth); ETBF = Eastern Tuna and Billfish Fishery (Commonwealth); JASDGLF = Joint Authority Southern Demersal Gillnet and Demersal Longline Fishery (Western Australia); MSF = Marine Scalefish Fishery (South Australia); OTLF = Ocean Trap and Line Fishery (New South Wales); SESSF = Southern and Eastern Scalefish and Shark Fishery (Commonwealth); WCDGLF = West Coast Demersal Gillnet and Demersal Longline Fishery (Western Australia); WTBF = Western Tuna and Billfish Fishery (Commonwealth)

Stock structure

Dusky Shark occurs off the west and south coasts of Australia between latitudes 18°S and 36°S^{1,2}, and off the east coast, where the range of the species is currently undefined. Tagging studies have demonstrated Dusky Shark movements between South Australia and Western Australia^{3,4}, and genetic analysis suggests restricted gene flow between Dusky Shark off eastern and western Australia⁵. Therefore, Dusky Shark in South Australian and Western Australian waters is considered to form a single biological stock (the western Australian stock). This biological stock exhibits a high degree of ontogenetic segregation, with juveniles being most common in temperate latitudes and adults in warmer northern latitudes^{1,6}. Because of negligible recorded catches in Victoria, Tasmania and the Northern Territory, the western Australian biological stock is believed to be separated from the east coast biological stock (the eastern Australian stock). The species is therefore thought to be represented by distinct eastern and western biological stocks in Australian waters. Status is reported at the level of these biological stocks.

^a Dusky Shark catches have historically been reported together with catches of similar-looking and co-occurring whaler sharks. Throughout this chapter, the term 'Dusky Shark' refers specifically to *Carcharhinus obscurus*, whereas the term 'whaler shark' refers to *C. obscurus* in combination with other whaler shark species, particularly *Carcharhinus brachyurus*.

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^c Department of Primary Industries, New South Wales

^d South Australian Research and Development Institute

^e Australian Bureau of Agricultural and Resource Economics and Sciences

Stock status

Western Australian biological stock

The cross-jurisdictional western Australian Dusky Shark stock has components in Western Australia, South Australia and the Commonwealth. This biological stock is most abundant in waters between north-west and southern Western Australia (to 120°E longitude). Its abundance in South Australian waters is generally lower, and possibly more seasonal and sporadic^{2,7}. Given that this stock's primary distribution is off the south-west coast and that Western Australian catches have historically been several times higher than those in the other jurisdictions, the status of the biological stock is determined from the Western Australian stock assessment.

Catches of Dusky Shark in the Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery, and the West Coast Demersal Gillnet and Demersal Longline Fishery have historically consisted of neonate (young of the year) and 1–2-year-old fish. Collectively, these age classes accounted for 89 per cent of the observed catch during the 1990s^{8,9}. The status of this stock has been assessed using demographic modelling techniques, fishing mortality rates estimated from a tagging study in the 1990s, and contemporary catch and catch-per-unit-effort data^{1,10}. The most recent assessment in 2005 confirmed that recorded catches of young juvenile sharks in the target fisheries have been sustainable since the mid-1990s. However, the model also predicted that very low levels of fishing mortality (1–2 per cent per year) applied to sharks older than 10 years would result in recruitment overfishing¹.

Previous assessments therefore concluded that the declining trend observed in the standardised Dusky Shark catch-per-unit-effort series between the mid-1990s and 2004–05 indicated that breeding biomass had been gradually depleted by low but poorly quantified levels of extraneous fishing mortality, including fisheries operating in other jurisdictions^{2,6,7}. This evidence indicates that the biomass of the biological stock was likely to be recruitment overfished. However, for the period 2006 to 2012, an increasing trend in the effective catch-per-unit-effort data suggests improved recruitment rates and a recovering biological stock. Thus, following the comprehensive measures to mitigate cryptic mortality of older Dusky Sharks within all Western Australian–managed commercial fisheries, and to reduce catches of juveniles to less than the levels determined to be sustainable in the mid-1990s, current management arrangements are considered suitably precautionary to ensure that the biological stock continues to recover from its recruitment overfished state.

On the basis of the evidence provided above, the biological stock is classified as a **transitional–recovering stock**.

Eastern Australian biological stock

In New South Wales, Dusky Shark was not identified and reported at the species level in the commercial catch logbooks until 2009. Observer data indicate that whaler sharks represent the second highest shark species catch in the Ocean Trap and Line Fishery (New South Wales), at 15 per cent of the overall catch¹¹. Insufficient information is available to determine status for any of the whaler shark species in New South Wales, including Dusky Shark¹².

Dusky Shark is taken as a nontarget species by Commonwealth fishers in the Eastern Tuna and Billfish Fishery, but its biological stock status has not been assessed. Occasional very small catches (200 kg or less) of Dusky Shark have also been reported from the Coral Sea Fishery (Commonwealth). Research is currently under way to confirm the stock status of Dusky Shark.

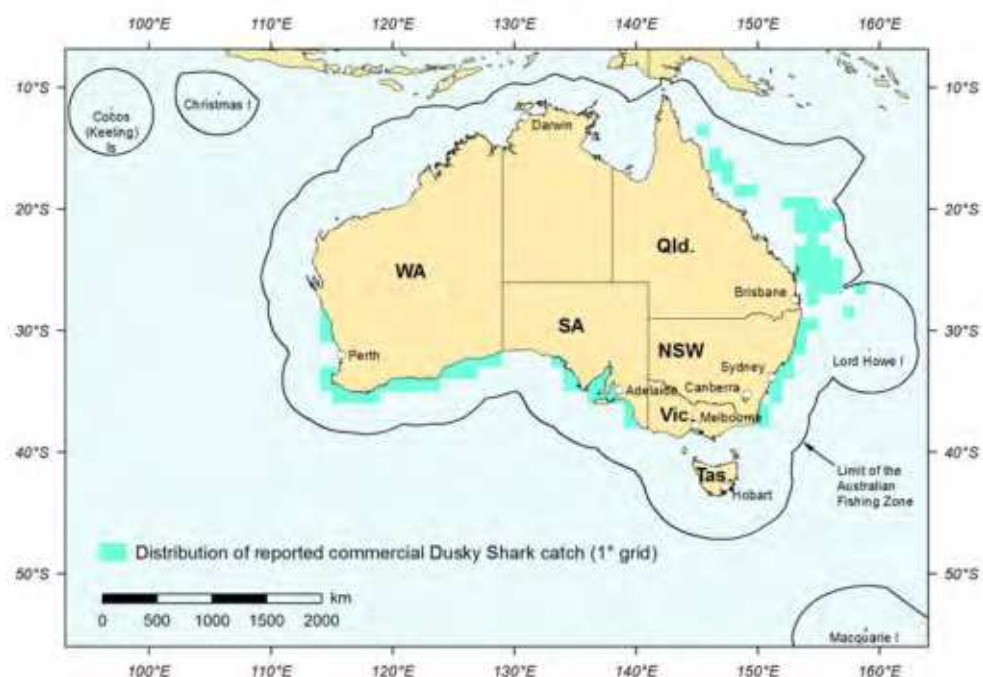
Insufficient information is available to confidently classify the status of this stock, and the biological stock is therefore classified as an **undefined stock**.

Table 2: Dusky Shark biology^(1,9,13)

Longevity and maximum size	Females: >40 years; 2890 mm FL Males: >32 years; 3560 mm TL (~2920 mm FL)
Maturity (50%)	Females: 27–35 years; 2540 mm FL

FL = fork length; TL = total length

Figure 1: Distribution of reported commercial catch of Dusky Shark in Australian waters, 2013 (calendar year)



Note: Catch includes undifferentiated whaler shark catch.

Table 3: Main features and statistics for Dusky Shark fisheries in Australia, 2013 (calendar year)

Jurisdiction	Western Australia	South Australia	New South Wales	Commonwealth
Fishing methods				
Commercial				
Demersal gillnet	✓	✓	✓	
Demersal longline		✓	✓	
Pelagic longline		✓		✓
Dropline		✓	✓	
Hand line		✓	✓	
Recreational ^a				
Rod and line	✓	✓	✓	
Hand line	✓	✓	✓	
Indigenous ^b				
	Unknown	Unknown	Unknown	None

Jurisdiction	Western Australia	South Australia	New South Wales	Commonwealth
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Effort limits	✓	✓		
Gear restrictions	✓	✓	✓	✓
Spatial closures	✓	✓	✓	
Possession limits	✓			✓
Processing restrictions	✓	✓		✓
Maximum size limit	✓			
Recreational ^a				
Bag limits	✓		✓	
Gear restrictions	✓	✓	✓	
Size limit	✓			
Indigenous ^{b-e}				
Gear restrictions	✓		✓	
Bag limits			✓	
Section 37(1)(c1), Aboriginal cultural fishing authority			✓	
Active vessels				
	17 in JASDGLF 5 in WCDGLF	97 in MSF	6 in NSW SMP 12 in OTLF	0 in CSF 21 in ETBF 0 in SESSF 0 in WTBF

Jurisdiction	Western Australia	South Australia	New South Wales	Commonwealth
Catch				
Commercial	137.2 t in JASDGLF (Dusky) 8.2 t in WCDGLF (Dusky)	57.2 t in MSF (whaler)	<1 t in NSW SMP ¹⁴ 2.4 t in OTLF (whaler)	0 t in CSF 2.8 t in ETBF (Dusky) 0 t in SESSF 0 t in WTBF
Recreational ^a	<10 t of whaler sharks caught from boats is retained ¹⁵ Shore-based catches are undetermined	6.3 t (2007–08) ¹⁶	Shore-based catches are undetermined but consist primarily of juveniles	
Indigenous ^b	Undetermined but likely to be negligible	Unknown		
Markets				
Domestic	✓	✓	✓	✓
Export	Unknown	Unknown	Unknown	✓

CSF = Coral Sea Fishery (Commonwealth); ETBF = Eastern Tuna and Billfish Fishery; JASDGLF = Joint Authority Southern Demersal Gillnet and Demersal Longline Fisheries (Western Australia); MSF = Marine Scalefish Fishery (South Australia); NSW SMP = NSW Shark Meshing Program; OTLF = Ocean Trap and Line Fishery (New South Wales); SESSF = Southern and Eastern Scalefish and Shark Fishery (Commonwealth); WCDGLF = West Coast Demersal Gillnet and Demersal Longline Fisheries (Western Australia); WTBF = Western Tuna and Billfish Fishery (Commonwealth)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

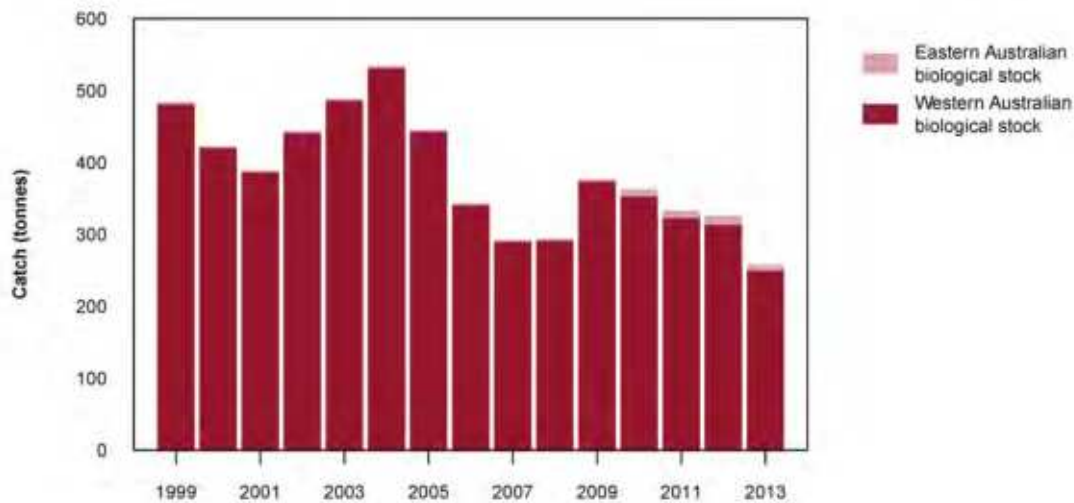
b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

c The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

d The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

e Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catches of whaler sharks in Australian waters, 1999 to 2013 (calendar years)



Note: Because Western Australian (state) Dusky Shark catches cannot be precisely differentiated from those of the conspecific Bronze Whaler (*Carcharhinus brachyurus*) before 2006, and South Australian catches are reported as undifferentiated whaler sharks, Western Australian (state) catches are for Dusky Shark and Bronze Whaler combined. Data for eastern Australian biological stock is only for Dusky Shark.

Effects of fishing on the marine environment

- Recent analysis of potential changes in ecosystem structure of finfish in the South and West Coast Bioregions¹⁷ found no evidence of any systematic change in species diversity or richness, or trophic index, indicating that this fishery is not having a material impact on the food chain or trophic structure.
- The demersal gillnets used to catch Dusky Shark in Western Australia are deployed infrequently, over a small proportion of the target fisheries' operational area. Under normal circumstances, the physical impact of the gear on benthic habitats is minimal⁶.
- Demersal gillnets are known to interact with a number of threatened and protected species in areas where they are used to catch Dusky Shark. However, such interactions occur at a very low frequency, and have been assessed as posing low to negligible risks to these populations⁶.

Environmental effects on Dusky Shark

- Climate change and climate variability have the potential to impact fish stocks in a range of ways, including influencing their geographic distribution (for example, latitudinal shifts in distribution). The impact of environmental changes on Dusky Shark stocks is unknown.

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27. Gummy Shark *Mustelus antarcticus*

Nic Marton^a, Anthony Fowler^b, Harry Gorfine^c, Jeremy Lyle^d, Rory McAuley^e and Vic Peddemors^f



Table 1: Stock status determination for Gummy Shark

Jurisdiction	Commonwealth, New South Wales, South Australia, Tasmania, Victoria, Western Australia	New South Wales
Stock	Southern Australian (CIF, EGF, ITF, JASDGLF, LACF, MSF, OF, OTF, OTLF, PPBF, SESSF [SGSHS], SF, WCDGLF, WPF)	Eastern Australian (EGF, EPTF, OTF, OTLF)
Stock status		
	Sustainable	Undefined
Indicators	Biomass, catch	None

CIF = Corner Inlet Fishery (Victoria); EGF = Estuary General Fishery (New South Wales); EPTF = Estuary Prawn Trawl Fishery (New South Wales); ITF = Inshore Trawl Fishery (Victoria); JASDGLF = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Western Australia); LACF = Lakes and Coorong Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); OF = Ocean Fishery (Victoria); OTF = Ocean Trawl Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales); PPBF = Port Phillip Bay Fishery (Victoria); SESSF (SGSHS) = Southern and Eastern Scalefish and Shark Fishery (Shark Gillnet and Shark Hook Sector) (Commonwealth); SF = Scalefish Fishery (Tasmania); WCDGLF = West Coast Demersal Gillnet and Demersal Longline Fishery (Western Australia); WPF = Western Port Fishery (Victoria)

Stock structure

Gummy Shark (*Mustelus antarcticus*) is distributed throughout the temperate waters of Australia, from at least Port Stephens in New South Wales to Geraldton in Western Australia (including Tasmania)^{1,2}. The most recent research on biological stock structure for Gummy Shark³ suggested that there is most likely one biological stock in southern Australia (extending from the lower west coast of Western Australia to Jervis Bay in New South Wales) and a second biological stock in eastern Australia (extending from Newcastle to the Clarence River in New South Wales). There are conflicting reports of a separate species (*M. walkeri*) off the Queensland coast. A study based primarily on morphology and meristics concluded that a separate species existed³, but a study of mitochondrial DNA was unable to detect differences at a genetic level⁴. The southern Australian biological stock is considered to comprise four separate subpopulations for formal stock assessment purposes: the continental shelf of Bass Strait, Tasmania, South Australia and Western Australia. The first three are assessed by the Commonwealth within an integrated assessment by the Shark Resource Assessment Group^{5,6}. The fourth is assessed separately by Western Australia⁷. Reporting of status is undertaken at the biological stock level. Status determination for the southern Australian biological stock considers information compiled in both the Commonwealth and Western Australian assessments.

^a Australian Bureau of Agricultural and Resource Economics and Sciences

^b South Australian Research and Development Institute

^c Department of Environment and Primary Industries, Victoria

^d Institute for Marine and Antarctic Studies, University of Tasmania

^e Department of Fisheries, Western Australia

^f Department of Primary Industries, New South Wales

Stock status

Southern Australian biological stock

There is a close relationship between the number of pups and both the number and length of females⁵ and so the Commonwealth assessment uses pup production as an indicator of biomass. The most recent assessment⁶ treats Bass Strait, South Australia and Tasmania as separate subpopulations, with no movement of animals between these regions and no density-dependent effects of one population on another. Gillnet closures off South Australia have been progressively implemented to reduce interactions with marine mammals (particularly Australian Sea Lions and dolphins), starting with voluntary closures in 2009–10, followed by mandatory closures in 2010–11⁸. These closures have reduced catch and catch per unit effort off South Australia. As a result of the large changes in operating conditions, the South Australian catch-per-unit-effort data after 2010 was considered to be a poor indicator and was not included in the model. The South Australian closures may have also reduced the catch per unit effort off Victoria, as inexperienced operators moved from South Australia to Victoria⁶. However, as these impacts were considered minor, catch and catch-per-unit-effort data up to 2012 from Victoria (and Tasmania) were retained in the model.

The base-case assessment estimated pup production to be above 48 per cent of the unfished level of pup production (1927) for all three Gummy Shark populations. Some model sensitivities that explored density dependence estimated pup production to be as low as 31 per cent (for the Bass Strait population), which is below the target reference point for the Commonwealth Harvest Strategy Policy, but above the limit reference point. These results indicate that the three populations examined (Bass Strait, South Australia and Tasmania) are not recruitment overfished⁹.

The Shark Resource Assessment Group's recommended biological catch for the three subpopulations combined was 1836 tonnes (t) for the 2013–14 season¹⁰. Total combined commercial catch for the three subpopulations in 2013 was 1661 t. This level of fishing mortality is not expected to cause this part of the biological stock to become recruitment overfished⁹.

The Western Australian component of the stock was assessed using an age-structured model developed in the mid-1990s to estimate total and breeding stock biomass¹¹. Since then, catches and catch per unit effort have been monitored in reference to those biomass estimates. A new assessment model incorporating movement rates within Western Australian waters is due to be completed by 2015. The most recent assessment⁷ concluded that reductions in demersal gillnet fishing effort since biomass was estimated to be 42.7 per cent of the unfished (1975) level, in 1997–98, should have ensured that biomass has remained above this level. Therefore, this part of the biological stock is not considered to be recruitment overfished.

These conclusions are supported by an increasing trend in standardised catch per unit effort between the mid-1990s and 2005–06. This is thought to be the result of reductions in demersal gillnet fishing effort in Western Australia from 1992 onwards, leading to increases in breeding stock biomass. A subsequent increase in catch per unit effort to unprecedented levels peaked in 2007–08 and was followed by a rapid decline to 2011–12 (the most recent year of available data). However, the catch per unit effort in 2011–12 was still at historically high levels, and this issue will be assessed through updated modelling for this part of the biological stock during the next 12 months. Despite the recent unusual spike and subsequent decline in catch per unit effort, current levels of fishing mortality are considered unlikely to cause this part of the biological stock to become recruitment overfished⁷.

On the basis of the evidence provided above, the entire biological stock is classified as a **sustainable stock**.

Eastern Australian biological stock

Available information indicates that there is little catch of Gummy Shark (less than 50 t per year) from the eastern Australian biological stock¹². Hence, insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

Table 2: Gummy Shark biology^{5,13–15}

Longevity and maximum size	16 years; 1850 mm TL (25 kg total body mass)
Maturity (50%)	Females: 1105–1253 mm TL Males: 950–1133 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Gummy Shark in Australian waters, 2013 (calendar year)

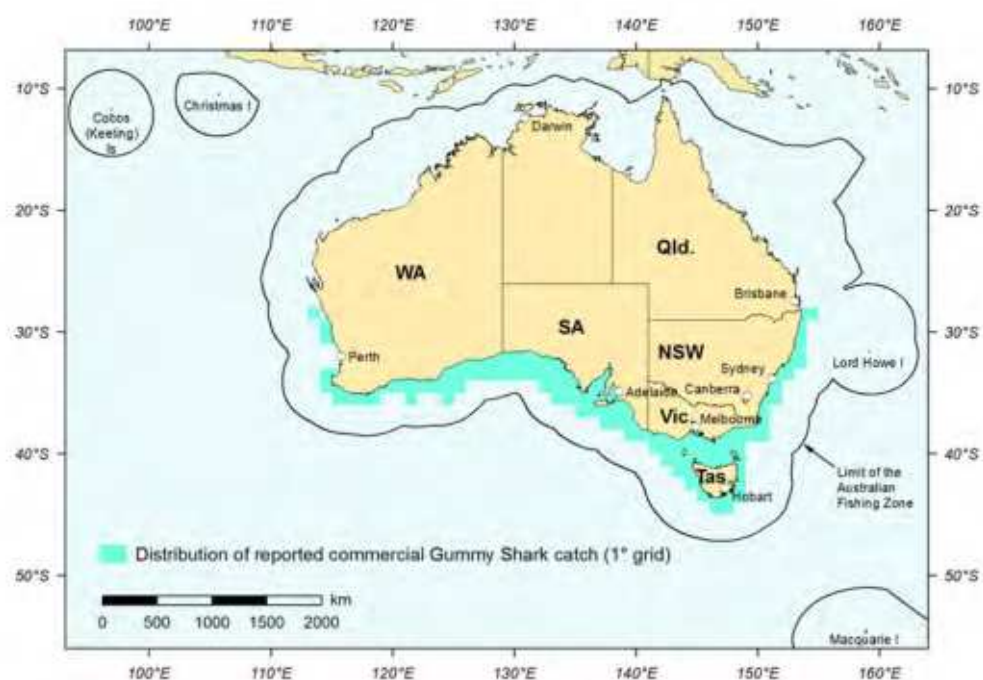


Table 3: Main features and statistics for Gummy Shark fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth ^a	New South Wales ^b	Victoria	Tasmania	South Australia	Western Australia
Fishing methods						
Commercial						
Demersal gillnet	✓	✓	✓	✓	✓	✓
Demersal longline	✓	✓	✓	✓	✓	
Dropline	✓	✓	✓		✓	
Mechanised hand line	✓					
Auto-longline	✓					
Hand line		✓	✓		✓	

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GUMMY SHARK

Jurisdiction	Commonwealth ^a	New South Wales ^b	Victoria	Tasmania	South Australia	Western Australia
Fish/prawn trawl			✓			
Haul seine			✓			
Recreational ^c						
Rod and line		✓	✓	✓		✓
Demersal longline				✓		
Gillnet				✓		
Indigenous ^{d,e}						
				Unknown	Unknown	Unknown
Management methods						
Commercial						
Limited entry	✓	✓	✓	✓	✓	✓
Gear restrictions	✓	✓	✓	✓	✓	✓
Spatial closures	✓		✓	✓		✓
Total allowable catch	✓					
Individual transferable quota	✓					
Effort limits (individual transferable effort)						✓
Processing restrictions	✓	✓			✓	✓
Trip limits			✓	✓	✓	✓
Size limits	✓	✓	✓	✓	✓	
Recreational ^c						
Bag limits			✓	✓	✓	✓
Size limits			✓	✓	✓	
Spatial closures				✓		

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
GUMMY SHARK

Jurisdiction	Commonwealth ^a	New South Wales ^b	Victoria	Tasmania	South Australia	Western Australia
Indigenous ^{d,e,f,g}						
Bag limits					✓	
Size limits					✓	
Active vessels						
	68 in SESSF (SGSHS)	3 in EGF 1 in EPTF 58 in OTF 42 in OTLF	18 in CIF 8 in ITF 28 in OF 28 in PPBF 1 in WPF	57 in SF	6 in LACF 160 in MSF	18 in JASDGLF 3 in WCDGLF
Catch						
Commercial	1506 t in SESSF (SGSHS)	0.2 t in EGF <0.01 t in EPTF 12.1 t in OTF 19.6 t in OTLF	9.8 t in CIF 0.4 t in ITF 2.4 t in OF 3.9 t in PPBF <0.2 t in WPF	2.1 t in SF	0.7 t in LACF 103.7 t in MSF	415.7 t in JASDGLF 0.4 t in WCDGLF
Recreational ^c		Unknown	Unknown	Unknown	18.7 t ¹⁶	~3 t caught from boats is retained ¹⁷ Shore-based catches are unknown
Indigenous ^{c-e}		Unknown	None	Unknown	Unknown	Unknown but likely to be negligible
Markets						
Domestic	✓	✓		✓	✓	✓
Export						

CIF = Corner Inlet Fishery (Victoria); EGF = Estuary General Fishery (New South Wales); EPTF = Estuary Prawn Trawl Fishery (New South Wales); ITF = Inshore Trawl Fishery (Victoria); JASDGLF = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Western Australia); LACF = Lakes and Coorong Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); OF = Ocean Fishery (Victoria); OTF = Ocean Trawl Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales); PPBF = Port Phillip Bay Fishery (Victoria); SESSF (SGSHS) = Southern and Eastern Scalefish and Shark Fishery (Shark Gillnet and Shark Hook Sector) (Commonwealth); SF = Scalefish Fishery (Tasmania); WCDGLF = West Coast Demersal Gillnet and Demersal Longline Fishery (Western Australia); WPF = Western Port Fishery (Victoria)

a Data provided for the Commonwealth align with the Commonwealth SESSF 2013–14 fishing season (1 May 2013 – 30 April 2014).

b Data provided for New South Wales align with the 2013–14 financial year.

c The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

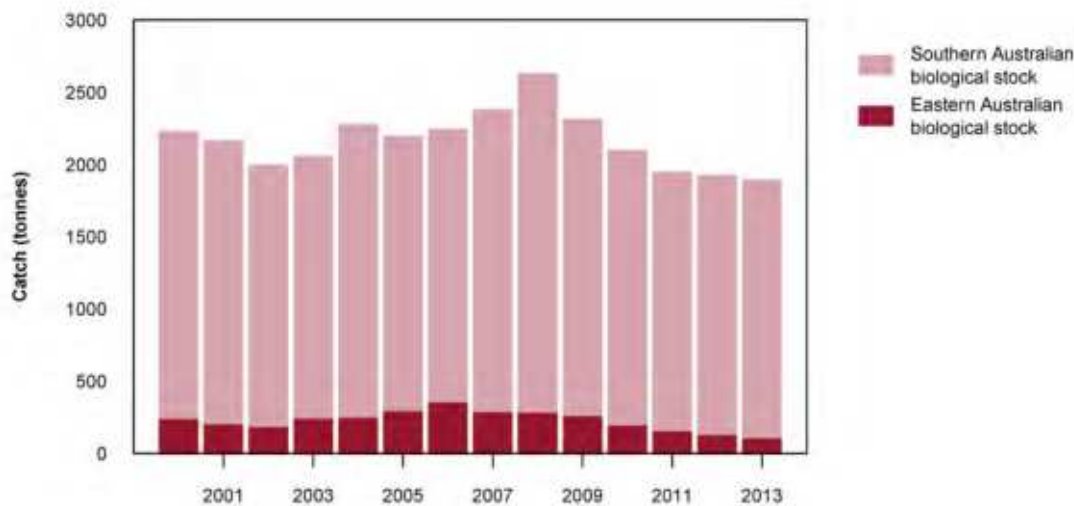
d The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

e In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Gummy Shark.

f The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

g The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Gummy Shark in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Interactions with marine mammals (Australian Sea Lions, Australian Fur Seals, New Zealand Fur Seals and dolphins) in some gillnet fisheries continue to be an issue. Mitigation actions that have been implemented include spatial closures, increased monitoring and implementation of the Australian Sea Lion Management Strategy¹⁸ and Dolphin Strategy¹⁹.
- Dolphin interactions in the Commonwealth gillnet sector of the SESSF Gillnet, Hook and Trap Sector have recently been identified as an issue, based on increased monitoring associated with managing interactions with Australian Sea Lions²⁰. The Australian Fisheries Management Authority has closed areas where most interactions occur and increased observer coverage to 100 per cent in adjacent areas. These management measures were revised through the Dolphin Strategy for the 2014–15 fishing season²⁰.
- Offal management strategies, introduced in April 2011, include requirements for gillnet operators to remove any biological materials from nets before they are set. This has been effective in reducing seabird interactions in other fisheries¹⁹.

- The use of auto-longlines in the SESSF Gillnet Hook and Trap Sector has raised concerns about the potential for interactions with seabirds, including albatrosses and shearwaters²¹. New measures have been implemented to assist industry to meet the Seabird Threat Abatement Plan²² and Performance Criteria²³.
- Demersal gillnets are known to interact with a number of threatened and protected species, including marine mammals and seabirds, in areas of Western Australia where they are used to catch Gummy Shark. However, such interactions occur at a very low frequency and have been assessed as posing low to negligible risks to these populations⁷.
- Recent analysis of potential changes in ecosystem structure of finfish in the South and West Coast Bioregions²⁴ of Western Australia found no evidence of any systematic change in species diversity or richness, or trophic index, indicating that the Western Australian fisheries are not having a material impact on the food chain or trophic structure in these regions.
- The demersal gillnets used to catch Gummy Shark in Western Australia are deployed infrequently, over a small proportion of the target fisheries' operational area. Under normal circumstances, the physical impact of the gear on the benthic habitat is minimal⁷.

Environmental effects on Gummy Shark

- Sea level rise and changes in sea temperature associated with climate change may negatively affect Gummy Shark stocks because the habitats that Gummy Shark use as nursery and feeding grounds are potentially sensitive to such effects²⁵.

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28. Sandbar Shark *Carcharhinus plumbeus*

Rory McAuley^a, Vic Peddemors^b, Anthony Roelofs^c and Grant Johnson^d



Table 1: Stock status determination for Sandbar Shark

Jurisdiction	Western Australia, Northern Territory	New South Wales, Queensland
Stock	Western Australian (JASDGLF, ONLF, WCDGLF)	Eastern Australian (ECIFFF, OTLF)
Stock status	↑	
	Transitional–recovering	Undefined
Indicators	Catch, CPUE, fishing mortality	Catch

CPUE = catch per unit effort; ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); JASDGLF = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Western Australia); ONLF = Offshore Net and Line Fishery (Northern Territory); OTLF = Ocean Trap and Line Fishery (New South Wales); WCDGLF = West Coast Demersal Gillnet and Demersal Longline Fishery (Western Australia)

Stock structure

Sandbar Shark (*Carcharhinus plumbeus*) occurs off both the east and west coasts of Australia, from approximately 17°S to 32°S latitude off the east coast, and 13°S to 36°S latitude off the west coast^{1,2}. In addition to genetic analysis that suggests limited gene flow between eastern and western *C. plumbeus*³, there are limited recorded catches in the Gulf of Carpentaria and southern Australia. Thus, the species is considered to be represented by separate eastern and western biological stocks in Australian waters. Status is reported at the level of these biological stocks.

Stock status

Western Australian biological stock

In Western Australia, Sandbar Shark is targeted by the West Coast Demersal Gillnet and Demersal Longline Fishery, and taken in lesser quantities by the Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery⁴. It was also previously targeted by the Western Australian North Coast Shark Fishery⁵. The Western Australian stock assessment uses current and historical data from all of these fisheries. Minor catches

a Department of Fisheries, Western Australia

b Department of Primary Industries, New South Wales

c Department of Agriculture, Fisheries and Forestry, Queensland

d Department of Primary Industry and Fisheries, Northern Territory

historically reported from the Offshore Net and Line Fishery (Northern Territory) are assumed to be from the western biological stock, but these are not explicitly included in assessments of this stock.

Because of the longevity of Sandbar Shark and the age-specific nature of targeted fishing mortality, a sufficiently long time series of catch-per-unit-effort data is not yet available for dynamic stock assessment modelling. Assessment of this stock has therefore been undertaken using empirically derived estimates of fishing mortality between 2001 and 2004, and demographic modelling techniques^{6,7}.

Demographic modelling indicated that combined levels of fishing mortality in Western Australian targeted shark fisheries, nontarget commercial fisheries and the recreational fishing sector became increasingly unsustainable between 2001 and 2004 (when catches peaked at 918 tonnes [t]) and had probably exceeded sustainable levels since 1997–98. These conclusions are supported by fishery-independent survey data that indicated declining breeding stock abundance between 2002 and 2005^{5,6}.

Since 2010, Sandbar Shark catches have remained well below the levels that will allow a gradual recovery of the breeding stock. The expected reductions in recruitment from previously excessive exploitation of the breeding stock are likely to be ameliorated by significant reduction in targeted fishing effort. Therefore, although the breeding stock is considered to be close to the minimum acceptable limit (40 per cent of unfished biomass), current levels of fishing are considered suitably precautionary to ensure the recovery of this biological stock.

On the basis of the evidence provided above, the biological stock is classified as a **transitional–recovering stock**.

Eastern Australian biological stock

In New South Wales, whaler sharks (*Carcharhinus* spp.), including Sandbar Shark (*C. plumbeus*), have historically not been adequately identified and reported at a species level in commercial catch logbooks. However, observer data indicate that Sandbar Shark represents the largest single-species component of catches in the Ocean Trap and Line Fishery (New South Wales), at 35 per cent of the overall shark catch⁸. Insufficient information is available to determine status for any of the whaler shark species in New South Wales, including Sandbar Shark⁹. The net fishery of the East Coast Inshore Fin Fish Fishery (Queensland) contributes minimal quantities (less than 2 t per year) to the overall eastern Australian harvest of Sandbar Shark.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

Table 2: Sandbar Shark biology^(2,10,11)

<i>Longevity and maximum size</i>	30–40 years; 1660 mm FL; 2150 mm TL
<i>Maturity (50%)</i>	Females: 16.2 years; 1360 mm FL Males: 13.8 years; 1270 mm FL

FL = fork length; TL = total length

Figure 1: Distribution of reported commercial catch of Sandbar Shark in Australian waters, 2013 (calendar year)

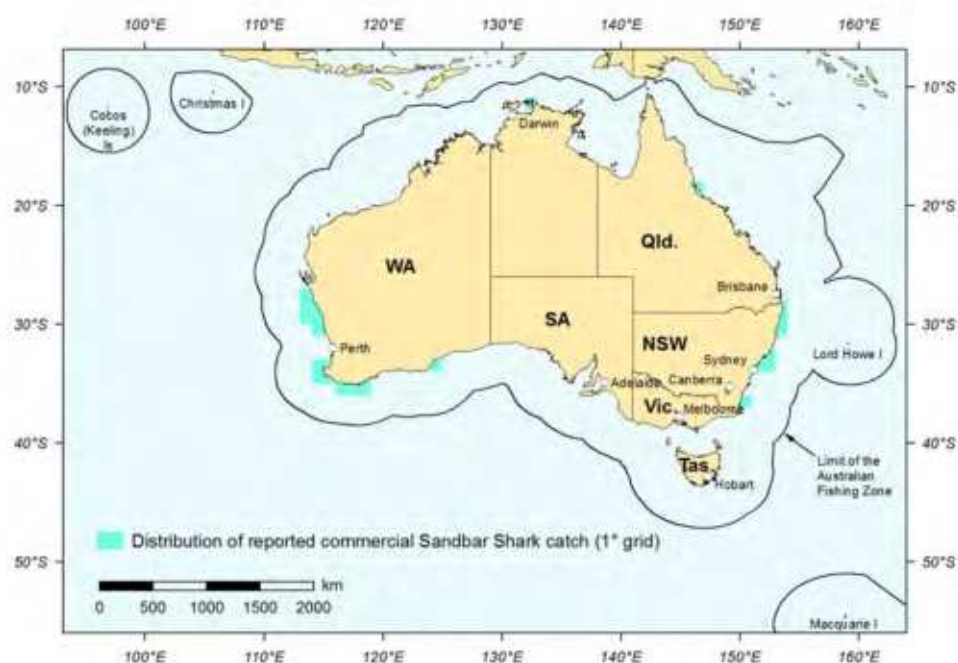


Table 3: Main features and statistics for Sandbar Shark fisheries in Australia, 2013 (calendar year)

Jurisdiction	Western Australia	Northern Territory	New South Wales	Queensland
Fishing methods				
Commercial				
Demersal gillnet	✓			✓
Demersal longline		✓	✓	✓
Pelagic gillnet		✓		
Recreational				
Rod and line	✓	✓	✓	✓
Hand line	✓	✓	✓	✓
Indigenous ^a				
	Unknown	Unknown	Unknown	Unknown

Jurisdiction	Western Australia	Northern Territory	New South Wales	Queensland
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Effort limits	✓	✓	✓	
Gear restrictions	✓	✓	✓	✓
Spatial closures	✓	✓	✓	✓
Possession restrictions	✓			✓
Processing restrictions	✓	✓		✓
Total allowable commercial catch				✓
Vessel restrictions		✓		✓
Recreational				
Bag limits	✓	✓	✓	
Possession limits				✓
Gear restrictions	✓	✓	✓	✓
Indigenous ^{a-d}				
Gear restrictions	✓	✓	✓	✓
Bag limits			✓	
Section 37(1)(c1), Aboriginal cultural fishing authority			✓	

Jurisdiction	Western Australia	Northern Territory	New South Wales	Queensland
Active vessels				
	12 in JASDGDLF 5 in WCDGDLF	7 in ONLF	12 in OTLF	1 in ECIFFF
Catch				
Commercial	25 t in JASDGDLF 16 t in WCDGDLF	<1 t in ONLF	5.6 t in OTLF	<1 t in ECIFFF
Recreational	<10 t retention of all whaler sharks caught from boats ¹² Shore-based catches are likely to be negligible ^e	Unknown but likely to be negligible ^e	Unknown but likely to be negligible ^e	Unknown but likely to be negligible ^e
Indigenous	Unknown but likely to be negligible ^e	Unknown but likely to be negligible ^e	Unknown but likely to be negligible ^{b,c,e}	Unknown but likely to be negligible ^e
Markets				
Domestic	✓	✓	n/a	✓
Export	✓	✓	n/a	✓

ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); JASDGDLF = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Western Australia); n/a = not available; ONLF = Offshore Net and Line Fishery (Northern Territory); OTLF = Ocean Trap and Line Fishery (New South Wales); WCDGDLF = West Coast Demersal Gillnet and Demersal Longline Fishery (Western Australia)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

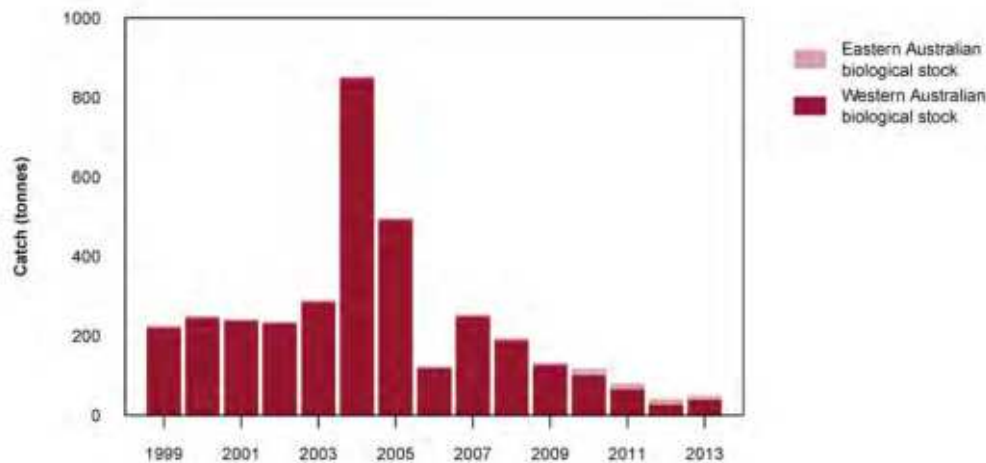
b The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

c The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

d Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

e Given the offshore distribution of Sandbar Shark, near-shore catches are likely to be negligible.

Figure 2: Commercial catch of Sandbar Shark in Australian waters, 1998 to 2013 (calendar years)



Effects of fishing on the marine environment

- Recent analysis of potential changes in ecosystem structure of finfish in the South and West Coast Bioregions of Western Australia¹³ found no evidence of any systematic change in species diversity or richness, or trophic index, indicating that this fishery is not having a material impact on the food chain or trophic structure.
- The demersal gillnets used to catch Sandbar Shark in Western Australia are deployed infrequently over a small proportion of the target fisheries' operational area. Under normal circumstances, the physical impact of the gear on the bottom is minimal³.
- Demersal gillnets are known to interact with a number of threatened and protected species in areas where they are used to catch Sandbar Shark. However, such interactions occur at a very low frequency, and have been assessed as posing low to negligible risks to these populations⁴.

Environmental effects on Sandbar Sharks

- Climate change and climate variability have the potential to impact fish stocks in a range of ways, including influencing their geographic distribution (for example, latitudinal shifts in distribution). However, the impact of environmental changes on Sandbar Shark stocks is unknown.

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29. School Shark *Galeorhinus galeus*

Nic Marton^a, Anthony Fowler^b, Corey Green^c, Jeremy Lyle^d, Rory McAuley^e and Vic Peddemors^f



Table 1: Stock status determination for School Shark

Jurisdiction	Commonwealth, New South Wales, South Australia, Tasmania, Victoria, Western Australia
Stock	Southern Australian (EGF, EPTF, JASDGLF, LACF, MSF, OF, OHF, OTF, OTLF, SESSF [SGSHS], SF)
Stock status	Overfished
Indicators	Estimate of biomass (relative pup production)

EGF = Estuary General Fishery (New South Wales); EPTF = Estuary Prawn Trawl Fishery (New South Wales); JASDGLF = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Western Australia); LACF = Lakes and Coorong Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); OF = Ocean Fishery (Victoria); OHF = Ocean Haul Fishery (New South Wales); OTF = Ocean Trawl Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales); SESSF (SGSHS) = Southern and Eastern Scalefish and Shark Fishery – Shark Gillnet and Shark Hook Sectors (Commonwealth); SF = Scalefish Fishery (Tasmania)

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, off South Africa, New Zealand and southern Australia. There is some uncertainty about the stock structure for School Shark^{1,2}. A single biological stock is assumed for management purposes. A spatially structured fishery assessment model is applied to assess this biological stock because insufficient data exist to support more complex stock structure analysis¹.

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^d Institute for Marine and Antarctic Studies, University of Tasmania

^e Department of Fisheries, Western Australia

^f Department of Primary Industries, New South Wales

Stock status

Southern Australian biological stock

Assessments since 1991 have consistently estimated that the School Shark biological stock is less than 20 per cent of the unfished biomass. As such, School Shark is subject to a rebuilding strategy. Recent analyses of catch data have not indicated any targeting of School Shark in the Southern and Eastern Scalefish and Shark Fishery – Shark Gillnet and Shark Hook Sectors. Therefore, all catch can be considered to be incidental. School Shark are predominantly taken as incidental catch in fisheries targeting Gummy Shark.

The most recent full stock assessment for school shark was published in 2009³. In 2012, the 2009 assessment was rerun with additional catch data for the years 2009 to 2012⁴. The updated model allows the rate of maximum sustainable yield ($MSY:B_{MSY}$) to be estimated within the model, rather than being fixed at an assumed value (as was the case in the 2006 assessment). This resulted in a higher rate of maximum sustainable yield (4.4 per cent) than the 2006 assessment (3.5 per cent).

Concern remains about the ability of the stock assessment to reliably estimate the state of the stock. The assessment incorporates a number of fishery-dependent (catch-and-effort) and fishery-independent (survey) data series. However, given the low total allowable catches in recent years (potentially affecting quota availability, and the accurate reporting of catch and discards), the reported avoidance behaviour of fishers, and recent introduction of spatial closures predominantly off South Australia that prohibit the use of gillnets, the catch-per-unit-effort index may have become less reliable as an index of abundance in recent years⁵.

The biological stock is still considered to be below the Commonwealth Harvest Strategy Policy⁶ limit reference point (20 per cent of unfished biomass; B_{20}) and as such is considered to be recruitment overfished⁷. Under a zero catch scenario, the stock was projected to rebuild to B_{20} within 23 years. However, even the setting of a total allowable catch that would allow rebuilding within 32 years (125 tonnes [t]) would severely constrain the Commonwealth Gummy Shark fishery. Catch scenarios up to 250 t were projected to allow recovery of the stock within three generation times (66 years), but catches of 275 t could not be sustained⁴. Total landed catch (that is, excluding discards) across all jurisdictions was 210 t in 2013.

Industry members have reported signs of increasing availability of School Shark, and that School Shark are becoming harder to avoid⁵. This is supported by preliminary survey work currently being conducted by the Institute for Marine and Antarctic Studies in pupping areas adjacent to Tasmania. The results are consistent with the 2009 stock assessment³, which suggested that adult biomass levels have stabilised or begun recovering. The results are also consistent with the 2012 stock assessment model results, which predict that rebuilding is likely to be occurring and that catches of 250 t or less would allow rebuilding, provided that gear selectivity and spatial and temporal distribution of catches remain similar to those in 2011. However, there is uncertainty around the rebuilding projections, resulting from uncertainty in assumptions relating to gear selectivity, and spatial and temporal distribution of catches in the 2012 assessment. It is therefore uncertain whether the total School Shark mortality (state and Commonwealth catches plus discards) is restricted to a level that will allow rebuilding. The above evidence indicates that it is uncertain whether the current level of fishing pressure is adequately controlled to allow the stock to recover from its recruitment overfished state⁷. Measurable improvements in biomass are yet to be detected.

On the basis of the evidence provided above, the biological stock is classified as an **overfished stock**.

Table 2: School Shark biology^{8–11}

Longevity and maximum size	50 years; ~1750 mm TL, 32.5 kg
Maturity (50%)	12–16 years; mean length at female maturity and pupping are 1240 and 1420 mm, respectively

TL = total length

Figure 1: Distribution of reported commercial catch of School Shark in Australian waters, 2013 (calendar year)

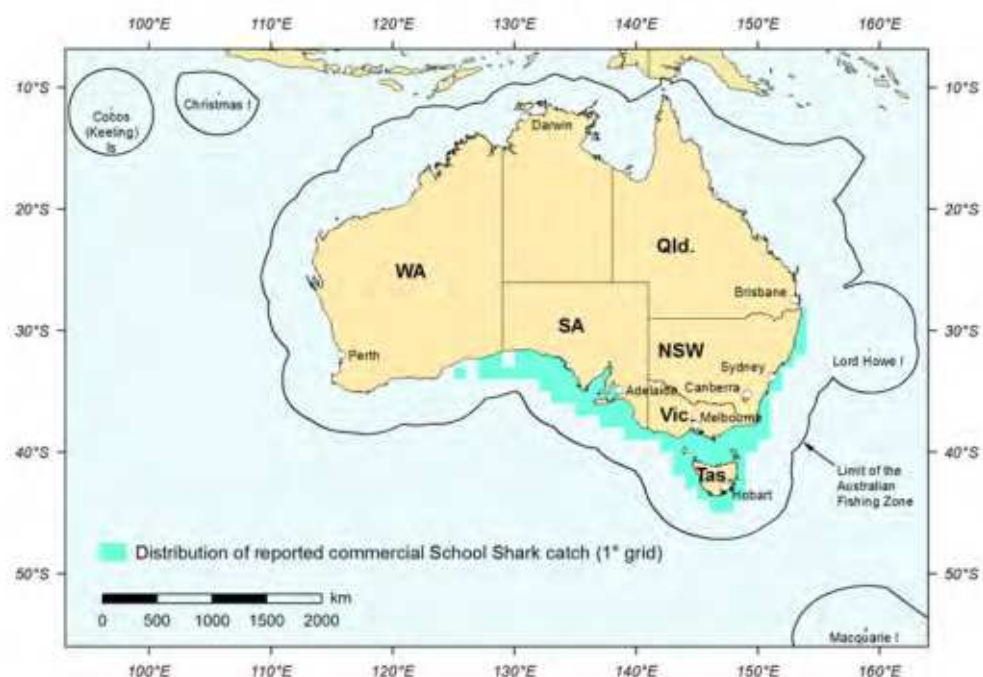


Table 3: Main features and statistics for School Shark fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth ^a	New South Wales ^b	Victoria	Tasmania	South Australia	Western Australia
Fishing methods						
Commercial						
Demersal gillnet	✓	✓	✓	✓		✓
Demersal longline	✓	✓	✓	✓	✓	
Dropline	✓		✓		✓	
Mechanised hand line	✓		✓			
Auto-longline	✓					
Hand line		✓			✓	
Ocean trawl		✓				

Jurisdiction	Commonwealth ^a	New South Wales ^b	Victoria	Tasmania	South Australia	Western Australia
Recreational ^c						
Rod and line		✓	✓	✓	✓	✓
Demersal longline				✓		
Gillnet				✓		
Indigenous ^{d,e}						
		Unknown		Unknown	Unknown	Unknown
Management methods						
Commercial						
Limited entry	✓	✓	✓		✓	✓
Gear restrictions	✓	✓	✓		✓	✓
Spatial closures	✓		✓	✓		✓
Total allowable catch	✓					
Individual transferable quotas	✓					
Effort limits (individual transferable effort)			✓			✓
Possession restrictions				✓		✓
Processing restrictions	✓	✓			✓	✓
Trip limits			✓	✓	✓	
Size limits	✓	✓	✓	✓	✓	
Recreational ^c						
Bag limits			✓	✓	✓	✓
Size limits		✓	✓	✓	✓	
Spatial closures			✓	✓		

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SCHOOL SHARK

Jurisdiction	Commonwealth ^a	New South Wales ^b	Victoria	Tasmania	South Australia	Western Australia
Indigenous ^{d,e,f,g}						
Bag limits		✓			✓	
Size limits					✓	
Gear restrictions		✓				
Section 37(1)(c1), Aboriginal cultural fishing authority		✓				
Active vessels						
	68 in SESSF (SGSHS)	13 in EGF 1 in EPTF 1 in OHF 15 in OTF 8 in OTLF	13 in OF	10 in SF	0 in LACF 54 in MSF	1 in JASDGDLF
Catch						
Commercial	191 t in SESSF (SGSHS)	0.6 t in EGF <0.01 t in EPTF 0.01 t in OHF 2.1 t in OTF 0.3 t in OTLF	0.6 t in OF	1 t in SF	0 t in LACF 12 t in MSF	0.5 t in JASDGDLF
Recreational ^c		Unknown	Unknown	Unknown	9.9 t (2007–08) ¹²	Negligible catches from boats ¹³ Shore-based catches are unknown
Indigenous ^{d,e}		Unknown	None	Unknown	Unknown	Unknown but likely to be negligible

Markets						
Domestic	✓	✓	✓	✓	✓	✓
Export						

EGF = Estuary General Fishery (New South Wales); EPTF = Estuary Prawn Trawl Fishery (New South Wales); JASDGLF = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Western Australia); LACF = Lakes and Coorong Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); OF = Ocean Fishery (Victoria); OHF = Ocean Haul Fishery (New South Wales); OTF = Ocean Trawl Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales); SESSF (SGSHS) = Southern and Eastern Scalefish and Shark Fishery – Shark Gillnet and Shark Hook Sectors (Commonwealth); SF = Scalefish Fishery (Tasmania)

a Data for the Commonwealth are for the SESSF 2013–14 fishing season (1 May 2013 – 30 April 2014).

b Data for New South Wales are for the 2013–14 financial year.

c The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

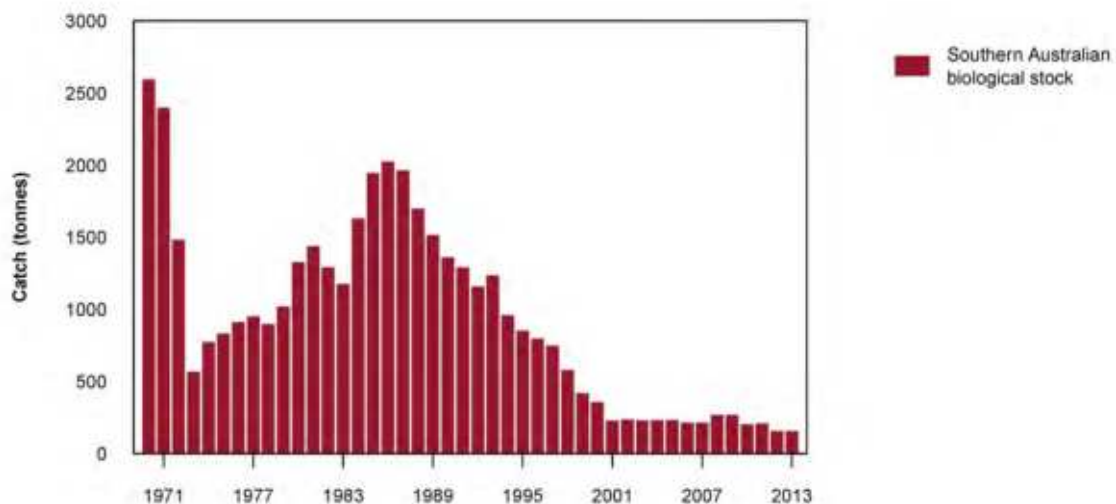
d The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

e In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access School Shark.

f The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

g The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of School Shark in Australian waters, 1970 to 2013 (calendar years)



Note: records of School Shark catch are unavailable for Victoria, New South Wales and Queensland for the period 1970–1999

Effects of fishing on the marine environment

- Interactions with marine mammals (Australian Sea Lions, Australian Fur Seals, New Zealand Fur Seals and dolphins) in some gillnet fisheries continue to be an issue. Mitigation actions that have been implemented include spatial closures, increased monitoring, and implementation of the Australian Sea Lion Management Strategy¹⁴ and Dolphin Strategy¹⁵.
- Dolphin interactions in the Commonwealth gillnet sector of the SESSF Gillnet, Hook and Trap Sector have recently been identified as an issue, based on the increased monitoring associated with managing interactions with Australian Sea Lions¹⁴. The Australian Fisheries Management Authority has closed areas where most interactions occur and increased observer coverage to 100 per cent in adjacent areas. These management measures were revised through the Dolphin Strategy for the 2014–15 fishing season¹⁵.
- Offal management strategies, introduced in April 2011 include requirements for gillnet operators to remove any biological materials from nets before they are set. This has been effective in reducing seabird interactions in other fisheries¹⁴.
- The use of auto-longlines in the SESSF Gillnet Hook and Trap Sector has raised concerns about the potential for interactions with seabirds, including albatrosses and shearwaters¹⁶. New measures have been implemented to assist industry to meet the Seabird Threat Abatement Plan¹⁷ and Performance Criteria¹⁸.
- Demersal gillnets are known to interact with a number of threatened and protected species, including marine mammals and seabirds, in areas of Western Australia where they are used to catch School Shark. However, such interactions occur at a very low frequency and have been assessed as posing low to negligible risks to these populations¹⁹.
- Recent analysis of potential changes in ecosystem structure of finfish in the South and West Coast Bioregions of Western Australia found no evidence of systematic changes in species diversity, richness or trophic index, indicating that the Western Australian fisheries are not having a material impact on the food chain or trophic structure in these regions²⁰.
- The demersal gillnets used to catch School Shark in Western Australia are deployed infrequently over a small proportion of the target fisheries' operational area. Under normal circumstances, the physical impact of the gear on the benthic habitat is minimal¹⁹.

Environmental effects on School Shark

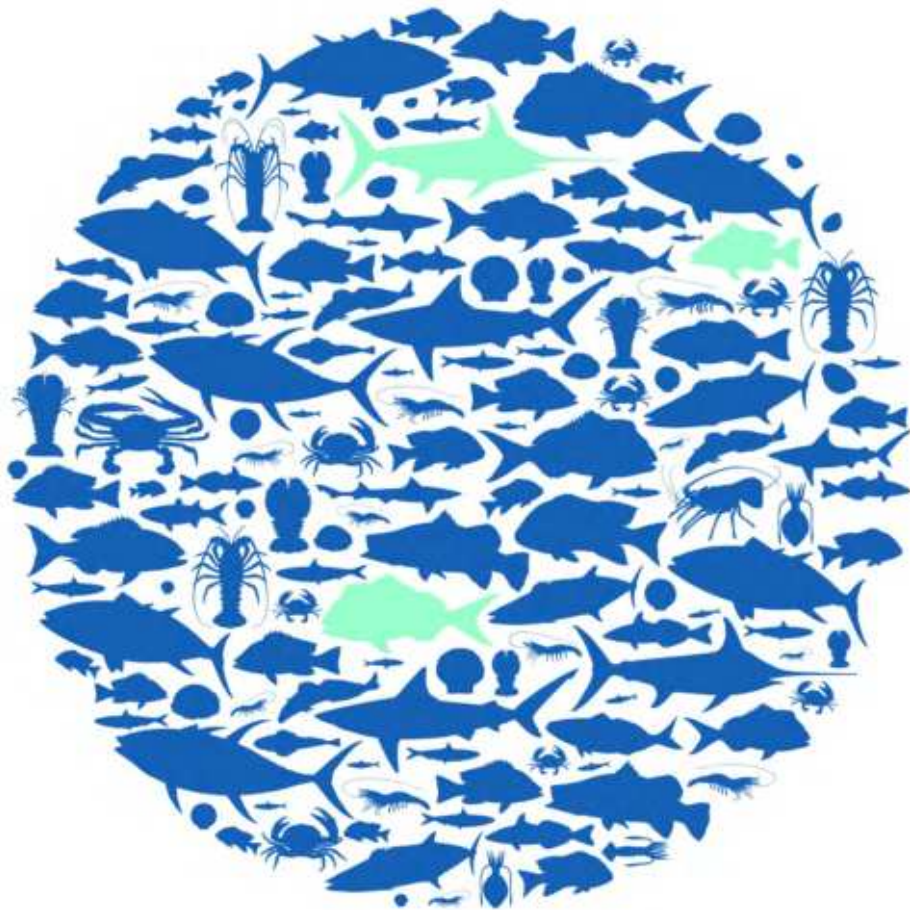
- Sea level rise and changes in sea temperature associated with climate change may negatively affect the School Shark biological stock because the habitats that School Shark use as nursery and feeding grounds are potentially prone to such effects²¹.

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Finfish



30. Australian Salmon *Arripis trutta*, *A. truttaceus*

John Stewart^a, Anthony Fowler^b, Jeremy Lyle^c, James Andrews^d and Kim Smith^e



Eastern Australian Salmon (*Arripis trutta*)

Table 1: Stock status determination for Eastern Australian Salmon

Jurisdiction	New South Wales, Tasmania, Victoria
Stock	Eastern Australian (CIF, GLF, OF, OHF, OPSF, PPBF, SF)
Stock status	
	Sustainable
Indicators	Catch, catch rates

CIF = Corner Inlet Fishery (Victoria); GLF = Gippsland Lakes Fishery (Victoria); OF = Ocean Fishery (Victoria); OHF = Ocean Hauling Fishery (New South Wales); OPSF = Ocean Purse Seine Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SF = Scalefish Fishery (Tasmania)

a Department of Primary Industries, New South Wales
b South Australian Research and Development Institute
c Institute for Marine and Antarctic Studies, University of Tasmania
d Department of Environment and Primary Industries, Victoria
e Department of Fisheries, Western Australia

Table 2: Stock status determination for Western Australian Salmon

Jurisdiction	South Australia, Victoria, Western Australia
Stock	Western Australian (CIF, GLF, LACF, MF, MSF, NZRLF, OF, OPSF, PPBF, SCSF, SWCSF, SZRLF)
Stock status	Sustainable
Indicators	Catch, catch rates

CIF = Corner Inlet Fishery (Victoria); GLF = Gippsland Lakes Fishery (Victoria); LACF = Lakes and Coorong Fishery (South Australia); MF = Miscellaneous Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); NZRLF = Northern Zone Rock Lobster Fishery (South Australia); OF = Ocean Fishery (Victoria); OPSF = Ocean Purse Seine Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SCSF = South Coast Salmon Managed Fishery (Western Australia); SWCSF = South West Coast Salmon Managed Fishery (Western Australia); SZRLF = Southern Zone Rock Lobster Fishery (South Australia)

Stock structure

There are two species of Australian Salmon: Eastern Australian Salmon (*Arripis trutta*) and Western Australian Salmon (*A. truttaceus*). Each species represents a single biological stock. The Eastern Australian Salmon biological stock is distributed from southern Queensland down the east coast of Australia to western Victoria and Tasmania. The Western Australian Salmon biological stock is distributed from Kalbarri in Western Australia southwards to South Australia, Victoria and the west coast of Tasmania. Both species have spawning areas that allow eggs and larvae to be dispersed by the prevailing currents—southwards by the East Australian Current (Eastern Australian Salmon), and southwards and then eastwards by the Leeuwin Current (Western Australian Salmon). The fish then grow and mature before moving back towards their spawning areas, which occur at the northern (up-current) parts of their distributions.

Stock status

Eastern Australian Salmon biological stock

The Eastern Australian Salmon cross-jurisdictional biological stock has components in New South Wales, Tasmania and Victoria. Each jurisdiction assesses that part of the biological stock that occurs in its waters. The status presented here for the entire biological stock has been established using evidence from all jurisdictions.

For the New South Wales part of the biological stock, commercial landings are influenced largely by market demands. Annual landings have varied substantially since the mid-1990s in response to these demands. Catch rates (median catch per day hauling) have increased steadily during the past decade. The size and age compositions of fish in commercial landings have remained similar since the late 1970s¹. The above evidence indicates that the biomass of this part of the stock is unlikely to be recruitment overfished. Australian Salmon in northern New South Wales are lightly fished commercially because fishing in this area is restricted to servicing of the commercial bait market, with an annual catch limit of 224 tonnes (t) in place. Estimates of overall fishing mortality are similar to estimates of natural mortality¹. The above evidence indicates that the current level of fishing pressure is unlikely to cause this part of the stock to become recruitment overfished.

For the Victorian part of the biological stock, commercial landings have varied between 300 and 700 t annually, with a peak during the mid-2000s. The annual catch in 2013 was relatively low (235 t) compared with the previous year (more than 730 t). The most recent assessment of this part of the stock indicates that, until 2011, there was little change in the size and age composition of fish in landings¹. Little information is available after this time. However, the fishery continues to target mainly adolescent fish, and the level of effort has remained steady. This evidence indicates that the Victorian part of the Eastern Australian Salmon biological stock is unlikely to be recruitment overfished and that the current level of fishing pressure by the Victorian fishery is unlikely to cause this part of the biological stock to become recruitment overfished.

For the Tasmanian part of the biological stock, the most recent assessment investigated catches up to 2012². Biomass was not estimated in this assessment. Although catches are at an all-time minimum, catch per unit effort remains high; the low catches are a result of a decline in effort, driven by decreased demand for Southern Rock Lobster bait². The above evidence indicates that the biomass of this part of the stock is unlikely to be recruitment overfished. In Tasmania, Eastern Australian Salmon are landed by a large number of vessels using a variety of methods. However, more than 80 per cent of landings are by beach-seine vessels, and therefore the fishing patterns of these vessels dictate the catch patterns. The above evidence indicates that the current level of fishing pressure is unlikely to cause this part of the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Western Australian Salmon biological stock

The Western Australian Salmon cross-jurisdictional biological stock has components in South Australia, Victoria and Western Australia. Each jurisdiction assesses that part of the biological stock that occurs in its waters. The status presented here for the entire biological stock has been established using evidence from all jurisdictions.

In Western Australia, total commercial landings have declined since the mid-1990s, with the strongest declines since 2004³. Since 2004, fishing effort has followed a similar downward trend, as a result of weak market demand and low wholesale prices (landings in Western Australia are mainly sold as bait). These catch and effort declines mainly reflect changes in the south coast fishery, where the majority of annual landings occur. Total commercial fishing effort directed towards Australian Salmon in Western Australia is currently very low compared with historical levels, and the reduction in effort accounts for much of the catch decline since 2004. However, a decline in commercial catch rate, and anecdotal reports from commercial and recreational fishers suggest a possible decline in stock abundance over the past decade that may also have contributed to the catch decline. Pronounced ocean warming around south-western Australia, and changes in the strength and seasonality of the Leeuwin Current over the past decade are among the environmental factors that may have negatively impacted on the breeding success of Australian Salmon, and resulted in a lower stock level. Fishery-independent monitoring annually since 1996 in Western Australia, and from 1981 to 2000 in South Australia has confirmed highly variable recruitment by this species, with variations in recruitment associated with fluctuations in the Leeuwin Current³⁻⁵. Despite the possibility of low stock abundance at present, the Western Australian recruitment index was relatively high in 2013, suggesting that the breeding stock level was adequate to maintain recruitment. The above evidence indicates that the biomass of this part of the stock is unlikely to be recruitment overfished. Very low levels of fishing effort are currently directed towards Western Australian Salmon across all jurisdictions. The above evidence indicates that the current level of fishing pressure is unlikely to cause this part of the stock to become recruitment overfished.

For the South Australian part of the biological stock, total commercial landings have declined markedly since the mid-1990s. However, commercial effort has declined similarly. The current commercial fishing effort directed towards Western Australian Salmon in South Australia is very low compared with historical levels, and, although variable, catch rates have not decreased⁶. This evidence indicates that the South Australian part of the Western Australian Salmon biological stock is unlikely to be recruitment overfished and that the current level of fishing pressure by the South Australian fishery is unlikely to cause this part of the biological stock to become recruitment overfished.

For the Victorian part of the biological stock, total commercial landings are very low compared with those in other states and compared with landings of Eastern Australian Salmon in Victoria. The low commercial landings of Western Australian Salmon relative to the catches taken by other jurisdictions indicate that the current level of fishing pressure by the Victorian fishery is low. This evidence indicates that the Victorian part of the Western Australian Salmon biological stock is unlikely to be recruitment overfished and that the current level of fishing pressure by the Victorian fishery is unlikely to cause this part of the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 3: Eastern (*Arripis trutta*) and Western (*A. truttaceus*) Australian Salmon biology^{1,7}

Longevity and maximum size	Eastern Australian Salmon: 12 years; 810 mm FL Western Australian Salmon: 12 years; 850 mm FL
Maturity (50%)	Eastern Australian Salmon: 2–4 years; 300–400 mm FL Western Australian Salmon: 3–5 years; 600–650 mm FL

FL = fork length

Figure 1: Distribution of reported commercial catch of Australian Salmon (both species) in Australian waters, 2013 (calendar year)

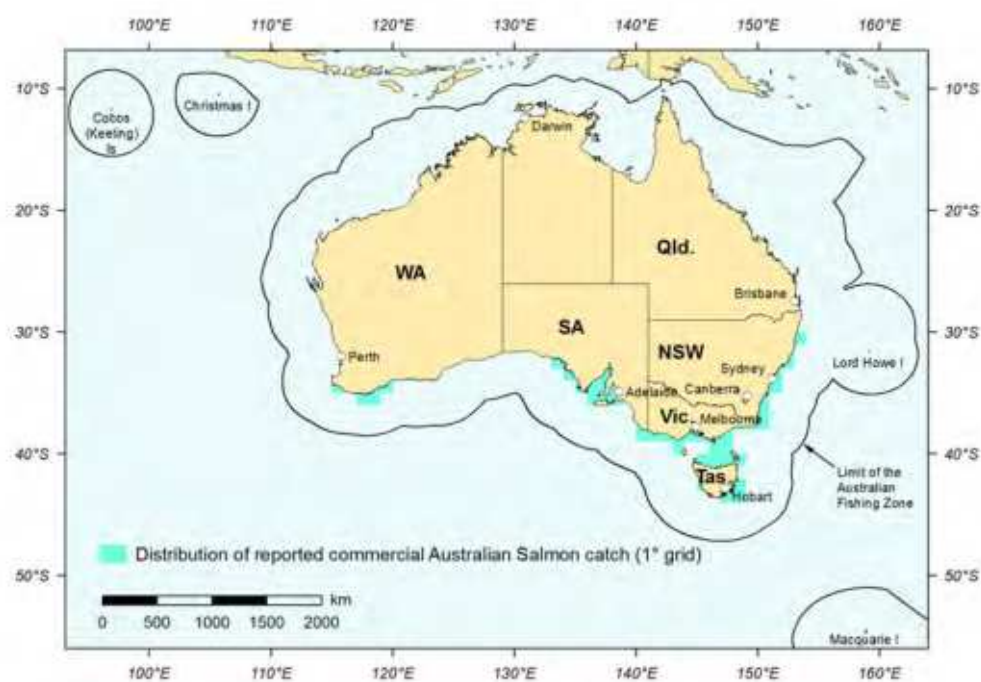


Table 3: Main features and statistics for Australian Salmon fisheries in Australia, 2013 (calendar year)

Jurisdiction	New South Wales	Victoria	Tasmania	South Australia	Western Australia
Fishing methods					
Commercial					
Purse-seine nets	✓	✓	✓	✓	
Beach-seine nets	✓	✓	✓		✓
Gillnet		✓	✓	✓	
Ring nets		✓		✓	
Trolling				✓	

Jurisdiction	New South Wales	Victoria	Tasmania	South Australia	Western Australia
Recreational					
Rod and line	✓	✓	✓	✓	✓
Gillnet			✓		
Indigenous					
Rod and line	✓				
Management methods					
Commercial					
Limited entry	✓	✓	✓	✓	✓
Gear restrictions	✓	✓	✓	✓	✓
Size limits		✓	✓	✓	
Trip limits	✓				
Spatial zoning	✓				✓
Vessel restrictions					✓
Recreational					
Bag limits	✓	✓	✓	✓	✓
Size limits		✓	✓	✓	✓
Gear restrictions	✓	✓	✓	✓	✓
Spatial closures	✓	✓	✓		✓
Licensing					✓ (boat based)
Indigenous ^{a-d}					
Bag limits	✓		✓		✓
Size limits			✓		✓
Spatial closures	✓				
Gear restrictions	✓				
Section 37(1)(c1), Aboriginal cultural fishing authority	✓				

Jurisdiction	New South Wales	Victoria	Tasmania	South Australia	Western Australia
Gillnet restrictions			✓		
Licensing					✓ (boat based)
Active vessels					
	127 in OHF	18 in CIF 9 in GLF 13 in OF and OPSF combined 31 in PPBF	37 in SF	2 in LACF 1 in MF 68 in MSF 2 in NZRLF 4 in SZRLF	7 in SCSF 2 in SWCSF
Catch					
Commercial	841 t in OHF	20.8 t in CIF 2.9 t in GLF 305.4 t in OF and OPSF combined 28.3 t in PPBF	236 t in SF	0.02 t in LACF 5 t in MF 54 t in MSF 0.4 t in NZRLF 0.1 t in SZRLF	138 t in SCSF 93 t in SWCSF
Recreational	181 t ^a (NRIFS in 2000–01)	Unknown	48.1 t (2007–08)	91 t ^b (2007–08)	11 t ¹⁰ (boat-based sector only ^e)
Indigenous	Unknown	None	Unknown	Unknown	Unknown
Markets					
Domestic	✓	✓	✓	✓	✓
Export					

CIF = Corner Inlet Fishery (Victoria); GLF = Gippsland Lakes Fishery (Victoria); LACF = Lakes and Coorong Fishery (South Australia); MF = Miscellaneous Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); NRIFS = National Recreational and Indigenous Fishing Survey; NZRLF = Northern Zone Rock Lobster Fishery (South Australia); OF = Ocean Fishery (Victoria); OHF = Ocean Hauling Fishery (New South Wales); OPSF = Ocean Purse Seine Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SCSF = South Coast Salmon Managed Fishery (Western Australia); SF = Scalefish Fishery (Tasmania); SWCSF = South West Coast Salmon Managed Fishery (Western Australia); SZRLF = Southern Zone Rock Lobster Fishery (South Australia)

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Australian Salmon.

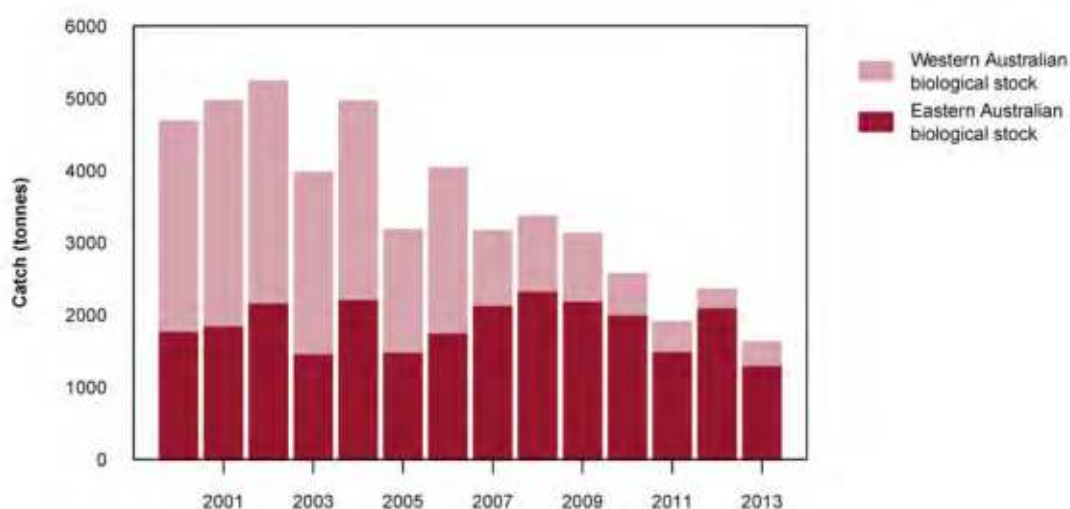
b The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

c The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

d Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

e Western Australian boat-based recreational catch from 1 March 2011 to 29 February 2012¹⁰

Figure 2: Commercial catch of Australian Salmon in Australian waters, 2001 to 2013 (calendar years)



Effects of fishing on the marine environment

- The fishing methods used to target Australian Salmon around Australia are highly selective and targeted. As a result, there is little bycatch in these fisheries^{1,3}.

Environmental effects on Australian Salmon

- The life cycles of Eastern and Western Australian Salmon are strongly linked to the prevailing currents throughout their distributions. The East Australian, Leeuwin and Capes currents appear to influence the distribution of spawning, larval dispersal, the strength and distribution of juvenile recruitment, and the distribution of fishery landings^{3,5}. Environmentally driven changes to these currents may affect recruitment, and the distribution and abundance of both species.

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31. Australian Sardine *Sardinops sagax*

Tim Ward^a, Brett Molony^b, John Stewart^c, James Andrews^d and Andy Moore^e



Table 1: Stock status determination for Australian Sardine

Jurisdiction	Commonwealth, New South Wales, Victoria	South Australia, Victoria	Western Australia	
Stock	Eastern Australia (NSWOHF, OPSF, SPF)	Southern Australia (PPBF, SASF)	Western Australia west coast (WCPF)	Western Australia south coast (SCPF)
Stock status				
	Sustainable	Sustainable	Sustainable	Sustainable
Indicators	Spawning biomass, exploitation rate,	Exploitation rate, catch data	Biomass, fishing mortality	Catch

NSWOHF = New South Wales Ocean Hauling Fishery; OPSF = Ocean Purse Seine Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SASF = South Australian Sardine Fishery; SCPF = South Coast Purse-seine Fishery (Western Australia); SPF = Small Pelagic Fishery (Commonwealth); WCPF = West Coast Purse-seine Fishery (Western Australia)

Stock structure

There is a growing consensus that, for the purposes of fisheries management, the Australian Sardine population comprises four separate biological stocks^{1,2}. Bass Strait effectively separates the biological stocks that occur off eastern and southern Australia³. A single biological stock occurs off South Australia and western Victoria². A further two separate biological stocks occur off the south and west coasts of Western Australia^{1,4}. As stock delineation is known for this species, reporting of status is undertaken at the level of individual biological stocks.

Stock status

The maximum sustainable yield for species at a low trophic levels (forage species), such as Australian Sardine, is typically achieved at a depletion level of approximately 60 per cent, equivalent to 40 per cent of unfished biomass⁵. However, harvest strategies for fisheries for these species also need to consider potential impacts on biodiversity, and ecosystem structure and function^{6,7}. Biomasses above 75 per cent of the unfished level have been identified as a global average for achieving a balance between protecting ecosystem function and biodiversity, and providing for food production and economic development of low-trophic level species⁵. However, the south-east Australian ecosystem, including the Great Australian Bight, has been shown to be less sensitive to harvesting of low-trophic level species than other systems worldwide⁵. A recent study using

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^c Department of Primary Industries, New South Wales

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^e Australian Bureau of Agricultural and Resource Economics and Sciences

ecosystem models suggests that maintaining biomasses of small pelagic fishes above 50 per cent of the unfished level will maintain the biodiversity and health of Australia's marine ecosystems⁸. Management strategy evaluations suggest that exploitation rates of less than about 30 per cent maintain the spawning biomass of Australian Sardine above 50 per cent of the unfished level⁸.

Low-trophic level species often undergo large fluctuations in abundance over a variety of spatial and temporal scales. For example, two mass mortality events in the 1990s, caused by Herpesvirus, each killed up to 70 per cent of the adult population of Australian Sardine^{1,9,10}. As well, considerable time and resources are required to develop robust estimates of biomass, and undertake the population modelling required to obtain the estimates of current and virgin biomass that are needed to estimate levels of depletion. For these reasons, performance indicators that relate to levels of depletion of unfished biomass have not been established for Commonwealth and state fisheries for Australian Sardine during their developmental phases^{11,12}. Instead, exploitation rates (that is, catch as a proportion of spawning biomass), based on estimates of spawning biomass obtained using the daily egg production method (DEPM)^{13–15}, have been used as performance indicators for setting total allowable commercial catches. More recently in the South Australian Sardine Fishery, estimates of spawning biomass have also been used as target and limit reference points. However, in the absence of reliable estimates of virgin biomass, it is difficult to relate these indicators to levels of depletion. Ecological performance indicators monitored and modelled in relation to the South Australian Sardine Fishery, combined with recent analyses⁸, suggest that exploitation rates of up to 30 per cent are likely to maintain spawning biomass at levels that take into account the ecological importance of Australian Sardine^{5,6,11,12}.

The information available to assess stock status and the frequency of formal assessments vary among jurisdictions, largely in response to recent catch levels. Catch-and-effort data are monitored annually in all jurisdictions; estimates of spawning biomass have been obtained using the DEPM for each of the four biological stocks; and population modelling has been undertaken for the southern Australian biological stock and the two western Australian biological stocks.

Eastern Australian biological stock

Estimates obtained in 1997, 1998 and 2004 using the DEPM suggest that the spawning biomass of Australian Sardine off eastern Australia is at least 25 000–30 000 tonnes (t)^{16–18}. Catches reached almost 5000 t in 2008–09, but declined to 1097 t in 2012–13 as a result of a reduction in fishing effort; this was partly caused by the destruction of a processing plant in Eden, New South Wales¹⁶. Catches from a vessel operating out of Lakes Entrance in Victoria have increased in recent years. The highest annual catch (approximately 5 t in 2009) was around 17 per cent of the best estimate of spawning biomass (around 29 000 t, based on samples collected in 2004). Recent catches equate to exploitation rates of less than 10 per cent¹⁶. The current level of fishing mortality is unlikely to cause the stock to become recruitment overfished¹⁹.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Southern Australian biological stock

The majority of the catch from the southern Australian stock is taken from South Australia, with much smaller catches from Port Phillip Bay, Victoria. Assessment of the South Australian Sardine Fishery has involved annual and, more recently, biennial DEPM surveys, and population modelling based on spawning biomass estimates, catch and catch-at-age data^{20,21}. The most recent estimate of spawning biomass was around 150 000 t²⁰, which is above the limit reference point of 75 000 t identified in the management plan²¹. The stock is not considered to be recruitment overfished. The current exploitation rate is around 23 per cent (that is, 34 000 t from an estimated spawning biomass of approximately 150 000 t), which is below the upper target reference point of 30 per cent. This exploitation rate is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Western Australia west coast biological stock

Population modelling, based on spawning biomass estimates (estimated using the DEPM), and catch-at-age and catch data²², suggest that exploitation rates since the late 2000s for the Western Australia west coast stock are less than 10 per cent (2328 t from an estimated spawning biomass of approximately 25 000 t)²³. The stock is not considered to be recruitment overfished. This level of fishing mortality is below the limit reference point and is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Western Australia south coast biological stock

Population modelling, based on spawning biomass estimates (estimated using the DEPM), and catch-at-age and catch data²³, suggest that exploitation rates since the late 2000s for the Western Australia south coast stock are around 3 per cent (less than 3000 t from an estimated spawning biomass of approximately 97 000 t)²³. The stock is not considered to be recruitment overfished. This level of fishing mortality is below the limit reference point and is unlikely to cause the stock to become recruitment overfished.

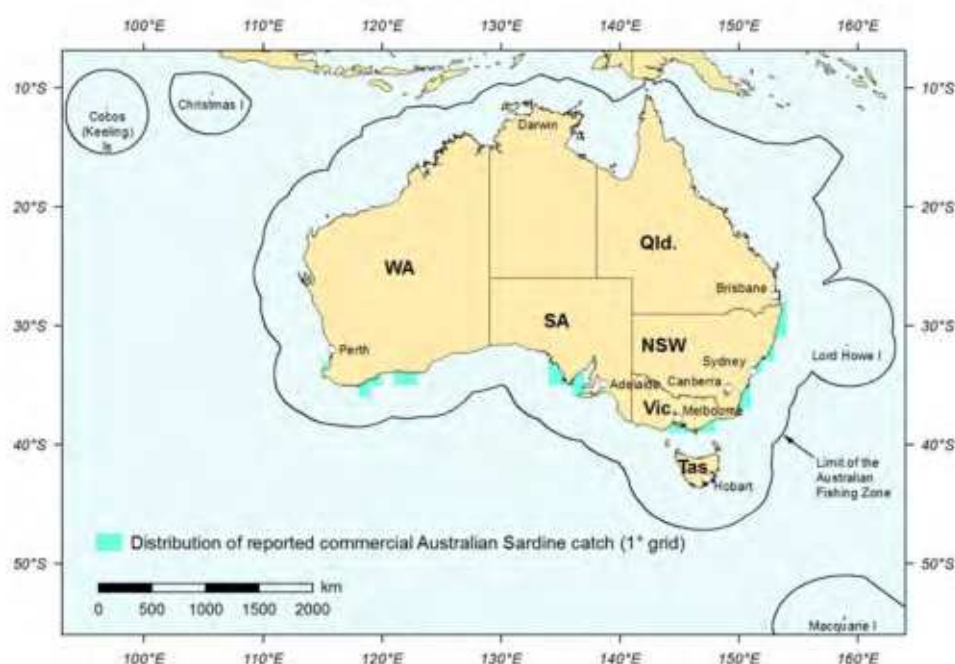
On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Australian Sardine biology^{2,17}

Longevity and maximum size	9 years; 200–250 mm SL
Maturity (50%)	1–2 years; 145 mm SL

SL = standard length

Figure 1: Distribution of reported commercial catch of Australian Sardine in Australian waters, 2013 (calendar year)



Note: Data for the Small Pelagic Fishery (Commonwealth), West Coast Purse-seine Fishery (Western Australia) and South Coast Purse-seine Fishery (Western Australia) are for the 2012–13 financial year. The Western Australian purse-seine fisheries operate over two different seasons; the South Coast Purse-seine Fishery (SCPF) season runs from 1 July to 30 June; the West Coast Purse-seine Fishery season runs from 1 April to 31 March.

Table 3: Main features and statistics for Australian Sardine fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth ^a	New South Wales	Victoria	South Australia	Western Australia ^{a,b}
Fishing methods					
Commercial					
Purse seine	✓	✓	✓	✓	✓
Trawling	✓				
Recreational ^c					
Rod and line		✓			
Indigenous ^d					
Rod and line		✓			
Management methods					
Commercial					
Limited entry	✓	✓	✓	✓	✓
Total allowable catch	✓			✓	✓
Effort limits			✓		✓
Spatial closures		✓			✓
Gear restrictions	✓	✓		✓	
Recreational ^c					
Bag limits		✓			
Spatial closures		✓			
Indigenous ^{d,e,f}					
Bag limits		✓			
Spatial closures		✓			
Section 37(1)(c1), Aboriginal cultural fishing authority		✓			
Active vessels					
	1 in SPF	9 in NSWOF	1 in OPSF 6 in PPBF	14 in SASF	13 in SCPF 2 in WCPF

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
AUSTRALIAN SARDINE

Jurisdiction	Commonwealth ^a	New South Wales	Victoria	South Australia	Western Australia ^{a,b}
Catch					
Commercial	Confidential	352 t in NSWOFH	0.2 t in PPBF	31 981 t in SASF	1983 t in SCPF 16 t in WCPF
Recreational ^c	No catch	Unknown	No catch	No catch	No catch
Indigenous	No catch	Unknown	No catch	Unknown	Unknown
Markets					
Domestic	✓	✓	✓	✓	✓
Export					

NSWOFH = New South Wales Ocean Hauling Fishery; OPSF = Ocean Purse Seine Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SASF = South Australian Sardine Fishery; SCPF = South Coast Purse-seine Fishery (Western Australia); SPF = Small Pelagic Fishery (Commonwealth); WCPF = West Coast Purse-seine Fishery (Western Australia)

a Data for the Small Pelagic Fishery (Commonwealth), West Coast Purse-seine Fishery (Western Australia) and South Coast Purse-seine Fishery (Western Australia) are for the 2012–13 financial year.

b The Western Australia purse-seine fisheries operate over two different seasons. The South Coast Purse-seine Fishery season runs from 1 July to 30 June. The West Coast Purse-seine Fishery season runs from 1 April to 31 March.

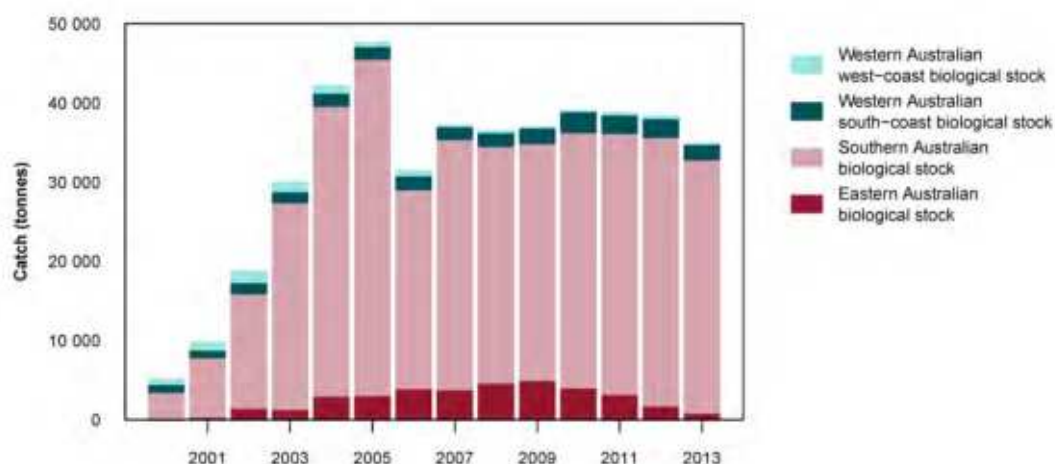
c The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

d The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

e The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

f In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Australian Sardine.

Figure 2: Commercial catch of Australian Sardine in Australian waters, 2000 to 2013 (financial years, except for South Australian Sardine Fishery for which data is provided in calendar years)



Effects of fishing on the marine environment

- The rapid growth of the South Australian Sardine Fishery led to community concerns that taking large catches could change the balance of the ecosystems in South Australia's gulfs and the Great Australian Bight, and potentially affect the region's higher-level marine predators, including Southern Bluefin Tuna (*Thunnus maccoyii*), seabirds and marine mammals. A large study was conducted to investigate the roles of Australian Sardine in the ecosystem and assess the potential ecological impacts of the fishery⁶. Despite the rapid growth of the fishery, negligible impacts were found on any species groups, even though several seabirds (for example, crested terns—*Sterna bergii*) were potentially sensitive to changes in Australian Sardine biomass.
- The South Australian Sardine Fishery was closed for 2 months in 2005 because of high levels of encirclement and mortality of the Short-beaked Common Dolphin (*Delphinus delphis*)²⁴. A Threatened, Endangered or Protected Species Code of Practice was developed during the closure period that outlined procedures for avoiding encirclements and releasing encircled animals²⁵. Interaction rates decreased significantly following the introduction of the code of practice^{24,26}. A working group that includes industry, fisheries managers, scientists and representatives of conservation agencies meets every quarter to review logbook and observer data, and assess the effectiveness of the code of practice in reducing interaction rates. A report on interaction rates and the effectiveness of the code of practice is published annually.
- A code of conduct was established in 2006 to reduce Fleshy Footed Shearwater (*Ardenna carneipes*) interactions in the Western Australian South Coast Purse Seine Fishery²⁷.
- A Purse Seine Code of Practice was established in 2008 by the Commonwealth industry operators that outlined best practice methods for minimising harmful interactions with threatened, endangered and protected species²⁸.

Environmental effects on Australian Sardine

- In 1995 and 1998–99, two mass mortality events each killed more fish, over a larger area, than any other monospecific fish kill ever recorded¹. These events were caused by a herpes virus to which the population had minimal or no immunity²⁹. Rates of recovery have been different between stocks; spawning biomass has increased quickly in the southern Australian stock and more slowly in the two Western Australian stocks^{14,23}.

- Fishers in Western Australia have reported reductions in the availability of large fish on historical fishing grounds in recent years. This may reflect changes in distribution and behaviour associated with warmer oceanic conditions, dredge plumes associated with port expansion, and increases in the abundance of Australian Salmon (*Arripis trutta*) and seabirds³⁰.
- There is a relationship between fish condition and upwelling strength. Recent industry reports of increases in fat content of South Australian Sardines may reflect the occurrence of several strong upwelling seasons over the past few years³¹.

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32. Banded Morwong *Cheilodactylus spectabilis*

Jeremy Lyle^a, Justin Bell^a, Corey Green^b and James Andrews^b



Table 1: Stock status determination for Banded Morwong

Jurisdiction	Tasmania	Victoria
Stock	TBMF	VBMF
Stock status	↓	
	Transitional–depleting	Undefined
Indicators	Catch, effort, CPUE trends, size/age composition	Catch, CPUE

CPUE = catch per unit effort; TBMF = Tasmanian Banded Morwong Fishery; VBMF = Victorian Banded Morwong Fishery

Stock structure

Banded Morwong is large temperate reef fish species that is targeted by gillnets for the domestic live fish trade. The species is distributed around south-eastern Australia, including southern New South Wales, and eastern Victoria and Tasmania, as well as occurring off north-eastern New Zealand. It is relatively common in depths of less than 50 m. There is currently no information available regarding the biological stock structure. However, once settled after a relatively long oceanic larval phase, they show a high degree of site fidelity^{1–3}, suggesting that the exploited Victorian and Tasmanian populations are likely to represent distinct populations. Banded Morwong has therefore been assessed at the management unit level.

Stock status

Tasmanian Banded Morwong Fishery management unit

The most recent assessment⁴ estimates that biomass in 2012–13 was 31 per cent (east coast region) to 44 per cent (south-east coast region) of the unfished (1990) level. Mature biomass has declined steadily since the early 2000s, although the stock is not considered to be recruitment overfished. If fishing pressure was to be kept at historic levels it is likely that this would cause the stock to become recruitment overfished. As a

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result reductions in catch quotas have been progressively applied⁴ to halt the biomass decline, but these reductions have not yet been successful. The above evidence indicates that the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **transitional–depleting stock**.

Victorian Banded Morwong Fishery management unit

The most recent assessment (undertaken in 2012) has not been published because of the limited number of operators and concerns about confidentiality. This work examined catch data from 2002 to 2012 and concluded that there was a clear downward trend in biomass since the mid-2000s. The standardised catch per unit effort may have fallen by up to 48 per cent from the peak. However, data from only two operators contributes to high levels of uncertainty. The total catch is currently less than 2 tonnes per year (catches are now limited to 625 fish per operator); some fish are also landed as byproduct from the Victorian Ocean Fishery. Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Table 2: Banded Morwong biology^{5,6}

Longevity and maximum size	96 years; 578 mm FL ^a
Maturity (50%)	2.5 years; 320 mm FL

FL = fork length

^a Maximum length is the maximum recorded from >2300 fish measured during on-board observation and research fishing⁷.

Figure 1: Distribution of reported commercial catch of Banded Morwong in Australian waters, 2013 (calendar year)

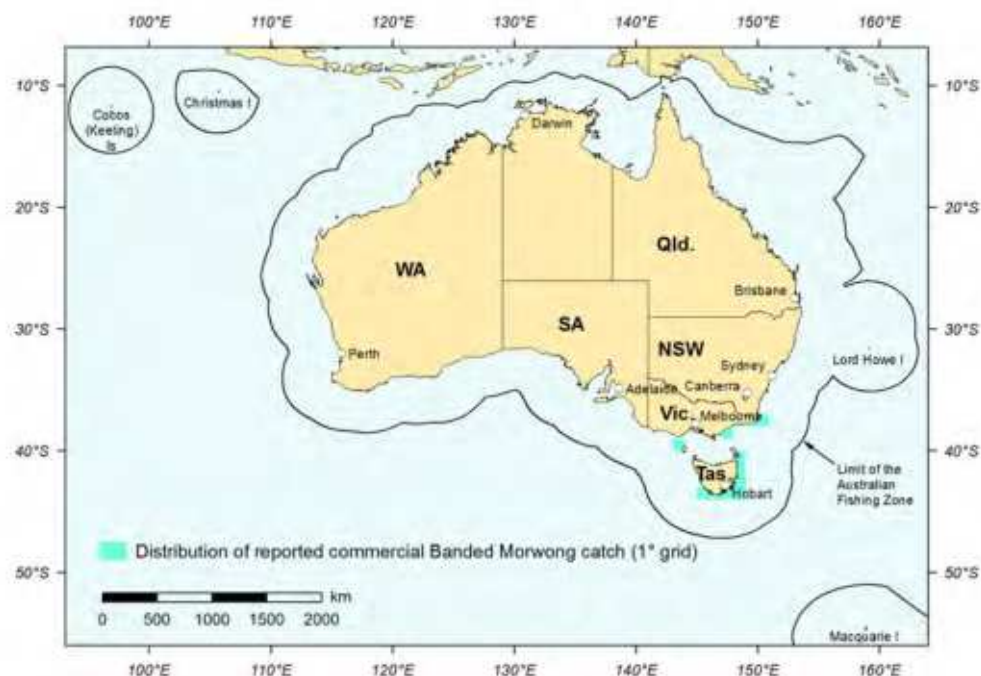


Table 3: Main features and statistics for Banded Morwong fisheries in Australia, 2013 (calendar year)

Jurisdiction	Tasmania	Victoria
Fishing methods		
Commercial		
Gillnet	✓	✓
Recreational		
Gillnet	✓	
Diving (spearfishing)	✓	✓
Indigenous ^a		
	None	
Management methods		
Commercial		
Limited entry	✓	✓
Size limits	✓ (lower and upper)	✓
Gear restrictions	✓	✓
Total allowable catch	✓	✓
Effort limits	✓	✓
Spatial closures		✓
Seasonal closures	✓	✓
Recreational		
Bag limits	✓	✓
Size limits	✓ (lower and upper)	✓
Seasonal closures	✓	✓
Indigenous ^a		
Customary fishing permits		✓
Active vessels		
	27 in TBMF	2 in VBMF

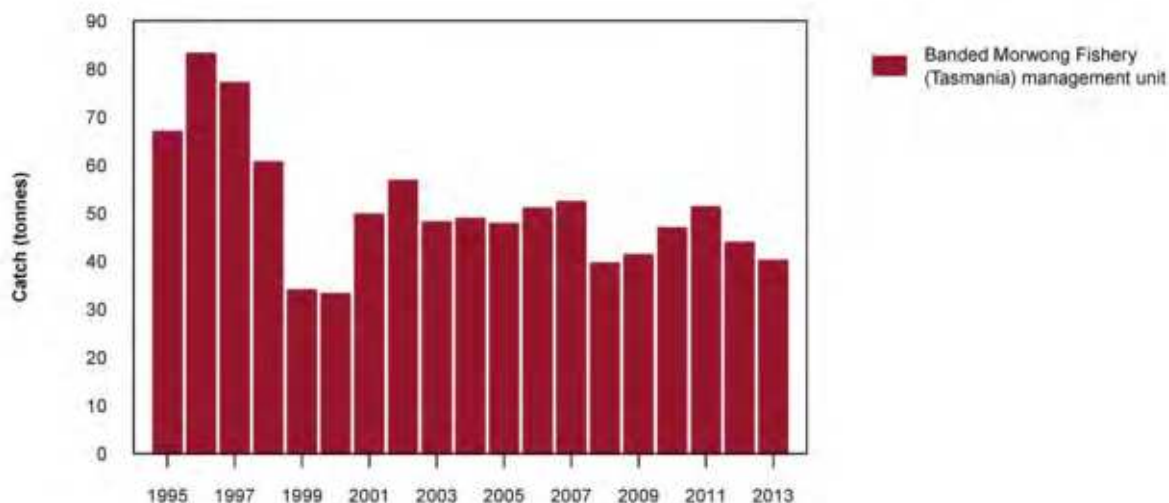
Jurisdiction	Tasmania	Victoria
Catch		
Commercial	40.1 t in TBMF	Confidential ^b
Recreational	1.6 t (2010)	Unknown
Indigenous	None	Nil
Markets		
Domestic	✓	✓
Export		

TSF = Tasmanian Banded Morwong Fishery; VBMF = Victorian Banded Morwong Fishery

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Banded Morwong.

b Data cannot be reported due to confidentiality clauses when fewer than five fishers are operating within a given fishery.

Figure 2: Commercial catch of Banded Morwong in Tasmanian waters, 1995 to 2013 (calendar years)



Note: Victorian catch could not be provided because of confidentiality clauses when fewer than five fishers are operating within a given fishery.

Effects of fishing on the marine environment

- Banded Morwong are solely targeted by fishers using large mesh gillnets. Nearly 100 species are taken as bycatch or byproduct, including threatened, endangered and protected species that include seabirds, marine mammals and syngnathids (seahorses and pipefishes), albeit in very low quantities⁷.
- The fish bycatch is dominated by four species: Draughtboard Shark (*Cephaloscyllium laticeps*), Marblefish (*Aplodactylus arctidens*), Bluethroat Wrasse (*Notolabrus tetricus*) and Longsnout Boarfish (*Pentaceropsis recurvirostris*). All but one of these (Bluethroat Wrasse) display high post-release survival⁷.
- When targeting Banded Morwong, gillnets occasionally interact with sessile invertebrates, typically sea tulips (*Pyura* spp.) and macro-algae, although such interactions very rarely result in entire organisms being dislodged⁷.

Environmental effects on Banded Morwong

- The impact of environmental factors on Banded Morwong stocks is unknown. However, there is evidence that ocean warming is affecting growth at the northern extreme of the distribution⁸. Banded Morwong have a 6–9-month oceanic larval phase, and there is potential for changing oceanographic patterns to lead to increased variability in recruitment success. Since the Tasmanian fishery is now heavily reliant on newly recruited fish⁴, and hence recruitment success, this will need to be monitored closely. Further, the formation of reef barrens due to algal grazing by the Long-spined Sea Urchin (*Centrostephanus rodgersii*) in both Victorian and Tasmanian waters, a phenomenon that is linked to climate change⁹, represents a potential threat for Banded Morwong populations through the reduction of suitable reef habitat.

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33. Barramundi *Lates calcarifer*

Thor Saunders^a, Stephen Newman^b and Olivia Whybird^c



Table 1: Stock status determination for Barramundi

Jurisdiction	Northern Territory	Western Australia
Stock	BF	KGBMF
Stock status		
	Sustainable	Sustainable
Indicators	Catch, CPUE, length and age frequencies, harvest rate	Catch, CPUE

BF = Barramundi Fishery (Northern Territory); CPUE = catch per unit effort; KGBMF = Kimberley Gillnet and Barramundi Managed Fishery (Western Australia)

a Department of Primary Industry and Fisheries, Northern Territory
b Department of Fisheries, Western Australia
c Department of Agriculture, Fisheries and Forestry, Queensland

Table 1 continued

Jurisdiction	Queensland						
Stock	Southern Gulf of Carpentaria (GOCIFFF)	Northern Gulf of Carpentaria (GOCIFFF)	Princess Charlotte Bay (ECIFFF)	North-east coast (ECIFFF)	Mackay (ECIFFF)	Central east coast (ECIFFF)	South-east coast (ECIFFF)
Stock status							
	Sustainable	Sustainable	Sustainable	Sustainable	Sustainable	Sustainable	Negligible ^a
Indicators	Catch, length and age frequencies, mortality rates	Catch	Catch	Catch, length and age frequencies, mortality rates	Catch, CPUE	Catch, length and age frequencies	Catch

CPUE = catch per unit effort; ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); GOCIFFF = Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland)

a 'Negligible' means historically low catch; no stock status. There was no catch from the south-east coast in 2013: in the past 10 years, the average catch from this biological stock was 769 kg.

Stock structure

Separate biological stocks of Barramundi exist at the scale of individual catchments across northern Australia^{1,2}. However, the difficulty in obtaining relevant biological and catch-and-effort information to assess each individual biological stock has meant that Barramundi have been assessed as two separate management units (Northern Territory and Western Australia) and seven genetic biological stocks (Queensland: Southern Gulf of Carpentaria, Northern Gulf of Carpentaria, Princess Charlotte Bay, north-east Coast, Mackay, central east coast and south-east coast). The assessments of the management units are based on the biological stocks that receive the highest harvest rates, whose status is assumed to be representative of the highest level of exploitation that occurs on any biological stock within each unit. In Queensland, many catchments are stocked with fingerlings, particularly on the east coast. However, stocking is with fish from hatcheries using parents from the same genetic stock, so it is unlikely that this process has compromised the above stock structure.

Stock status

Barramundi Fishery (Northern Territory) management unit

Commercial catches in the Barramundi Fishery (Northern Territory) are stable and well within historical levels, and monitored stocks have a healthy size and age distribution³. Catch rates have increased over the past 5 years. However, there was a substantial decrease in the 2013 rate, associated with a poor wet season and several experienced operators selling their licences. Recaptures from tagging programs suggest that the annual harvest rate from all sectors combined is consistently below 5 per cent. Abundance surveys indicate high levels of recruitment during high-rainfall wet seasons³. The above evidence indicates that the stocks in this management unit are unlikely to be recruitment overfished and that current catch levels are unlikely to cause the stocks to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Kimberley Gillnet and Barramundi Managed Fishery (Western Australia) management unit

The harvest strategy for Barramundi in the Kimberley Gillnet and Barramundi Managed Fishery in the Kimberley region of Western Australia is based on a constant commercial catch policy where the annual commercial catches of Barramundi are allowed to vary within the target catch range, which is based on a historical catch range that has been shown not to impair recruitment. The threshold values have been calculated as being within the range 33–44 tonnes (t), with a limit reference range of 23–54 t⁴.

The Barramundi catch in 2013 was 52.1 t, above the target catch range but below the limit range. The increase in catch was due to an increase in fishing effort in two sectors of the fishery (the Kimberley Coast and Broome). The increased catch was obtained with high catch rates (kg/block day) across the fishery, indicating that it was not a direct result of a declining stock biomass for Barramundi. Furthermore, in 2013, two licences were removed from the Broome sector of the fishery⁴, which is now only open to recreational and Indigenous fishing. This effort removal is likely to reduce levels of catch in future years. The above evidence indicates that the biomass of the stocks in this management unit is unlikely to be recruitment overfished and that current levels of fishing mortality (catch) are unlikely to cause the stocks to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Southern Gulf of Carpentaria biological stock

The southern Gulf of Carpentaria contributes almost the entire Gulf of Carpentaria Inshore Fin Fish Fishery (Qld) commercial harvest and receives the greatest fishing pressure⁵. Biological monitoring and anecdotal reports indicate good numbers of large fish present in the stock. Total mortality rate estimates are stable, and fishing mortality rates have been less than natural mortality rates for the past 4 years⁵. Commercial catches of Barramundi have been increasing since 1992 and reached record levels in 2011⁵. However, the Barramundi commercial harvest in 2013 was almost 51 per cent lower than in 2011, and the lowest since 2005⁵. This was likely to be due partly to poor seasonal river flows, which are known to affect catchability of Barramundi⁶. Age-structure monitoring indicates a stock with varied but continual recruitment. Low recruitment in 2012 and 2013, possibly due to low river flows in those years, prevented 3- and 4-year-olds from fully recruiting to the estuarine fishery⁶. Queensland size limits, and seasonal and spatial closures for Barramundi ensure that a large proportion of the spawning stock is protected. As a result, the biomass of the Southern Gulf of Carpentaria biological stock is not considered to be recruitment overfished, and current fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Northern Gulf of Carpentaria biological stock

Commercial catches of the northern Gulf of Carpentaria biological stock are small and variable, as the small river systems in this area are unlikely to support a large stock of Barramundi⁵. Biological evidence indicates that the growth rate of fish in this stock may be slower and fish mature earlier than in other stocks and management units⁷, such that the size limits protect a larger proportion of the spawning population⁵. Catch from this stock has declined since 2010, mainly as a result of reductions in fishing effort for economic reasons⁵. There has been a rising trend in catch rate over the past 20 years, which indicates that the biomass of this stock is unlikely to be recruitment overfished (unpublished data from the Queensland Department of Agriculture, Fisheries and Forestry). The above evidence indicates that this stock is unlikely to be recruitment overfished and the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Princess Charlotte Bay biological stock

Commercial catches of the Princess Charlotte Bay stock are small (4 per cent of the catch of the East Coast Inshore Fin Fish Fishery)⁵. Numbers of commercial operators in the Princess Charlotte Bay region have halved since 2008 to just five operators reporting catches in 2013. Spatial closures introduced in 2009, seasonal closures and size limits protect significant parts of the Princess Charlotte Bay spawning stock from commercial fishing. The catch history since 1993 is relatively stable, and catch rates have increased⁵. The above evidence indicates that the biomass of the Princess Charlotte Bay biological stock is not considered to be recruitment overfished and current fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

North-east coast biological stock

The north-east coast stock represents approximately 24 per cent of the 2013 Barramundi harvest on the Queensland east coast⁵. Summer rainfall and flow rates have had a positive effect on catches from this stock, both immediately on catchability and through a 3–4-year lag effect on enhanced recruitment⁸. Biological

monitoring and anecdotal reports indicate relatively stable length and age structures over time, and good numbers of large fish are present in the stock⁵. Total mortality rate estimates are stable, and fishing mortality rates are less than natural mortality rates⁵. Although commercial catches have declined since 2011, this has been predominantly due to poor seasonal river flows. Queensland size limits, and seasonal and spatial closures for Barramundi ensure that a large proportion of the spawning stock is protected. As a result, the biomass of the north-east coast stock is not considered to be recruitment overfished, and current fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Mackay biological stock

Commercial catches in the Mackay stock represent around 20 per cent of the East Coast Inshore Fin Fish Fishery (Qld) catch⁵. The catch history has been relatively stable over time, with a slight increasing trend; catch rates show a similar but somewhat stronger upward trend⁵. Queensland size limits, and seasonal and spatial closures for Barramundi ensure that a large proportion of the spawning stock is protected. The above evidence indicates that the biomass of the biological stock is not considered to be recruitment overfished and current fishing pressure is unlikely to cause the Mackay biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Central east coast biological stock

The central east coast is the major stock on the Queensland east coast, comprising 53 per cent of the 2013 East Coast Inshore Fin Fish Fishery (Qld) catch. In 2011, there was a fivefold increase in commercial catch, which has remained at high levels⁵. These high catches were due to stocked fish from Lake Awoonga moving into the Gladstone area following a flood in late 2010 to early 2011. Two subsequent high river flow years increased catchability in both the Gladstone area and Fitzroy River, with strong year-classes entering these systems during this time. Fishery-dependent monitoring shows stable length and age structures⁵. Queensland size limits, and seasonal and spatial closures for Barramundi ensure that a large proportion of the spawning stock is protected. The above evidence indicates that the biomass of the central east coast biological stock is not considered to be recruitment overfished and current fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Barramundi biology⁷

<i>Longevity and maximum size</i>	35 years; 1500 mm TL
<i>Maturity (50%)</i>	Northern Territory: males 2–5 years, 730 mm TL; females 5–7 years, 910 mm TL Queensland: males 2–5 years, 640 mm TL; females 5–7 years, 820 mm TL

TL = total length; estimates not available for Western Australia

Figure 1: Distribution of reported commercial catch of Barramundi in Australian waters, 2013 (calendar year)

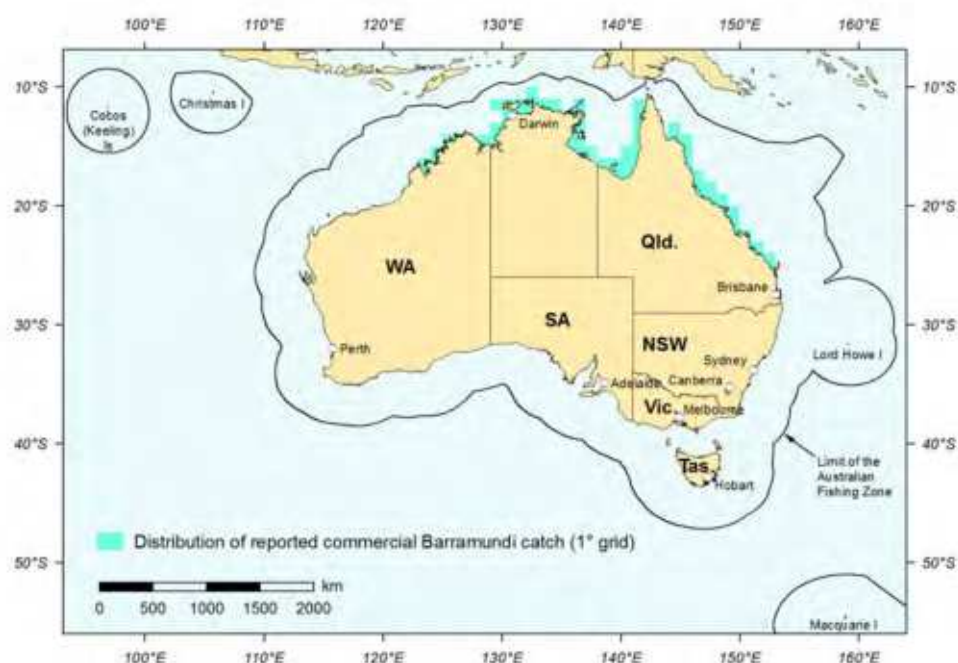


Table 3: Main features and statistics for Barramundi fisheries in Australia, 2013 (calendar year)

Jurisdiction	Northern Territory	Queensland	Western Australia
Fishing methods			
Commercial			
Gillnet	✓	✓	✓
Recreational			
Rod and line	✓	✓	✓
Spearfishing	✓	✓	✓
Indigenous ^{a,b}			
Spearfishing	✓	✓	✓
Hand line		✓	

Jurisdiction	Northern Territory	Queensland	Western Australia
Management methods			
Commercial			
Size limits	✓	✓	✓
Limited entry		✓	✓
Spatial zoning		✓	✓
Vessel restrictions	✓	✓	✓
Catch limits		✓	
Spatial closures	✓	✓	✓
Temporal closures	✓	✓	✓
Gear restrictions	✓	✓	✓
Recreational			
Temporal closures	✓	✓	
Licensing			✓
Spatial closures	✓	✓	✓
Size limits	✓	✓	✓
Bag limits			✓
Possession limits	✓	✓	✓
Gear restrictions	✓	✓	✓
Charter			
Limited entry	✓		✓
Spatial zoning	✓	✓	✓
Passenger restrictions	✓		✓
Size limits	✓	✓	✓
Bag limits			✓
Possession limits	✓	✓	✓
Spatial closures	✓	✓	✓
Seasonal closures	✓	✓	

Jurisdiction	Northern Territory	Queensland	Western Australia
Indigenous ^{a,b}			
Laws of general application			✓
Active vessels			
	17 in BF	71 in southern Gulf of Carpentaria (GOCIFF) <5 in northern Gulf of Carpentaria (GOCIFFF) 5 in Princess Charlotte Bay (ECIFFF) 68 in north-east coast (ECIFFF) 48 in Mackay (ECIFFF) 53 in central east coast (ECIFFF)	6 in KGBMF
Catch			
Commercial	433 t in BF	492 t in southern Gulf of Carpentaria (GOCIFF) Northern Gulf of Carpentaria (GOCIFFF) not reportable ^c 16 t in Princess Charlotte Bay (ECIFFF) 93 t in north-east coast (ECIFFF) 78 t in Mackay (ECIFFF) 211 t in central east coast (ECIFFF)	52 t in KGBMF
Recreational	155 t (2010)	181 ± 31 t ^d (2010–11) ⁹	2.1–9 t ^e (2011–12) ¹⁰
Charter	34 t FTO (2012)	Included in recreational estimate	1–4 t
Indigenous	110 t (2000)	Unknown	Unknown

Markets			
Domestic	✓	✓	✓
Export			

BF = Barramundi Fishery (Northern Territory); ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); FTO = Fishing Tour Operator (Northern Territory); GOCIFFF = Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland); KGBMF = Kimberley Gillnet and Barramundi Managed Fishery (Western Australia)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and bag limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

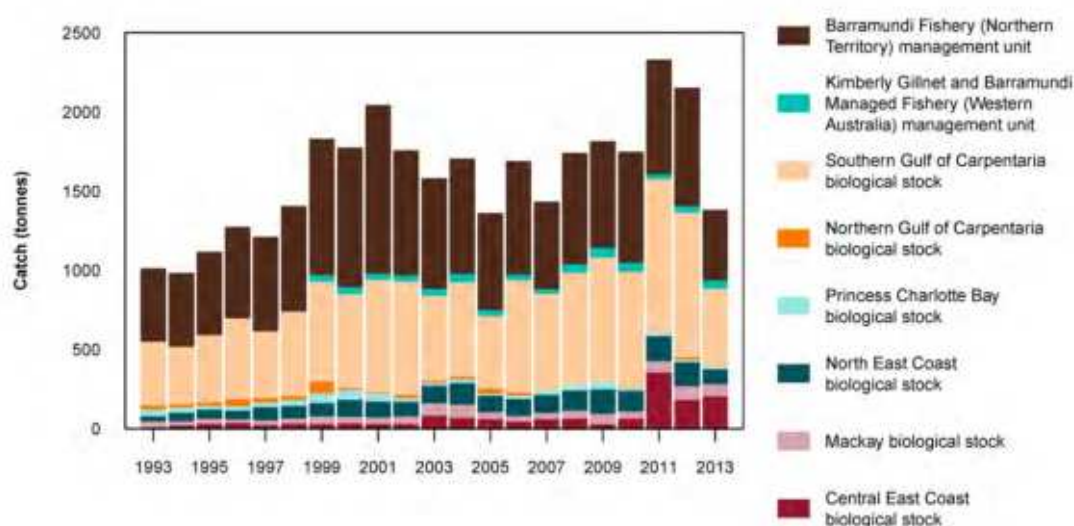
b Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

c Northern Gulf of Carpentaria catch is not reportable as fewer than five boats operated in the fishery in 2013.

d Survey of Queensland residents only⁹

e Recreational catch estimates for Barramundi will be underestimates as they were derived from boat-based fishers; shore-based fishers and boat-based fishers that fished only in fresh water were out of scope of the 2011–12 survey¹⁰.

Figure 2: Commercial catch of Barramundi in Australian waters, 1993 to 2013 (calendar years)



Note: Northern Gulf of Carpentaria catch is not reportable from 2007 to 2011, and for 2013 because fewer than five boats operated in the fishery.

Effects of fishing on the marine environment

- Commercial gillnets have limited direct impact on the environment and are quite selective, with bycatch making up only a small proportion of the catch¹¹. However, commercial gillnets do interact with threatened, endangered and protected species. Although reported interactions are low, the impact on the populations of these species is unknown^{3,5,11}.

Environmental effects on Barramundi

- The duration, magnitude and timing of the wet season strongly drives biomass and harvest of Barramundi stocks, with large wet seasons resulting in higher recruitment than smaller wet seasons^{6,8,12}.

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34. Black Jewfish *Protonibea diacanthus*

Thor Saunders^a, Anthony Roelofs^b, Stephen Newman^c and Chris Errity^a



Table 1: Stock status determination for Black Jewfish

Jurisdiction	Northern Territory	Queensland	Queensland	Western Australia
<i>Stock</i>	Northern Territory (BF, CLF, DF, FTO, TRF)	Gulf of Carpentaria (GOCIFFF)	Queensland east coast (ECIFFF)	Western Australia (KGBMF, NBPMF, PFTIMF, PLF)
<i>Stock status</i>				
	Overfished	Undefined	Undefined	Undefined
<i>Indicators</i>	Biomass, egg production, catch, CPUE	Catch	Catch	Catch

BF = Barramundi Fishery (Northern Territory); CPUE = catch per unit effort; CLF = Coastal Line Fishery (Northern Territory); DF = Demersal Fishery (Northern Territory); ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); FTO = Fishing Tour Operator (Northern Territory); GOCIFFF = Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland); KGBMF = Kimberley Gillnet and Barramundi Managed Fishery (Western Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PLF = Pilbara Line Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

Stock structure

Black Jewfish is a widespread Indo-Pacific species that is found from the Kimberley in Western Australia across northern Australia to the east coast of Queensland. The stock structure for this species is currently under investigation and undefined; hence, status is reported at the management unit or jurisdiction level rather than for individual biological stocks.

Stock status

Northern Territory

The most recent assessment (2011) estimates that the biomass of Black Jewfish in the Northern Territory is at approximately 62 per cent of unfished biomass¹. Egg production is estimated at 38 per cent of unfished levels, resulting in a high probability (71 per cent) that Black Jewfish stocks have been overfished and a moderate probability (21 per cent) that current fishing pressure is continuing to cause overfishing¹. The assessments are driven by the populations that receive the highest harvest rates, so the status for the Northern Territory can

^a Department of Primary Industry and Fisheries, Northern Territory

^b Department of Agriculture, Fisheries and Forestry, Queensland

^c Department of Fisheries, Western Australia

be assumed to reflect the highest level of exploitation that occurs on any population. The immediate area of concern is in waters around Darwin, where most of the fishing pressure occurs and where abundance, catch and catch rate have substantially declined since 2004². Black Jewfish have also been shown to be highly susceptible to barotrauma when caught in waters deeper than 10 metres³. It is estimated that fishing pressure needs to be reduced by a further 20 per cent to allow the biomass of Black Jewfish stocks to recover¹. The evidence provided above indicates that these stocks are recruitment overfished and that the current levels of fishing pressure are expected to prevent the stocks from recovering from their recruitment overfished state.

On the basis of the evidence provided above, Black Jewfish in the Northern Territory is classified as an **overfished stock**.

Gulf of Carpentaria (Queensland) management unit

In the Gulf of Carpentaria (Queensland) management unit, Black Jewfish are taken by commercial net fishers and recreational anglers. Commercial catches of Black Jewfish in the Queensland Gulf of Carpentaria Inshore Fin Fish Fishery have decreased from a reported historical high of 33 tonnes (t) in 1990 to less than 0.5 t in 2013⁴. However, specific reporting of Black Jewfish commercial harvest ceased in 2006, and catches reported as 'Jewfish—Other' have averaged 6 t per year since this change; Black Jewfish are likely the major component of this harvest. From 1999 to 2000, there was a distinct lack of large mature fish found in the north Cape York region⁵. The overall downward trend in catches and the reduced spawning biomass, combined with the vulnerable biology of Black Jewfish (late maturing, aggregating to spawn), resulted in a 2-year ban on fishing for Black Jewfish in key aggregation areas. In 2002, Queensland prohibited the harvest of Black Jewfish in the north Cape York region (north of Crab Island)⁴. No studies have been undertaken to measure recovery in this region or the overall biomass of Black Jewfish in the Queensland part of the Gulf of Carpentaria.

There are no reliable estimates of recreational harvest for Black Jewfish in the Queensland Gulf of Carpentaria⁴, but it is known as a popular recreational species in the region. The Queensland legal size limit (60 cm total length) in the Gulf of Carpentaria is well below the reported age of first maturity for females (85–90 cm total length) and may not be effective in protecting spawning females from fishing. A conservative possession limit (two fish) reduces recreational fishing pressure on the stock. Overall, insufficient information is available to confidently classify the status of the stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Queensland east coast management unit

Black Jewfish are taken by commercial net fishers and recreational anglers on the Queensland east coast. The East Coast Inshore Fin Fish Fishery (Queensland) contributes minimal quantities (5-year average = 2 t per year) to the overall Queensland east coast harvest. There are no reliable estimates of recreational harvest⁶. The legal size limit (75 cm total length) is below the reported age of first maturity for females and may not be effective in protecting spawning females from fishing. A conservative possession limit (two fish) reduces recreational fishing pressure on the stock. Insufficient information is available to confidently classify the status of the stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Western Australia

Black Jewfish are not a target species in the Kimberley Gillnet and Barramundi Managed Fishery of Western Australia but are landed in small quantities as byproduct⁷. They have also been landed in very small quantities as byproduct in the Nickol Bay Prawn Managed Fishery, the Pilbara Fish Trawl Interim Managed Fishery and the Pilbara Line Fishery. Black Jewfish catches have only been reported from a small area of their range in Western Australia. They are landed in small quantities by charter fishers, primarily in the Kimberley region of Western Australia. Given the low level of take of Black Jewfish in Western Australia, it is unlikely that this species is recruitment overfished, or that the level of fishing mortality is likely to cause it to become recruitment overfished. However, insufficient information is available to confidently classify the status of Black Jewfish in Western Australia.

On the basis of the evidence provided above, Black Jewfish in Western Australia is classified as an **undefined stock**.

Table 2: Black Jewfish biology⁸

Longevity and maximum size	15 years; 1500 mm TL, 30 kg
Maturity (50%)	Northern Territory: 2 years; 890 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Black Jewfish in Australian waters, 2013 (calendar year)

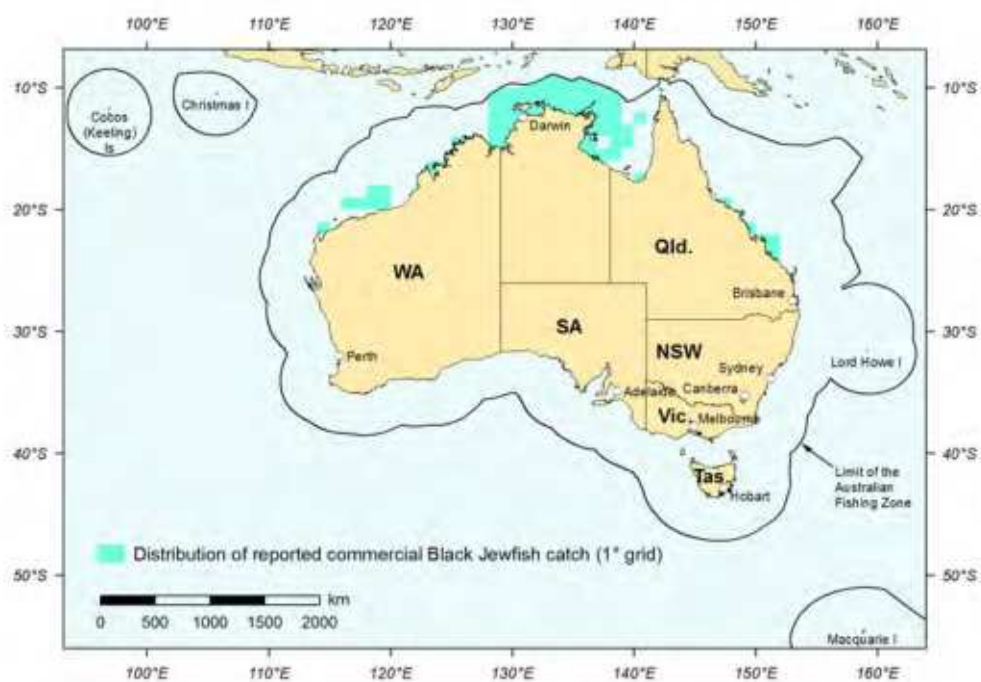


Table 3: Main features and statistics for Black Jewfish fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland	Northern Territory	Western Australia
Fishing methods			
Commercial			
Gillnets	✓	✓	✓
Hand line	✓	✓	✓
Trawl		✓	✓
Traps and pots		✓	
Recreational			
Rod and line	✓	✓	✓
Spearfishing	✓	✓	

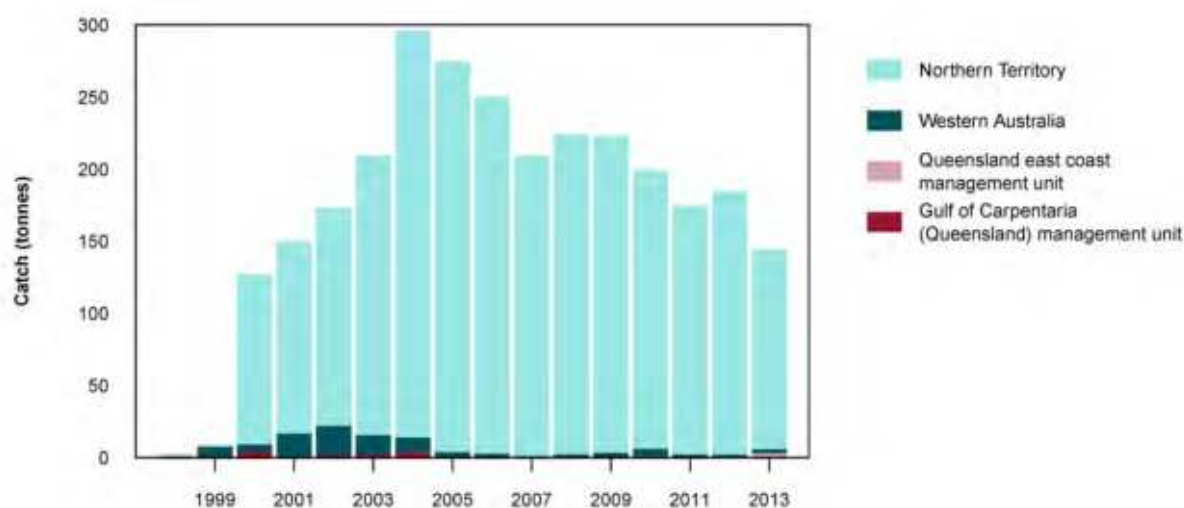
Jurisdiction	Queensland	Northern Territory	Western Australia
Indigenous ^a			
Hand line	✓	✓	
Management methods			
Commercial			
Spatial zoning			✓
Limited entry	✓	✓	✓
Size limits	✓		✓
Gear restrictions	✓	✓	✓
Spatial closures	✓	✓	✓
Vessel restrictions	✓	✓	✓
Catch limits	✓	✓	
Temporal closures	✓	✓	✓
Recreational			
Licensing			✓
Gear restrictions	✓	✓	✓
Spatial closures	✓	✓	✓
Possession limits	✓	✓	✓
Bag limits			✓
Size limits	✓		✓
Indigenous ^a			
Gear restrictions	✓	✓	✓
Active vessels			
	7 in ECIFFF 2 in GOCIFFF	14 in BF 9 in CLF 9 in DF 8 in TRF	4 in KGBMF 1 in NBPMF 2 in PFTIMF 1 in PLF

Jurisdiction	Queensland	Northern Territory	Western Australia
Catch			
Commercial	4 t in ECIFFF <0.5 t (+3 t Jewfish—Other) in GOCIFFF	11 t in BF 116 t in CLF 20 t in DF 1 t in TRF	2 t in KGBMF <0.5 t in NBPMF <0.5 t in PFTIMF <0.5 t in PLF
Recreational	Unknown	75 t (2010)	Unknown
Charter	None	23 t in FTO	<0.5 t
Indigenous	Unknown	Unknown	Unknown
Markets			
Domestic	✓	✓	✓
Export			

BF = Barramundi Fishery (Northern Territory); CLF = Coastal Line Fishery (Northern Territory); DF = Demersal Fishery (Northern Territory); ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); FTO = Fishing Tour Operator (Northern Territory); GOCIFFF = Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland); KGBMF = Kimberley Gillnet and Barramundi Managed Fishery (Western Australia); NBPMF = Nickol Bay Prawn Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PLF = Pilbara Line Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

Figure 2: Commercial catch of Black Jewfish in Australian waters, 1998 to 2013 (calendar years)



Effects of fishing on the marine environment

- Black Jewfish are mainly targeted by fishers in all sectors using hand lines and rods. Beyond the removal of target and a small proportion of bycatch species, there is little evidence that this gear has significant impacts on benthic or pelagic ecological communities.
- In Queensland, coastal river- and estuary-set gillnets have been shown to have minimal impact on the environment and are quite selective in their harvest⁹. Bycatch is generally low compared with the harvest of the target species.
- Commercial trawl gear used in waters across northern Australia has the potential to affect the benthic habitat. However finfish trawl nets have been designed to fish above the seabed, reducing interaction with benthic habitats⁶. Additionally, the trawl fishery across northern Australian waters comprises a very small fleet and only fishes approximately 7 per cent of the available area¹⁰.

Environmental effects on Black Jewfish

- The impact of environmental factors on Black Jewfish is largely unknown. However, juveniles mainly inhabit coastal estuaries and bays, making these phases of their life cycle sensitive to ocean current strength and direction; rainfall; river flow; and water temperature, salinity and acidity³.

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35. Blue Grenadier *Macruronus novaezelandiae*

Andrew Penney^a and Andy Moore^a



Table 1: Stock status determination for Blue Grenadier

Jurisdiction	Commonwealth	
Stock	CTS	GABTS
Stock status		
	Sustainable	Sustainable
Indicators	Spawning stock biomass, fishing mortality	Current and historical fishing pressure

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector (Commonwealth)

Stock structure

Comparative analysis of otolith chemistry and shape indicates two separate biological stocks of Blue Grenadier: one in the region of the Great Australian Bight Trawl Sector (Commonwealth) and the other in the region of the Commonwealth Trawl Sector¹. There is some evidence that Blue Grenadier from the western Tasmanian and eastern Bass Strait regions of the Commonwealth Trawl Sector may constitute separate substocks, but these are currently assessed and managed as a single Commonwealth Trawl Sector stock².

Stock status

Commonwealth Trawl Sector biological stock

Blue Grenadier in the Commonwealth Trawl Sector and the Gillnet, Hook and Trap Sector (Commonwealth) of the Southern and Eastern Scalefish and Shark Fishery (Commonwealth) is managed under a multiyear total allowable catch (TAC). The Commonwealth Trawl Sector accounts for the majority of the catch from these two sectors. Given the small catch from the Gillnet Hook and Trap Sector, the biological stock is referred to in this report as the Commonwealth Trawl Sector biological stock.

In 2013, the Blue Grenadier stock assessment was updated using acoustic and egg survey indices, and new catch-at-age and catch-rate data up to 2012³. The assessment estimated a large recruitment event in 2010. The stock was assessed as being above the target reference point at 77 per cent of unfished biomass in 2012, and trending upwards, indicating that the biological stock is not recruitment overfished⁴.

Blue Grenadier has been managed under a 3-year TAC, first implemented in 2011–12. After adjustment for uncaught quota and carryover from the 2012–13 fishing season, the TAC for the 2013–14 fishing season was set at 5704 tonnes (t)⁵. Total commercial catch in 2013 was 3828 t, and the 2013–14 fishing season catch was below the TAC, at 3847 t. This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished⁴.

^a Australian Bureau of Agricultural and Resource Economics and Sciences

The 2013 assessment³ provided recommendations for increased multiyear recommended biological catches. The South East Management Advisory Committee accepted a recommendation for a 3-year recommended biological catch of 8810 t for the 2014–15, 2015–16 and 2016–17 fishing seasons. After application of the large change limiting rule and proposals for a phased increase to facilitate stability, the agreed TAC was set at 6800 t for the 2014–15 fishing season⁶.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Great Australian Bight Trawl Sector (Commonwealth) biological stock

There have been no stock assessments for the Great Australian Bight Trawl Sector (Commonwealth) biological stock of Blue Grenadier, and no estimates of fishing mortality or biomass have been made. A catch trigger of 400 t is in place; if this is exceeded, data collection and the development of an assessment plan are required. A cease-to-fish catch trigger of 500 t also applies⁷.

This Blue Grenadier biological stock is targeted on the upper continental slope (around 200–700 m depth). Fishing effort on the Great Australian Bight continental slope has decreased since 2005 because of the targeting of shelf species rather than slope species. There are large areas of slope habitat across the Great Australian Bight and Western Australia, with fishing generally limited to a small area. It is therefore likely that parts of this biological stock remain unfished. Commercial catches of Blue Grenadier are typically low in the Great Australian Bight Trawl Sector (20 t in 2013, with a peak commercial catch in 2005 of 421 t). The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished. In addition, the low level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Blue Grenadier biology¹

Longevity and maximum size	25 years; ~1100 mm TL, 6 kg
Maturity (50%)	4–5 years; females 640 mm TL, males 570 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Blue Grenadier in Australian waters, 2013 (calendar year)

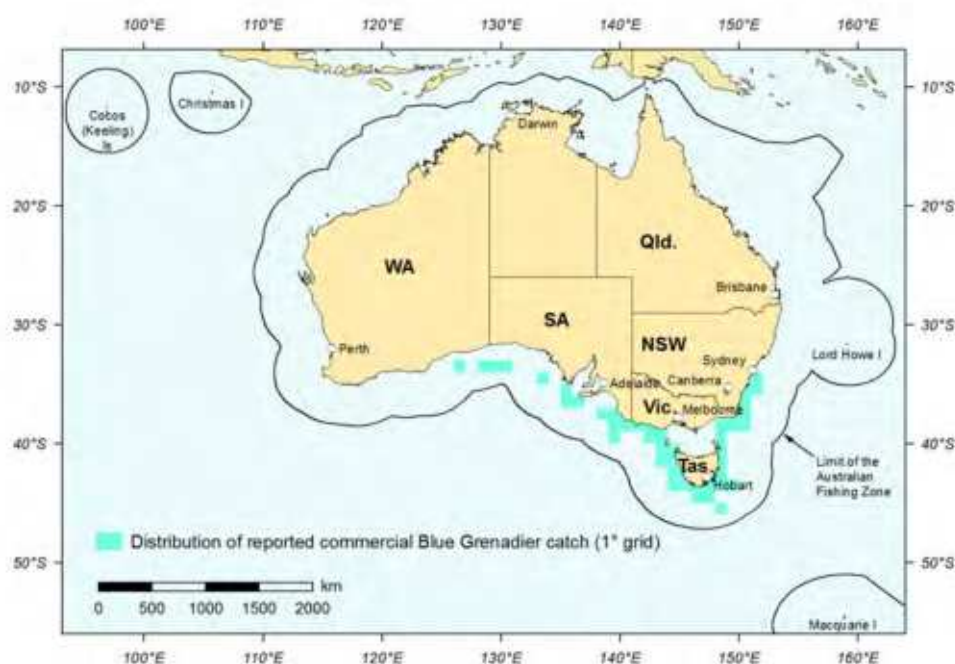


Table 3: Main features and statistics for Blue Grenadier fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth
Fishing methods	
Commercial	
Demersal trawl	✓
Midwater trawl	✓
Demersal longline	✓
Dropline	✓
Recreational ^a	
Rod and line (electric reel)	✓
Indigenous ^b	
Management methods	
Commercial	
Limited entry	✓
Total allowable catch (CTS)	✓
Trigger limits (GABTS)	✓
Spatial closures	✓
Recreational ^a	
Indigenous ^b	
Active vessels	
	35 in CTS 3 in GABTS
Catch	
Commercial	3828 t in CTS 20 t in GABTS
Recreational ^a	
Indigenous ^b	

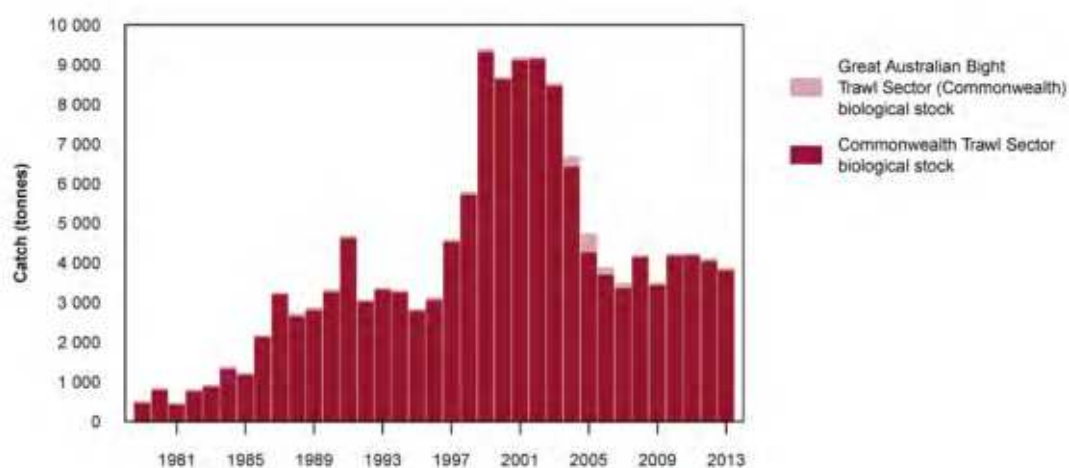
Jurisdiction	Commonwealth
Markets	
Domestic	✓
Export	✓

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector (Commonwealth)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

Figure 2: Commercial catch of Blue Grenadier in Australian waters, 1979 to 2013 (calendar years)



Effects of fishing on the marine environment

- There can be a substantial level of bycatch in the fish trawl sector. In 2006, mandatory requirements for otter trawls to use 90 mm square-mesh codend panels were introduced to reduce the catch of small species and juvenile fish⁸.
- Interactions also occur with animals protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), including marine mammals (dolphins, seals and sea lions), seabirds, some shark species and seahorses and pipefish (syngnathids). These interactions are reported quarterly by the Australian Fisheries Management Authority⁹ and on-board observer programs are used to validate the reporting in commercial logbooks.
- In 2007, the South East Trawl Fishing Industry Association 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 generally¹⁰. Operators have developed other mitigation protocols that have further reduced seal mortalities, including using breakaway ties that keep the net closed until it is below depths that seals regularly inhabit, adopting techniques to close the trawl opening during recovery to minimise opportunities for seals to enter the net, switching off gantry lights that are not required during night trawling to avoid attracting bait species and seals, and dumping offal only when the boat is not engaged in deploying or hauling gear¹⁰.

- In 2011, AFMA mandated individual vessel seabird management plans¹¹. The seabird action plans are used in the Commonwealth Trawl Sector to mitigate the impacts of trawling on seabirds. Seabird mitigation measures include warp deflectors ('pinkys'), bird bafflers (a system of ropes and PVC piping that protects the warp cable) and seal excluder devices.
- The effects of trawl fishing on the marine environment are assessed through an environmental risk assessment and risk management framework and mitigated through spatial closures, and the implementation of bycatch and discard workplans in the Commonwealth Trawl Sector and Great Australian Bight Trawl Sector fisheries.

Environmental effects on Blue Grenadier

- Changes in ecosystem structure and function due to changes in climate may affect larval recruitment of Blue Grenadier¹². Stock assessments indicate substantial interannual recruitment variability, with occasional years of very high recruitment, which are probably environmentally driven³.

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36. Coral Trout *Plectropomus* spp., *Variola* spp.

Malcolm Keag^a, Stephen Newman^b, Nic Marton^c and Thor Saunders^d



Common coral trout (*Plectropomus leopardus*)

Table 1: Stock status determination for Coral Trout

Jurisdiction	Commonwealth	Northern Territory	Queensland		Western Australia
Stock	TSFF	Northern Territory (CLF, FTO, TRF)	CRFFF	Gulf of Carpentaria (DFFTF, GOCLF)	Western Australia (NDSMF, PFTIMF, PTMF, WCDSIMF)
Stock status					
	Sustainable	Undefined	Sustainable	Undefined	Undefined
Indicators	Management strategy evaluation	Catch	Quantitative stock assessment, catch	Catch, CPUE	Catch, CPUE

CPUE = catch per unit effort; CLF = Coastal Line Fishery (Northern Territory); CRFFF = Coral Reef Fin Fish Fishery (Queensland); DFFTF = Developmental Fin Fish Trawl Fishery (Queensland); FTO = Fishing Tour Operation (Northern Territory); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory); TSFF = Torres Strait Finfish Fishery (Commonwealth); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia)

Stock structure

Assessments of Coral Trout take into account a species complex in the Commonwealth and Queensland jurisdictions. This complex comprises Common Coral Trout (*Plectropomus leopardus*), Barcheek Coral Trout (*P. maculatus*), Bluespotted Coral Trout (*P. laevis*), Passionfruit Coral Trout (*P. areolatus*), Yellow-edge Coronation Trout (*Variola louti*) and White-edge Coronation Trout (*V. albigmarginata*). In Western Australia, the Coral Trout species complex comprises Common Coral Trout, Barcheek Coral Trout, Yellow-edge Coronation Trout and White-edge Coronation Trout. The biological stock structure of Coral Trout species is spatially complex¹⁻⁴ and remains uncertain; hence, status is reported at the management unit level rather than for individual biological stocks.

a Department of Agriculture, Fisheries and Forestry, Queensland

b Department of Fisheries, Western Australia

c Australian Bureau of Agricultural and Resource Economics and Sciences

d Department of Primary Industries and Fisheries, Northern Territory

Stock status

Torres Strait Finfish Fishery (Commonwealth) management unit

No formal stock assessment has been conducted in the Torres Strait Finfish Fishery (Commonwealth), but a management strategy evaluation⁵ tested four model simulations. All models estimated that biomass in 2004 was greater than 60 per cent of the unfished level, and that biomass would be greater than 70 per cent of the unfished level by 2025 at 2007 fishing levels. Catch in recent years has been below historical catch levels and well below the lowest catch level simulated in the management strategy evaluation (80 tonnes [t] per year). A catch simulation at 80 t suggested that Coral Trout biomass in the fishery would increase to greater than 80 per cent of the unfished biomass within 20 years⁵. Catch in the Torres Strait Finfish Fishery has declined from historical highs following a voluntary surrender process for all non-Traditional Inhabitant commercial operators in the Torres Strait Finfish Fisheries in 2005. In addition, complications with supply logistics (consistent supply of product to a point of landing) are likely to have negatively affected profitability and interest in the Torres Strait Finfish Fishery. Because fishers have limited access to freezing capacity, supply to processors has been inconsistent, leading to a negative impact on marketability and, in turn, prices and catches. The closure of a freezing facility on Murray Island in late 2010 contributed to this problem (Torres Strait Regional Authority, pers. comm., 2011).

The above evidence indicates that the biomass of this management unit stock is unlikely to be recruitment overfished⁶. The level of fishing pressure in recent years is unlikely to cause the management unit to become recruitment overfished⁶.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Northern Territory

The status of Coral Trout in the Northern Territory is unknown. Only small catches are reported from the Fishing Tour Operator sector, Coastal Line Fishery and Timor Reef Fishery⁷.

On the basis of the evidence provided above, Coral Trout in the Northern Territory is classified as an **undefined stock**.

Coral Reef Fin Fish Fishery (Queensland) management unit

Common Coral Trout dominates catches in the Coral Reef Fin Fish Fishery (Queensland)⁸. The most recent assessment of Common Coral Trout⁸ estimated that the biomass in 2012 was 60 per cent of the unfished (1962) levels in areas open to fishing. Given this current biomass ratio of the predominant target species in the species complex, the Coral Trout stock is not considered to be recruitment overfished.

The most recent assessment⁸ estimates that current catch levels are lower than the estimated maximum sustainable yield for the stock. This level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Gulf of Carpentaria (Queensland) management unit

Coral Trout is not a target species in Queensland-managed commercial fisheries in the Gulf of Carpentaria. They are taken as byproduct in the Developmental Fin Fish Trawl Fishery (Queensland) and Gulf of Carpentaria Line Fishery (Queensland), but only small catches are reported. Coral Trout is a popular recreational species for Gulf of Carpentaria residents and visiting fishers. Catch information was reported during the latest recreational survey; however, harvest levels were unreliable as a result of survey limitations (unpublished data from the Queensland Department of Agriculture, Fisheries and Forestry). Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Western Australia

Coral Trout is not a target species in the demersal fisheries of Western Australia but is landed as byproduct. Only small catches of Barcheek Coral Trout and Common Coral Trout are reported, and very small catches are reported for Yellow-edge Coronation Trout and White-edge Coronation Trout⁹. Insufficient information is available to confidently classify the status of the Western Australian stock.

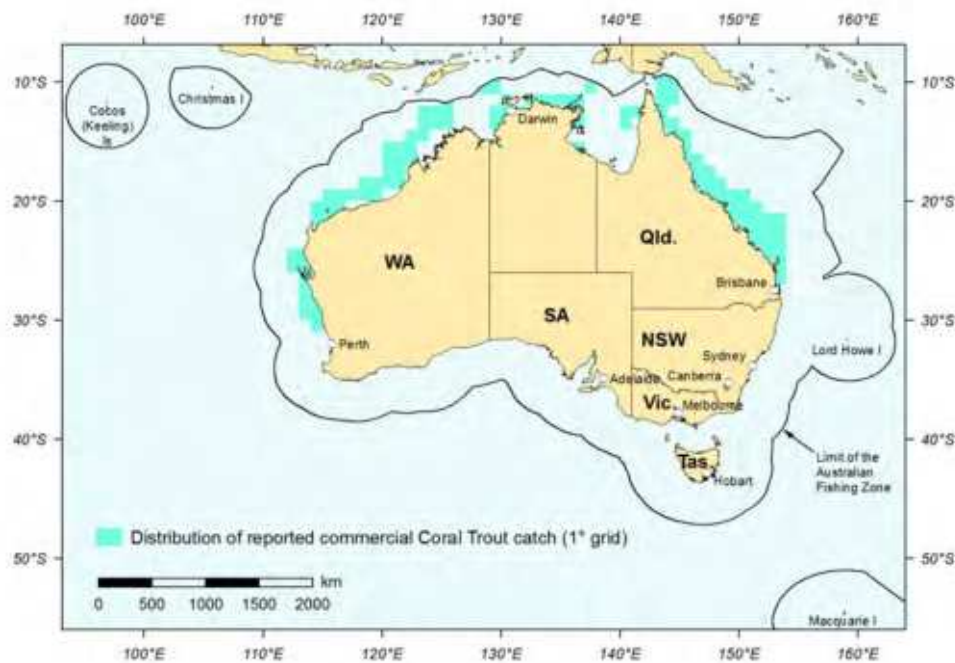
On the basis of the evidence provided above, Coral Trout in Western Australia is classified as an **undefined stock**.

Table 2: Coral Trout biology^{10–14}

Longevity and maximum size	17 years; ~800 mm FL
Maturity (50%)	~280 mm FL (female) The species is a protogynous hermaphrodite (individuals are born female and later become male), with sex change occurring at around 500 mm FL.

FL = fork length

Figure 1: Distribution of reported commercial catch of Coral Trout in Australian waters, 2013 (calendar year)



Note: Data for the Northern Territory and Western Australia align with the 2013 calendar year, whereas data for the Commonwealth and Queensland align with the 2012–13 financial year.

Table 3: Main features and statistics for Coral Trout fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth ^a	Northern Territory ^b	Queensland ^a	Western Australia ^b
Fishing methods				
Commercial				
Hand line	✓	✓	✓	✓
Dropline		✓		✓
Rod and line		✓	✓	✓
Fish trawl		✓	✓	✓
Fish trap		✓		✓
Recreational ^c				
Hand line		✓	✓	✓
Rod and line		✓	✓	✓
Spearfishing		✓	✓	✓
Indigenous ^{d-f}				
Hand line		✓	✓	✓
Rod and line		✓	✓	✓
Spearfishing		✓	✓	✓
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Gear restrictions	✓	✓	✓	✓
Total allowable effort				✓
Spatial zoning ^f				✓
Size limits	✓		✓	✓
Vessel restrictions	✓		✓	✓
Catch restrictions	✓		✓	
Spatial closures	✓		✓	✓
Temporal closures			✓	

Jurisdiction	Commonwealth ^a	Northern Territory ^b	Queensland ^a	Western Australia ^b
Recreational ^c				
Licensing				✓
Gear restrictions		✓	✓	✓
Possession limits		✓	✓	✓
Size limits			✓	✓
Spatial closures		✓	✓	✓
Temporal closures			✓	
Charter				
Licensing		✓	✓ (vessel)	
Limited entry				✓
Passenger restrictions				✓
Spatial zoning ^g				✓
Gear restrictions		✓	✓	✓
Possession limits		✓	✓	✓
Bag limits				✓
Size limits			✓	✓
Spatial closures		✓	✓	✓
Temporal closures			✓	
Indigenous ^{d-f}				
Laws of general application apply				✓
Spatial closures			✓	
Active vessels				
	1 in TSFF	9 in CLF 114 in FTO (2012) 8 in TRF	181 in CRFFF 1 in DFFTF 0 in GOCLF	7 in NDSMF 3 in PFTIMF 2 in PTMF 22 in WCDSIMF

Jurisdiction	Commonwealth ^a	Northern Territory ^b	Queensland ^a	Western Australia ^b
Catch				
Commercial	22 t in TSFF	0.2 t in CLF 0.6 t in TRF	750 t in CRFFF <1 t in DFFTF 0 t in GOCLF	7 t in NDSMF 5 t in PFTIMF 3 t in PTMF 2 t in WCDSIMF
Recreational ^c		2.8 t (2010) 0.7 t in FTO (2012)	196 000 fish (~200 t) (2010)	9034 fish (~22 t) (2011–12) ¹⁶
Charter			61 t	1915 fish (~5 t)
Indigenous ^{d,e}		Negligible	Unknown	Unknown
Markets				
Domestic	✓	✓	✓	✓
Export	✓	✓	✓	

CLF = Coastal Line Fishery (Northern Territory); CRFFF = Coral Reef Fin Fish Fishery (Queensland); DFFTF = Developmental Fin Fish Trawl Fishery (Queensland); FTO = Fishing Tour Operation (Northern Territory); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory); TSFF = Torres Strait Finfish Fishery (Commonwealth); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia)

a Data provided for the Commonwealth and Queensland align with the 2012–13 financial year.

b Data provided for the Northern Territory and Western Australia align with the 2013 calendar year.

c The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

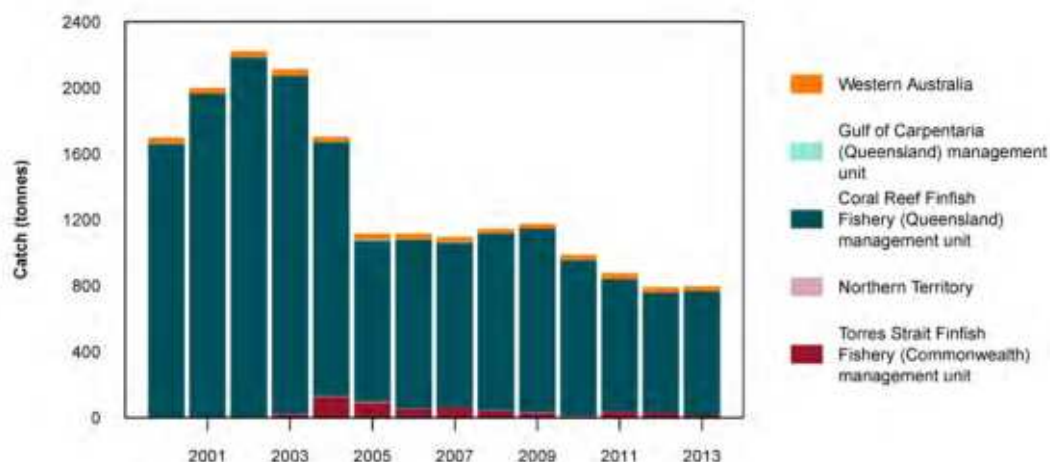
d The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters (with the exception of the Torres Strait). In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters. In the Torres Strait, both commercial and noncommercial Indigenous fishing is managed by the Torres Strait Protected Zone Joint Authority (PZJA) through the Australian Fisheries Management Authority (Commonwealth); the Department of Agriculture, Fisheries and Forestry (Queensland); and the Torres Strait Regional Authority. The PZJA also manages non-Indigenous commercial fishing in the Torres Strait.

e Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

f Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

g In Western Australia, different zones within fisheries may have different effort allocations.

Figure 2: Commercial catch of Coral Trout in Australian waters, 2000 to 2013 (calendar years)



Note: Data for the Northern Territory and Western Australia are reported by calendar year, whereas data for the Commonwealth and Queensland are by financial year

Effects of fishing on the marine environment

- There were no reported interactions with protected species by the Torres Strait Finfish Fishery (Commonwealth) in 2013, or the Coral Reef Fin Fish Fishery (Queensland) in the 2012–13 fishing season, indicating that the impact of these fisheries on protected species is low.
- Line fishing for Coral Trout is likely to have little direct effect on the marine environment¹⁷. However, there is evidence that the removal of predators (including Coral Trout) can lead to an increase in the abundance of their prey species, which is indicative of food web changes¹⁷. The impacts of this are unknown.
- Commercial trawl gear used in the Northern Territory has the potential to impact on the benthic habitat. However, trawl nets in the Northern Territory have been designed to fish off the seabed, reducing interaction with benthic habitats¹⁸. The trawl fishery in the Northern Territory comprises a very small fleet and only fishes about 7 per cent of the available area¹⁸.

Environmental effects on Coral Trout

- The most recent Queensland Coral Trout stock assessment⁸ notes the impact of cyclones on reducing Coral Trout catch rates. Tobin et al. (2010)¹⁹ reported on the effects of three tropical cyclones on the Coral Reef Fin Fish Fishery industry, including a decrease in Coral Trout catch rates of around one-third in regions with the most structural reef damage. The destruction, scouring and displacement of reef habitat were significant and widespread across large areas of the reef. In addition to the structural reef damage, commercial fishers reported reduced catch rates of all species throughout the directly impacted areas¹⁹. The analysis identifies depressed catch rates for 12–24 months in affected areas following cyclones.
- Climate change impacts are a concern for coral reef ecosystems. Climate change has been linked to changes in ocean chemistry, and increases in the frequency and extent of coral bleaching events²⁰. These events can also affect the replenishment rates of coral reef fin fish populations, individual growth rates²¹ and spawning output^{22,23}, and may influence the geographic distribution of coral reef species (for example, latitudinal shifts in distribution).

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37. Gemfish *Rexea solandri*

Lee Georgeson^a, Andy Moore^a and Geoffrey Liggins^b



Table 1: Stock status determination for Gemfish

Jurisdiction	Commonwealth, New South Wales	Commonwealth
Stock	Eastern (CTS, GHaT, OTF, OTLF)	Western (CTS, GHaT, GABTS)
Stock status	Overfished	Sustainable
Indicators	Biomass, fishing mortality	Biomass, fishing mortality

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector (Commonwealth); GHaT = Gillnet Hook and Trap Sector (Commonwealth); OTF = Ocean Trawl Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales)

Stock structure

There are considered to be two biologically distinct stocks of Gemfish in Australia—an eastern and a western biological stock—separated by a boundary at the western end of Bass Strait¹. Studies suggest that there are no genetic differences between Gemfish in eastern Australia and New Zealand¹. For the purposes of management and assessment, the eastern Australian population is treated as a single biological stock, independent of the New Zealand population.

Stock status

Eastern biological stock

Historically high catches of Gemfish from the eastern biological stock through the 1970s and 1980s substantially reduced the biomass of eastern Gemfish by the 1990s². The biological stock has remained at a depressed level, with limited recruitment over this period³. The most recent (2010) estimate of spawning stock biomass was 15.6 per cent of the unfished (1968) level³. The biological stock is considered to be recruitment overfished⁴.

A spawning potential ratio analysis⁵ suggested 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 20 per cent of unfished biomass in 2025⁶, which is less than the one generation time plus 10 years required under the Commonwealth Fisheries Harvest Strategy Policy⁷. However, this rebuilding projection is based on average levels of recruitment, and total removals being limited to the 100 tonnes (t) incidental catch allowance (no

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^b Department of Primary Industries, New South Wales

targeting is allowed), assumptions that may underestimate the time that it will take to rebuild the stock. Total landed catch in 2013 was 161 t, and discard estimates were 28 t in 2012 (unknown for 2013). Recruitment has remained low in recent years⁵. There is a lack of evidence on recreational fishing catch. The above evidence indicates that it is uncertain whether current fishing pressure is constrained by management to a level that will allow the stock to recover from its recruitment overfished state⁴. Measurable improvements in biomass are yet to be detected. The Australian Fisheries Management Authority is reviewing the rebuilding timeframe as part of the 2014 review of the rebuilding strategy.

On the basis of the evidence provided above, the biological stock is classified as an **overfished stock**.

Western biological stock

An updated integrated stock assessment model was developed for the western biological stock of Gemfish in the Commonwealth Trawl Sector and Great Australian Bight Trawl Sector (Commonwealth) in 2013⁸. The updated assessment gave a spawning biomass estimate of 74 per cent of unfished biomass, which was similar to the estimate from the 2011 assessment (69 per cent). A catch-rate analysis⁹ for the Commonwealth Trawl Sector estimated that catch rates were above the Commonwealth limit but below the target catch rate (based on a historical reference catch period). The biological stock is not considered to be recruitment overfished⁴.

The total allowable catch for the Southern and Eastern Scalefish and Shark Fishery (Commonwealth) for the 2013–14 fishing season was 199 t. Landed catch of western Gemfish from this fishery in the 2013–14 fishing season was 72 t. This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished⁴.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Gemfish biology^{10–12}

Longevity and maximum size	10–15 years; up to 1100 mm TL, 15 kg
Maturity (50%)	Males 3–5 years, females 4–6 years; 500 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Gemfish in Australian waters, 2013 (calendar year)

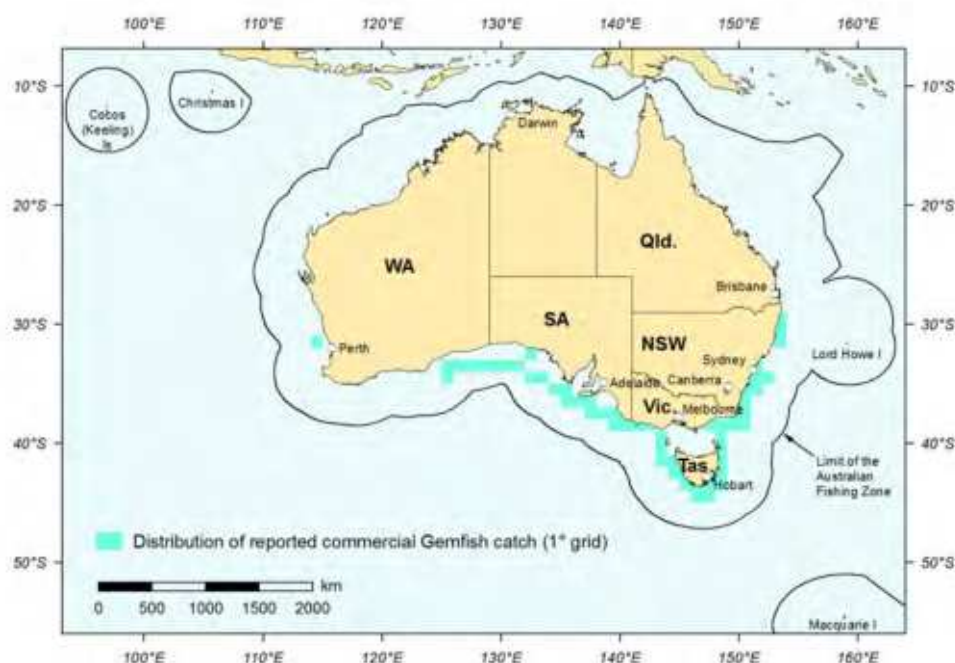


Table 3: Main features and statistics for Gemfish fisheries in Australia, 2013

Jurisdiction	New South Wales ^a	Commonwealth ^a
Fishing methods		
Commercial		
Otter trawl	✓	✓
Hand line	✓	
Dropline	✓	✓
Setline (demersal)	✓	✓
Recreational ^b		
Rod and line	✓	
Electric (automatic) reel	✓	
Indigenous ^c		
Rod and line	✓	
Management methods		
Commercial		
Limited entry	✓	✓
Total allowable catch (incidental)		✓
Trip limits	✓	✓
Spatial closures	✓	✓
Gear restrictions	✓	✓
Recreational ^b		
Bag limits	✓	
Spatial closures	✓	
Gear restrictions	✓	

Jurisdiction	New South Wales ^a	Commonwealth ^a
Indigenous ^{c,d,e}		
Bag limits	✓	
Spatial closures	✓	
Gear restrictions	✓	
Aboriginal cultural fishing authority	✓	
Active vessels		
	6 in OTF 22 in OTLF	34 in CTS 6 in GABTS 7 in GHaT
Catch		
Commercial	<1 t in OTF 10 t in OTLF	106 t in CTS 26 t in GABTS 18 t in GHaT
Recreational ^b	Unknown	
Indigenous ^c	Unknown	
Markets		
Domestic	✓	✓
Export		

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector (Commonwealth); GHaT = Gillnet Hook and Trap Sector (Commonwealth); OTF = Ocean Trawl Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales)

a Data for New South Wales align with the 2013 calendar year. Data for the Commonwealth align with the Commonwealth Southern and Eastern Scalefish and Shark Fishery 2013–14 fishing season (1 May 2013 – 30 April 2014).

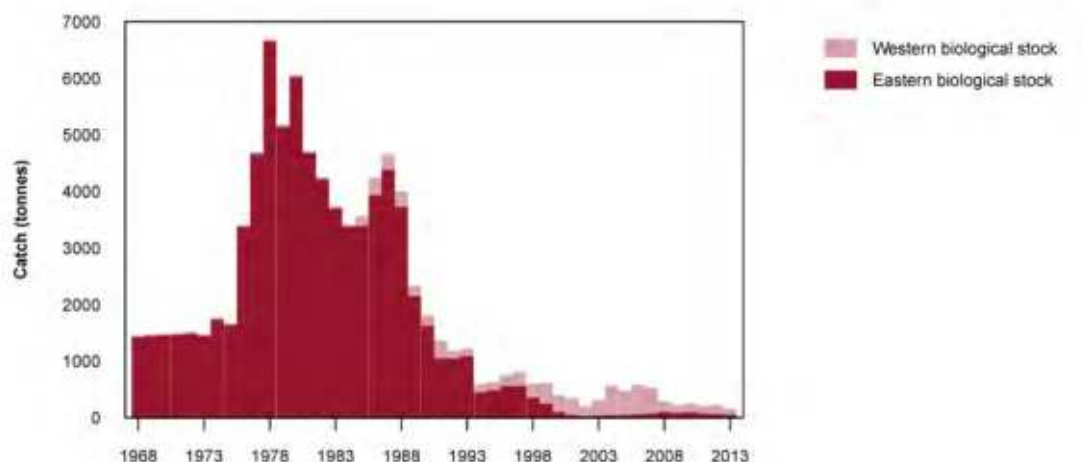
b The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

c The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

d The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

e The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Gemfish in Australian waters, 1968 to 2013 (calendar years)



Effects of fishing on the marine environment

- There can be a substantial level of bycatch in the fish trawl sector. In 2006, mandatory requirements for otter trawls to use 90 mm square-mesh codend panels were introduced to reduce the catch of small species and juvenile fish¹³.
- Interactions also occur with animals protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), including marine mammals (dolphins, seals and sea lions), seabirds, some shark species and seahorses and pipefish (syngnathids). These interactions are reported quarterly by the Australian Fisheries Management Authority¹⁴ and on-board observer programs are used to validate the reporting in commercial logbooks.
- In 2007, the South East Trawl Fishing Industry Association 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 generally¹⁵. Operators have developed other mitigation protocols that have further reduced seal mortalities, including using breakaway ties that keep the net closed until it is below depths that seals regularly inhabit, adopting techniques to close the trawl opening during recovery to minimise opportunities for seals to enter the net, switching off gantry lights that are not required during night trawling to avoid attracting bait species and seals, and dumping offal only when the boat is not engaged in deploying or hauling gear¹⁵.
- In 2011, AFMA mandated individual vessel seabird management plans¹⁶. The seabird action plans are used in the Commonwealth Trawl Sector to mitigate the impacts of trawling on seabirds. Seabird mitigation measures include warp deflectors ('pinkys'), bird bafflers (a system of ropes and PVC piping that protects the warp cable) and seal excluder devices.
- The effects of trawl fishing on the marine environment are assessed through an environmental risk assessment and risk management framework and mitigated through spatial closures, and the implementation of bycatch and discard workplans in the Commonwealth Trawl Sector and Great Australian Bight Trawl Sector fisheries.
- The eastern biological stock of Gemfish is listed as 'Conservation Dependent' under the EPBC Act¹⁷ and is subject to a stock rebuilding strategy⁶.

Environmental effects on Gemfish

- The abundance of Gemfish is likely to be affected by environmental conditions, including ocean currents and temperatures, which may influence habitat suitability, food availability and recruitment¹².

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38. Mulloway *Argyrosomus japonicus*

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Table 1: Stock status determination for Mulloway

Jurisdiction	Western Australia	South Australia		Victoria
Stock	Western Australia (GDSMF, JASDGLFM1, JASDGLFM2, OA, SBBSMNMF, SBPMF, SCEMF, SWTMF; WCDGDLIMF, WCDSIMF, WCEIMF)	LCF	MSF	Victoria (PPBF)
Stock status				
	Undefined	Sustainable	Undefined	Undefined
Indicators	Catch	Catch, CPUE, age structure	Catch, CPUE	Catch

CPUE = catch per unit effort; GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); JASDGLFM1 = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery Zone 1 (Western Australia); JASDGLFM2 = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery Zone 2 (Western Australia); LCF = Lakes and Coorong Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); OA = Open Access – fishing not formally managed (Western Australia); PPBF = Port Phillip Bay Fishery (Victoria); SBBSMNMF = Shark Bay Beach Seine and Mesh Net Managed Fishery (Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); SWTMF = South-west Trawl Managed Fishery (Western Australia); WCDGDLIMF = West Coast Demersal Gillnet and Demersal Longline Interim Managed Fishery (Western Australia); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia); WCEIMF = West Coast Estuarine (Interim) Managed Fishery (Western Australia)

a South Australian Research and Development Institute

b Department of Primary Industries, New South Wales

c Department of Agriculture, Fisheries and Forestry, Queensland

d Department of Fisheries, Western Australia

e Department of Environment and Primary Industries, Victoria

Table 1 continued

Jurisdiction	New South Wales	Queensland
Stock	New South Wales (EGF, OTTF, OHF, OPTF, OTLF)	Queensland (ECIFFF)
Stock status		
	Overfished	Undefined
Indicators	Catch, catch rates, length and age structure, mortality rates	Catch

ECIFF = East Coast Inshore Fin Fish Fishery (Queensland); EGF = Estuary General Fishery (New South Wales); OTTF = Ocean Fish Trawl Fishery (New South Wales); OHF = Ocean Hauling Fishery (New South Wales); OPTF = Ocean Prawn Trawl Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales)

Stock structure

Mulloway is widely distributed in estuaries and near-shore coastal waters (less than 200 m depth) of the Pacific and Indian Oceans, including subtropical and temperate waters of Australia^{1–3}. In Australia, it occurs along the south coast from Exmouth in Western Australia to the Burnett River in Queensland⁴.

Attempts to understand the biological stock structure of Mulloway in Australia have yielded differing results^{1,3,5}. It has been suggested that a single panmictic population of Mulloway occurs in Australia⁵, but this is not supported by studies that suggest substructuring between populations in New South Wales, South Australia and Western Australia^{1,3,6}. As a result, stock status is reported at the jurisdictional level for Western Australia, Victoria, New South Wales and Queensland. For South Australia, status is reported for two functionally independent management units that reflect spatial patterns in commercial fishing⁶.

Stock status

Western Australia

In Western Australia, commercial catches have steadily declined from around 60 tonnes (t) in 2002 to 12 t in 2013⁷. This progressive decline in catch is likely to be related to reductions in fishing effort resulting from changes during that period to the management of some fisheries—for example, the West Coast Demersal Scalefish (Interim) Managed Fishery and Gascoyne Demersal Scalefish Managed Fishery. The lack of biological information and time series of catch-and-effort or catch-rate data for Mulloway in Western Australia limits our understanding of recruitment patterns that could otherwise identify a trend of declining or increasing biomass. As such, there is insufficient information available to confidently classify status in Western Australia.

On the basis of the evidence provided above, Mulloway in Western Australia is classified as an **undefined stock**.

Lakes and Coorong Fishery (South Australia) management unit

The Lakes and Coorong Fishery management unit has traditionally been the most important of the South Australian fisheries for Mulloway, accounting for an average of around 91 per cent of the state's total catch since 2000. From 2003 to 2011, catches of Mulloway by the Lakes and Coorong Fishery were relatively low (less than 45 t per year), reflecting low levels of targeted effort and low catch per unit effort (CPUE)—an available estimate of relative abundance for Mulloway in the Coorong estuary⁸. Since that period, catch has increased sharply, to around 115 t in 2013, and mean annual CPUE has increased to historically high levels. Age-structure analysis revealed that the recent high catches and catch rates were due mainly to the recruitment of a large biomass of juvenile (3–6-year old) fish to the fishery (J Earl, South Australian Research and Development Institute, personal communication). The information provided above suggests that the biomass of Mulloway harvested by the Lakes and Coorong Fishery is unlikely to be recruitment overfished.

Furthermore, the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Marine Scalefish Fishery (South Australia) management unit

The Marine Scalefish Fishery (South Australia) management unit has traditionally provided much lower catches than the Lakes and Coorong Fishery (South Australia). Catches were historically low through the mid- to late 2000s, as a result of historically low targeted fishing effort. However, since the early 1990s, commercial CPUE has followed an increasing trend, indicating a possible gradual increase in fishable biomass⁸. The lack of age data for Mulloway harvested by the Marine Scalefish Fishery limits our understanding of recruitment patterns that could otherwise inform trends in biomass in this management unit. As such, there is insufficient information available to confidently classify the status of this management unit.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Victoria

Commercial catches in Victoria have mostly been landed from Port Phillip Bay, and from Western Port until Western Port was closed to commercial net fishing in 2008. Most of the catch was taken using mesh nets and haul seines. Over the past 10 years, annual catch by the commercial sector has been less than 0.6 t.

Recreational fishing for Mulloway has become increasingly popular over the past few years. The fishery is distributed throughout Victorian estuaries, rivers and nearby beaches. No assessment or review of the data available for this species has been conducted in recent years. The lack of biological information and time series of catch-and-effort or catch-rate data for Mulloway in Victoria limits our understanding of recruitment patterns and our ability to make a meaningful assessment. As such, there is insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, Mulloway in Victoria is classified as an **undefined stock**.

New South Wales

Commercial landings in New South Wales steadily declined from almost 400 t in the mid-1970s to 37 t in 2008–09. Commercial landings have been less than 100 t per year since the mid-1990s. In 2013, the total commercial catch for New South Wales was 65 t. Nominal commercial catch rates for Mulloway have declined during the past 20 years in both the ocean and estuarine fisheries (unpublished data from New South Wales Department of Primary Industries). The average lengths of Mulloway landed by the commercial fishery have declined since the mid-1990s^{3,9}. The age composition of fish in commercial landings in the early 2000s was indicative of a heavily fished stock (98 per cent of catch was less than 5 years old)^{3,9}. Fishing mortality is estimated to be greater than natural mortality^{3,9}. The spawning potential ratio for Mulloway was estimated to be between 4 and 14 per cent^{3,10}, which is below the threshold reference point of 25 per cent. This indicates that there may be a high risk of recruitment failure^{11,12}. The above evidence indicates that the stock is likely to be recruitment overfished.

In 2013, a recovery program for Mulloway was introduced in New South Wales to arrest the decline in commercial and recreational Mulloway fisheries. Management changes to the recreational Mulloway fishery consisted of an increase in legal minimum size from 45 to 70 cm (the approximate size-at-maturity for female Mulloway in New South Wales^{3,9,13}) and a 40 per cent reduction in the bag limit. Management changes to the commercial Mulloway fishery consisted of the above increase in legal minimum size (with bycatch limits for the estuarine mesh net fishery) and a 500 kg trip limit for the beach-hauling net sector. The above evidence indicates that current fishing pressure is constrained by management to a level that should allow the stock to recover from its recruitment overfished state. However, measurable improvements are yet to be detected.

On the basis of the information provided above, Mulloway in New South Wales is classified as an **overfished stock**.

Queensland

Mulloway are predominantly taken by recreational anglers in Queensland, with an estimated 133 t caught in 2010–11¹⁴. The East Coast Inshore Fin Fish Fishery (Queensland) contributes minimal quantities (5-year average of 2 t) to the overall Queensland harvest of Mulloway. The legal size limit (75 cm total length) protects a proportion of spawning fish from fishing, while a conservative recreational bag limit (two fish) reduces

fishing pressure on the stock. There are anecdotal reports of incidental mortality of Mulloway below the legal minimum size from commercial net fisheries; however, this has not been quantified. Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Mulloway in Queensland is classified as an **undefined stock**.

Table 2: Mulloway biology^{1,13,15,16}

Longevity and maximum size	42 years; 2000 mm TL
Maturity (50%)	2–6 years; 510–1070 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Mulloway in Australian waters, 2013 (calendar year)

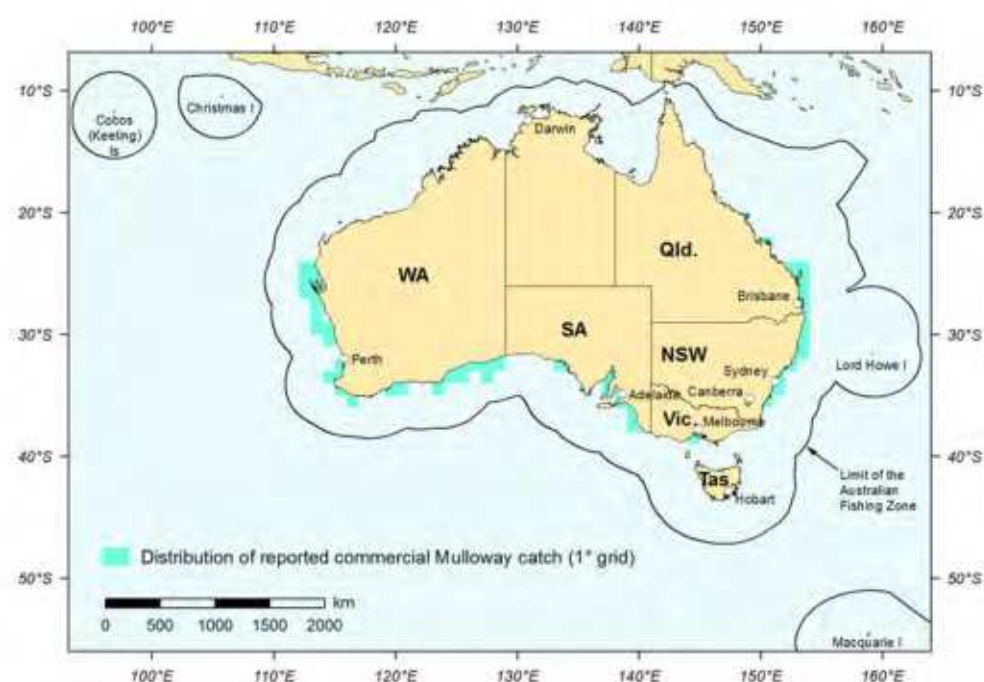


Table 3: Main features and statistics for Mulloway fisheries in Australia, 2013 (calendar year)

Jurisdiction	Western Australia	South Australia	Victoria	New South Wales	Queensland
Fishing methods					
Commercial					
Haul nets	✓	✓	✓	✓	
Beach-seine nets	✓		✓	✓	✓
Trawl nets	✓			✓	
Swinger nets		✓			
Longline	✓	✓			

Jurisdiction	Western Australia	South Australia	Victoria	New South Wales	Queensland
Mesh (gill) nets	✓	✓	✓	✓	✓
Rod and line	✓	✓		✓	
Recreational					
Rod and line	✓	✓	✓	✓	✓
Mesh (gill) nets		✓			
Spearfishing	✓			✓	✓
Indigenous ^{a,b,c}					
Rod and line		✓		✓	✓
Mesh (gill) nets		✓			
Spearfishing				✓	
Traditional apparatus	✓	✓			✓
Management methods					
Commercial					
Limited entry	✓	✓	✓	✓	✓
Size limits	✓	✓	✓	✓	✓
Gear restrictions	✓	✓	✓	✓	✓
Spatial closures	✓	✓	✓	✓	✓
Vessel restrictions	✓				
Catch limits	✓			✓	
Effort limits	✓			✓	
Temporal closures	✓	✓			✓
Bycatch limits ^d				✓	
Recreational					
Licence	✓ ^e		✓	✓	
Gear restrictions	✓	✓	✓	✓	✓
Spatial closures	✓	✓	✓	✓	✓

Jurisdiction	Western Australia	South Australia	Victoria	New South Wales	Queensland
Temporal closures	✓	✓		✓	
Bag limits	✓	✓	✓	✓	✓
Possession limits					✓
Size limits	✓	✓	✓	✓	✓
Indigenous ^{a,b,f,g}					
Licence	✓ ^e			✓	
Gear restrictions	✓	✓		✓	✓
Spatial closures	✓	✓		✓	
Temporal closures	✓	✓		✓	
Bag limits	✓	✓		✓	
Size limits	✓	✓		✓	
Section 37(1)(c1), Aboriginal cultural fishing authority				✓	
Active vessels					
	10 in GDSMF 2 in JASDGDLMF1 9 in JASDGDLMF2 2 in OA 2 in SBBSMNMF 4 in SBPMF 6 in SCEMF 2 in SWTMF 2 in WCDGDLIMF 22 in WCDSIMF 1 in WCEIMF	28 in LCF 16 in MSF	2 in PPBF	226 in EGF 16 in OFTF 19 in OHF 20 in OPTF 78 in OTLF	18 in ECIFFF
Catch					
Commercial	3 t in GDSMF 2 t in JASDGDLMF1	115 t in LCF 3 t in MSF	<1 t in PPBF	41 t in EGF <1 t in OFTF 8 t in OHF	2 t in ECIFFF

Jurisdiction	Western Australia	South Australia	Victoria	New South Wales	Queensland
	3 t in JASDGLFM2 <1 t in OA <1 t in SBBSMNMF <1 t in SBPMF <1 t in SCEMF <1 t in SWTMF <1 t in WCDGDLIMF 4 t in WCDSIMF <1 t in WCEIMF			<1 t in OPTF 15 t in OTLF	
Recreational	6 t (2011–12)	38 t (2007–08)	11 t (2000–01)	274 t (2000–01)	133 t (2010–11)
Indigenous	Unknown	Unknown	None	Unknown	Unknown
Markets					
Domestic	✓	✓	✓	✓	✓
Export					

ECIFF = East Coast Inshore Fin Fish Fishery (Queensland); EGF = Estuary General Fishery (New South Wales); GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); JASDGLFM1 = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery Zone 1 (Western Australia); JASDGLFM2 = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery Zone 2 (Western Australia); LCF = Lakes and Coorong Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); OA = Open Access – fishing not formally managed (Western Australia); OFTF = Ocean Fish Trawl Fishery (New South Wales); OHF = Ocean Hauling Fishery (New South Wales); OPTF = Ocean Prawn Trawl Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales); PPBF = Port Phillip Bay Fishery (Victoria); SBBSMNMF = Shark Bay Beach Seine and Mesh Net Managed Fishery (Western Australia); SBPMF = Shark Bay Prawn Managed Fishery (Western Australia); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); SWTMF = South-west Trawl Managed Fishery (Western Australia); WCDGDLIMF = West Coast Demersal Gillnet and Demersal Longline Interim Managed Fishery (Western Australia); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia); WCEIMF = West Coast Estuarine (Interim) Managed Fishery (Western Australia)

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Mulloway.

b Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and bag limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

c Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

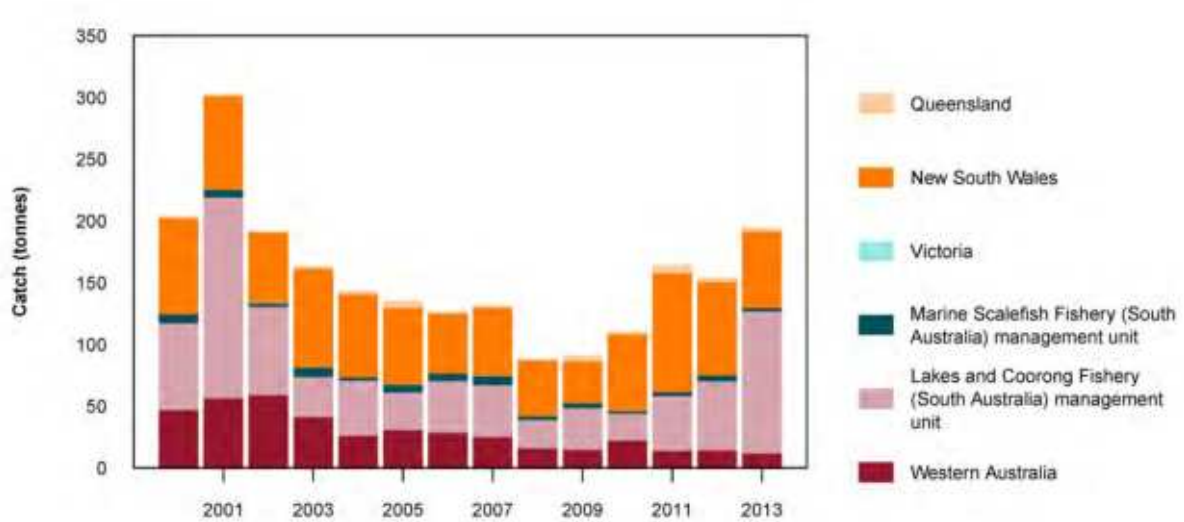
d Fishers using meshnets in the New South Wales commercial Estuary General Fishery are permitted a bycatch allowance of 10 mulloway, between 45 and 70 cm per day.

e In Western Australia, a recreational fishing licence is required for boat-based fishing only.

f The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

g The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Mulloway in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Mulloway are targeted by commercial fisheries using mainly gill nets, hauling nets and line fishing. These activities are considered to pose a low risk to the physical environment (for example, substratum and benthic habitats)^{7,17}.
- Some bycatch may be expected from mesh nets used to target Mulloway, including the capture of small individuals of some species^{18,19}. However, gill nets are relatively selective¹⁷.

Environmental effects on Mulloway

- Estuaries are important nursery areas for Mulloway through the first 3–8 years of their life history¹⁶. The quality and availability of habitat and trophic resources for Mulloway in estuaries are largely dependent on the quality, magnitude, frequency and timing of seasonal freshwater inflows to estuaries, which affect recruitment and the availability of fish to estuarine-based fisheries.

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39. Murray Cod *Maccullochella peelii*

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Table 1: Stock status determination for Murray Cod

Jurisdiction	South Australia	Victoria	New South Wales	Australian Capital Territory	Queensland
<i>Stock</i>	South Australia	Victoria	New South Wales	Australian Capital Territory	Queensland
<i>Stock status</i>					
	Undefined	Undefined	Undefined	Undefined	Undefined
<i>Indicators</i>	CPUE, age/size composition	CPUE, age/size composition	CPUE, age/size composition	CPUE, age/size composition	CPUE, age/size composition

CPUE = catch per unit effort

Stock structure

Murray Cod is the largest solely freshwater fish in Australia. It occurs throughout most of the Murray–Darling system, except for the upper reaches of some tributaries in Victoria and southern New South Wales. Investigation of the genetic structure of Murray Cod in the Murray–Darling Basin has demonstrated that, where there is connectivity between catchments, one large genetically panmictic biological stock exists throughout most of its distribution¹. However, genetically distinct populations have been identified in the Lachlan, Macquarie and Gwydir catchments¹. This separation appears to be the result of restricted gene flow due to wetland barriers, but may also be influenced by stocking programs¹.

Although genetic studies show evidence for one large biological stock, stock status of Murray Cod is reported at a jurisdictional level because of differences in management arrangements and available information.

Stock status

Murray Cod is the most socially, economically and culturally important freshwater fish species in the Murray–Darling Basin. It supports important recreational fisheries and is an important fish to Indigenous Australians^{2,3}. For example, anglers specifically targeting Murray Cod in Victoria alone contribute approximately \$59 million

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per year to the economy and support an estimated 374 jobs²; this figure is expected to be much higher across the species' range. Commercial fishing for Murray Cod is currently prohibited in the Murray–Darling Basin.

Since European settlement, populations of Murray Cod have generally declined throughout its range as a result of a number of threats, including river regulation, habitat degradation, disease, and exploitation by commercial and recreational fishers^{4–7}. Take by recreational anglers has also been shown to affect population structure⁸. Consequently, Murray Cod is listed as 'Vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). A national recovery plan has been developed for this species⁹. A cross-jurisdictional Murray Cod Fishery Management Group was established to improve collaboration on, and alignment of, recreational fisheries management and research for the species across the Basin¹⁰. Management strategies, including the closure of commercial fisheries, harvest restrictions, restocking, and seasonal closures to protect spawning populations, have resulted in recovery in some areas^{11–16}. However, there are still concerns for Murray Cod stocks across much of their range, and Basin-wide recovery may take decades.

South Australia

In South Australia, previous stock assessments for Murray Cod in the lower Murray River and Lower Lakes highlighted a significant decline in annual commercial landings, from 140 tonnes (t) in the late 1950s to less than 10 t in the 1970s and 1980s^{17,18}. Following a moratorium on commercial and recreational fishing, combined with high flows in the early 1990s, annual catch increased gradually to 28.5 t in 2001–02. The Murray Cod commercial fishery ceased in the South Australian lower Murray River in July 2003 following restructuring of inland native fisheries. Although Murray Cod is still a 'permitted species' to be taken in the commercial Lakes and Coorong Fishery, there is currently a temporary closure (implemented in 2010 under the *Fisheries Management Act 2007* (SA)) that prohibits Murray Cod from being harvested. Unlike some other jurisdictions, stocking practices have not been adopted in the South Australian lower Murray¹⁹.

In the absence of a commercial fishery, ongoing recreational fishery surveys or dedicated fishery-independent Murray Cod monitoring programs, the most recent assessment of the population dynamics of South Australian Murray Cod was conducted using data from three long-term (8–11-year) fish assemblage monitoring projects undertaken in the lower Murray River from 2002 to 2013²⁰. Catch per unit effort of electrofishing and drum netting indicates that Murray Cod relative abundance has remained reasonably constant over the past 8–11 years. Length-frequency distributions suggest that the majority of Murray Cod collected in the main channel habitats of the lower Murray River were large (more than 800 mm in length), and these fish represent a broad range of age classes (8–46 years). Murray Cod recruitment was minimal in the predominantly stillwater main channel habitats during the drought from 2001 to 2010. Nevertheless, some juvenile fish (less than 500 mm total length) were collected in main channel habitats in years following increases in water flow (for example, 2010–11). Consistent recruitment was evident in the flowing water habitats of the Chowilla anabranch system during the same period (2002 to 2013). Construction and operation of a regulator on Chowilla Creek may modify the hydraulic characteristics of the anabranch system and presents a risk to Murray Cod recruitment in this important area²¹. Despite these data, insufficient information is available to confidently classify the biomass of Murray Cod in the South Australian reaches of the Murray River.

The most recent South Australian Recreational Fishing Survey, in 2007–08, estimated that 507 Murray Cod (around 2.1 t) were harvested from the lower Murray River²². No Murray Cod were reported as caught in the Lower Lakes region. There was little change in the total number of fish caught since the 2000–01 survey²³, but release rates have increased from 16 per cent in 2000–01 to 73 per cent in 2007–08. The 2007–08 figures should be considered only as indicative because the precision levels of all estimates were low (for example, numbers $\pm$ 971) as a result of low numbers of participants reporting Murray Cod catch, as well as low numbers of Murray Cod harvested. There was a moratorium on recreational fishing for this species in 2009 and 2010 in South Australia. Since 2011, a catch-and-release fishery has been permitted for Murray Cod in the South Australian Murray River, except for a closure area in Chowilla. However, uncertainty remains about the level of fishing effort and overall post-release mortality associated with the catch-and-release fishery. The above evidence indicates that insufficient information is available to confidently classify the fishing pressure on Murray Cod.

Because of the uncertainty regarding mortality and biomass, insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Murray Cod in South Australia is classified as an **undefined stock**.

Victoria

In Victoria, Murray Cod numbers are currently much lower than pre-European levels. During the 19th century Murray Cod populations were considered abundant in the Loddon, Campaspe and Goulburn rivers²⁴. However, by the middle of the 20th century, these populations of Murray Cod had declined in these rivers²⁵. Commercial catch rates continued to decline across the Murray–Darling Basin, including in Victoria, in the 1960s. In Victoria, commercial catches of Murray Cod were highest between 1954–55 and 1960–61, at approximately 10–15 t per year; catches were approximately 1.5 t per year on average in the next 10 years and negligible thereafter²⁶. No estimates of catch per unit effort have been recorded for Victoria; consequently, it is difficult to compare Victorian commercial catch data through time.

Hatchery-produced Murray Cod have been stocked in Victoria since 1981. In 2013, approximately 600 000 Murray Cod were stocked into 29 waters across Victoria. Other surveys, such as the Murray–Darling Basin Authority Sustainable Rivers Audit¹², indicate fish biomass to have increased in some catchments (Ovens, Goulburn and Loddon rivers) and declined in others (Broken and Kiewa rivers)¹³. In the absence of current statewide recreational fishing survey data, insufficient information is available to confidently classify the biomass of Murray Cod.

The last statewide estimate of recreational catch of Murray Cod in Victoria was measured as part of the National Recreational and Indigenous Fishing Survey²³. The 2000–01 survey estimated that 11 943 Murray Cod were harvested by Victorian anglers, equating to 27 469 kg of biomass. Between 2006 and 2008, recreational fishing creel surveys have been conducted on selected river reaches in Victoria, including the Goulburn, Ovens, Loddon and Murray rivers²⁷. Total Murray Cod catch within these river reaches was estimated at more than 98 000 fish, of which just over 6500 were harvested. Release rate for Murray Cod was around 90 per cent overall, with most releases being compulsory because the fish were smaller than the legal minimum length. Voluntary release rates of 14–32 per cent of fish larger than the minimum size limit were observed in the Goulburn and Murray rivers. The above evidence indicates that insufficient information is available to confidently classify the fishing pressure on Murray Cod.

On the basis of the evidence provided above, Murray Cod in Victoria is classified as an **undefined stock**.

New South Wales

In New South Wales, Murray Cod numbers are generally considered to be much lower than pre-European levels. Concerns were raised as early as 1880 about declines in the abundance of Murray Cod in New South Wales, based largely on falling catch rates in the commercial fishery⁷. The commercial fishery for Murray Cod was established throughout the lower Murray–Darling Basin in New South Wales in the mid-1800s. Catch rates declined dramatically from a high in the mid-1950s of around 140 t to less than 35 t by the mid-1960s, while fishing effort remained at around the same level⁷. The annual catch remained below 35 t in all years but 1974–75 until the fishery was closed in New South Wales in 2001.

Anecdotal reports and scientific surveys¹¹ suggest that there has been an increase in the abundance of Murray Cod in some New South Wales rivers²⁸. These include the Murrumbidgee River and many of the rivers in the Border Rivers region in the far north of the state.

As part of the recovery process in New South Wales, hatchery-reared Murray Cod have been stocked extensively in many of the impoundments and rivers throughout the state. It is estimated that 5 million fry and fingerlings have been produced and released since the program commenced in the early 1980s²⁸. Until recently, little was known of the success of these stockings, and it was largely assumed that stocking was a primary contributor to the recovery of the species in some systems. As part of the New South Wales Effectiveness of Stocking program, an assessment of Murray Cod stocks was undertaken in two rivers in the southern Murray–Darling Basin and one impoundment in north-western New South Wales²⁹. A comparatively low proportion of stocked Murray Cod was caught in the Murray River (7 per cent) and Murrumbidgee River (15 per cent), which could suggest that these populations are primarily self-supporting through natural recruitment²⁸. In contrast, stocked Murray Cod comprised almost the entire population (94 per cent) within Copeton Dam²⁸. These data suggest that, although stocking is helping with the recovery of Murray Cod in New South Wales, other management actions such as closed seasons, size-and-bag regulations and habitat rehabilitation are also contributing. The above evidence indicates that insufficient information is available to confidently classify the biomass of Murray Cod.

Although there is now no commercial fishery for Murray Cod in New South Wales, the recreational fishery for this species has continued to grow. The 2000–01 national survey estimated that, at that time, about 483 000 Murray Cod were caught annually by recreational anglers throughout south-eastern Australia, with around 78 per cent of these fish released²³. A more recent survey undertaken in 2012–13 across 76 km of the Murrumbidgee River estimated annual catch of Murray Cod within the reach to be as high as 32 000, with only 5 per cent of these retained²⁹. These results suggest that targeting of the species by the recreational sector remains high, and that the practice of catch and release may be increasing. The above evidence indicates that insufficient information is available to confidently classify the fishing pressure on Murray Cod.

On the basis of the evidence provided above, Murray Cod in New South Wales is classified as an **undefined stock**.

Australian Capital Territory

In the Australian Capital Territory, Murray Cod numbers are generally considered to be much lower than pre-European levels. Anecdotal evidence noted that the species had declined considerably before 1980³⁰. Murray Cod is stocked in a number of urban lakes to provide recreational fishing opportunities, as well as to provide an apex predator for these artificial systems³¹. Approximately 690 000 Murray Cod fingerlings have been stocked since the program began in 1981³¹, with approximately 20 000–30 000 stocked annually. Stocking of native fish for recreational purposes is not conducted in riverine environments, and there have been no conservation stockings of the species³¹. Murray Cod have never been commercially harvested in the Australian Capital Territory, but have long been a popular recreational target both in the Murrumbidgee and Molonglo rivers and in the urban lakes. An angler survey in 1999–2001 of the Murrumbidgee River in the Australian Capital Territory identified that Murray Cod were the equal highest species targeted (along with Golden Perch)³². The National Recreational and Indigenous Fishing Survey²³ did not report Murray Cod harvest data for the Australian Capital Territory. However, data from associated sampling, although sparse, indicate that only 25 per cent of Murray Cod were retained and that a higher proportion of retained fish (40 per cent) were captured from rivers than from dams. Stocked populations in urban lakes continue to provide localised, but well-regarded, recreational fisheries. However, the absence of regular or consistent creel or angler surveys on either the urban lakes or the Murrumbidgee River means that insufficient information is available to confidently classify the fishing pressure on Murray Cod.

Because the majority of ecological knowledge of Murray Cod has been derived from studies in lowland habitats^{33–35}, and there is little knowledge of Murray Cod ecology in upland regions, management arrangements and regulations for Murray Cod in the Australian Capital Territory have largely mirrored those in force in surrounding New South Wales. This arrangement has also minimised confusion for cross-border anglers. A recent 3-year study into the recruitment ecology of Murray Cod in the upper Murrumbidgee River revealed that spawning occurs at similar times to that recorded in lowland environments, with peak larval drift usually occurring in mid-November.

No obvious change in abundance of riverine populations of Murray Cod in the Australian Capital Territory has been seen since the 1980s. A standardised biennial fish monitoring program in the Murrumbidgee River in the Australian Capital Territory from 1994 to 2008 revealed little change in cod abundance, but sampling techniques (net based) were not particularly appropriate for sampling Murray Cod (unpublished data from the ACT Government). Subsequent monitoring has employed boat electrofishing, with higher numbers of cod captured. The above evidence indicates that insufficient information is available to confidently classify the biomass of Murray Cod.

On the basis of the evidence provided above, Murray Cod in the Australian Capital Territory is classified as an **undefined stock**.

Queensland

It is generally accepted that native fish populations in the Murray–Darling Basin’s rivers have declined to an estimated 10 per cent of the levels before European settlement⁶; this is partially supported by anecdotal evidence provided by anglers in Queensland³⁶. The decline has resulted from flow regulation, habitat degradation, reduced water quality, barriers to movement, introduced species and overexploitation from illegal fishing⁶. The recent Murray–Darling Basin Authority Sustainable Rivers Audit and anecdotal evidence from recreational anglers suggest an increase in Murray Cod numbers in the Border Rivers region, which may be attributed to the extensive stocking in this catchment³⁷. The audit and other fishery-independent monitoring have been undertaken in several other rivers and catchments in Queensland^{6,36}. However, the lack

of consistency in sampling methodologies and the low numbers of Murray Cod recorded during the monitoring provided insufficient data to estimate biomass of Murray Cod in Queensland. Targeted monitoring is required to determine the current biomass of Murray Cod stocks in Queensland.

Approximately 100 000 Murray Cod have been stocked each year throughout their range in Queensland since the inception of the Recreational Fishing Enhancement Program in the mid-1980s. A large proportion of these fingerlings are stocked into impounded areas, where the levels of natural recruitment are low. The Queensland area of the Murray–Darling Basin has never supported a commercial fishery for this species. The above evidence indicates that insufficient information is available to confidently classify the biomass of Murray Cod.

Murray Cod support a considerable recreational fishery throughout the northern Murray–Darling catchment in Queensland. The species is mostly targeted within the Dumaresq, Macintyre, Moonie, Condamine, Balonne and Warrego rivers and their tributaries; fish are also occasionally reported from the Paroo River^{36,38}. A survey of recreational participation and catch was conducted in 2010³⁸. Unfortunately, little catch data for Murray Cod were collected during the survey, and any estimates of harvest for Murray Cod are unreliable and not informative. Data from a more recent study in the Border Rivers region suggest that harvest of Murray Cod remains high, with most fish being removed from the population within a couple of years of reaching legal size³⁷. Insufficient information is available to confidently determine the overall fishing mortality of the Murray Cod stock in Queensland, and further research is required to acquire this information. The above evidence indicates that insufficient information is available to confidently classify the fishing pressure on Murray Cod.

On the basis of the evidence provided above, Murray Cod in Queensland is classified as an **undefined stock**.

Table 2: Murray Cod biology^{34,39–44}

Longevity and maximum size	At least 48 years; ~1800 mm TL, 83 kg
Maturity (50%)	First maturity at ~4–5 years; ~450–600 mm TL for both sexes Variable across geographic regions

TL = total length

Figure 1: Distribution of Murray Cod based on reported catch in the Murray–Darling Basin, Australia, 2006 to 2013 (calendar years)

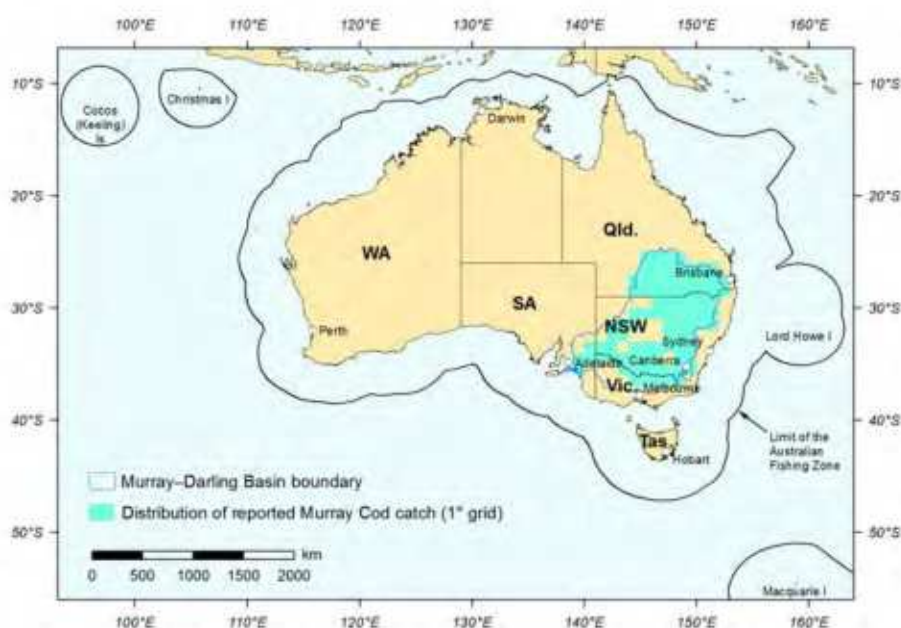


Table 3: Main features and statistics for Murray Cod in Australia, 2013 (calendar year)

Jurisdiction	South Australia	Victoria	New South Wales	Australian Capital Territory	Queensland
Fishing methods					
Commercial					
	None	None	None	None	None
Recreational					
Rod and line	✓	✓	✓	✓	✓
Hand line	✓	✓	✓	✓	✓
Indigenous					
Rod and line	✓	✓	✓	✓	✓
Hand line	✓	✓	✓	✓	✓
Traditional gear (e.g. spears, nets, traps)	✓	✓	✓		✓
Management methods					
Commercial ^a					
	n/a	n/a	n/a	n/a	n/a
Recreational					
Bag limits	✓	✓	✓	✓	✓
Size limits		✓	✓	✓	✓
Seasonal closures	✓	✓	✓	✓	✓
Area closures	✓			✓	✓
Indigenous ^{b,c}					
Bag limits	✓	✓	✓	✓	✓
Size limits	✓	✓	✓	✓	✓
Catch					
Commercial	None	None	None	None	None
Recreational	Unknown	Unknown	Unknown	Unknown	Unknown
Indigenous	Unknown	Unknown	Unknown	Unknown	Unknown

Jurisdiction	South Australia	Victoria	New South Wales	Australian Capital Territory	Queensland
Markets					
Domestic					
Export					

n/a = not applicable

a Murray Cod captured by the Lakes and Coorong Fishery are currently protected under South Australian fishing regulations.

b Indigenous fishers who can satisfy the requirements of the *Native Title Act 1993* (Cth) in relation to their connection to the specific area or waters may take sufficient Murray Cod to satisfy their customary, noncommercial domestic needs in South Australia and Queensland. Indigenous fishers who do not satisfy these requirements are subject to the standard recreational bag limits, size limits and closures.

c In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (for example, different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Murray Cod.

Effects of fishing on the freshwater environment

- Although Murray Cod is no longer targeted by commercial fishing, it is a highly prized catch for recreational anglers. Release rates are very high for this species because of catch-and-release practices or specific fishing regulations²³, which differ considerably between jurisdictions. Studies have investigated the post-release mortality of Murray Cod and found it to be between 2 and 15 per cent^{45,46}. In some cases, post-release mortality may contribute at least as much to fishing mortality of Murray Cod as harvest⁴⁵.
- Recreational fishers targeting Murray Cod often make incidental catches of other native species, such as Trout Cod and Golden Perch. The recreational catch of these other species is also controlled under state and territory recreational fishing regulations, but there may be post-release mortalities for these species. In general, recreational fishing for Murray Cod is thought to have minimal impact on the freshwater environment¹. Implications of disease and other potential environmental risks also need to be considered¹⁹. In addition, use of live organisms as bait is considered risky because of its potential to introduce and spread disease or noxious species, and the negative impacts that this may have on ecosystems⁴⁷.

Environmental effects on Murray Cod

- Like many freshwater fish in the Murray–Darling Basin, Murray Cod populations have declined since the early 1900s as a result of anthropogenic impacts, such as altered natural flow regimes, habitat loss, barriers to movement, cold-water releases from dams, interactions with alien species and overharvesting⁵. Murray Cod prefer structurally complex habitats (for example, coarse wood and overhanging vegetation) in the main channel of the river and anabranches^{48,49}. Habitat alteration, such as removal of snags from the main channel and anabranches, will decrease habitat availability and potentially reduce Murray Cod abundance. In addition, fast-flowing lotic habitats are considered to be important for survival of Murray Cod larvae, and as a habitat for juveniles and adults²⁰. Alteration to these conditions through anthropogenic (river regulation and water extraction) or natural (floods and drought) factors are likely to affect stocks.
- Enhanced recruitment of Murray Cod in lowland areas has been linked to increased river flow or flooding^{18,34}. The exact mechanism behind recruitment is unknown, but it is likely to be linked to an increase in food resources for larvae and juveniles following floodplain inundation³⁴.
- In lowland rivers, Murray Cod can undertake small- to large-scale movements (greater than 100 km) within the main river channel and anabranches, and between these habitats^{50,51}. Lateral and longitudinal

disconnection (for example, by structures or reduced flow) will alter the movement patterns of the species. In upland rivers, movements are likely to be limited by natural barriers such as gorges and waterfalls.

- Cold-water pollution due to low-level releases from dams has been deemed responsible for the loss of Murray Cod populations downstream of a number of impoundments^{52,53}. Anoxic blackwater events in lowland environments that may occur as a result of flooding after prolonged periods of low flow, and other poor water quality events, can result in considerable mortality of Murray Cod^{51,54}.

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40. Pink Ling *Genypterus blacodes*

Andrew Penney^a and Michael Lowry^b



Table 1: Stock status determination for Pink Ling

Jurisdiction	Commonwealth, New South Wales	
Stock	Western (CTS, GABTS, GHaTS)	Eastern (CTS, GHaTS, OTLF)
Stock status		
	Sustainable	Undefined
Indicators	Spawning stock biomass, fishing mortality	Spawning stock biomass, fishing mortality

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector (Commonwealth); GHaTS = Gillnet, Hook and Trap Sector (Commonwealth); OTLF = Ocean Trap and Line Fishery (New South Wales)

Stock structure

Clear and persistent differences in size and age composition, and substantial differences in trends in catch rates indicate the existence of different stocks east and west of South Cape, Tasmania (147°E). However, no genetic differences have been identified between these areas¹. The stocks were previously managed as a single stock, but in 2013 it was agreed that they would be managed separately. For the purposes of this report, separate eastern and western biological stocks are assumed.

Stock status

Before 2013, Pink Ling was managed as a single stock. About 54 per cent of the catch was taken from the eastern biological stock until 2009. Catches have been close to the single stock total allowable catch (TAC) over the past decade, and assessments indicate that catches exceeded sustainable levels for the eastern biological stock over that period.

Western biological stock

In 2013, the Australian Fisheries Management Authority's Slope Resource Assessment Group accepted an updated stock assessment for Pink Ling² that assumed separate stocks. The western stock experienced a 20 per cent decline in standardised catch rates between 1986 and 2009. The 2013 assessment estimated the biomass of the western stock to be at 58 per cent of unfished spawning biomass, well above the management target (48 per cent of unfished spawning biomass)². The stock is not considered to be recruitment overfished³. The assessment estimated a long-term yield of 661 tonnes (t), and this was adopted as a 3-year recommended biological catch. Western catches were below this level in 2012 and 2013, and the assessment indicates that this level of fishing mortality will not result in the stock becoming recruitment overfished.

On the basis of the evidence provided above, the western biological stock is classified as a **sustainable stock**.

Eastern biological stock

Most of the eastern Pink Ling catch is made in the Commonwealth trawl and autoline fisheries within the

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^b Department of Primary Industries, New South Wales

Southern and Eastern Scalefish and Shark Fishery. Catches of eastern Pink Ling in this fishery have declined steadily from about 1000 t per year in 2000 to less than 400 t per year in 2013. The New South Wales Ocean Trap and Line Fishery in the same region also takes Pink Ling; the New South Wales catch increased from about 10 t in 2000 to about 50 t in 2013.

The 2013 updated two-stock assessment² determined that the status of the eastern stock declined steadily from 1975, reaching the limit reference point (20 per cent of unfished spawning biomass) in about 2009, indicating that the stock was recruitment overfished at that stage. Based on the 2010 stock assessment, the Commonwealth TAC for this assumed single stock was reduced from 996 t for 2012–13 to 834 t for the 2013–14 fishing season. As a result of management and industry efforts to reduce catches in the east in response to this TAC decrease, the eastern stock contribution (283 t) to total Pink Ling catch declined to about 43 per cent in 2013.

The eastern fishery experienced a 54 per cent decline in standardised catch rates between 1986 and 2009, but is assessed to have increased thereafter. The 2013 assessment² estimated the biomass of the eastern stock to be above the limit reference point, at 26 per cent of unfished spawning biomass, but with a 15 per cent probability of being below the limit. The assessment was used as the basis for considered projections of rebuilding to the target biomass at a range of alternative future catch levels, from 0 t (projected to rebuild to target by 2019) to 500 t (projected to rebuild to target by 2047). The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

The Australian Fisheries Management Authority implemented a combined Commonwealth Pink Ling TAC of 996 t for the 2014–15 fishing season, with the intention of administering this as separate 3-year TACs of 349 t for the eastern stock and 647 t for the western stock. This level is above the short-term RBC level derived from the harvest strategy decision rule for the eastern stock. However, limiting eastern catches to 349 t is projected to rebuild the eastern biological stock to the management biomass target by about 2026, with a less than 10 per cent risk of the stock being below the limit reference point in 2015 and beyond. It remains to be seen whether the stock does indeed continue to trend upwards at this catch level. Given uncertainty in the reliability of projections, it is not yet clear whether fishing mortality is below the level required to rebuild towards the target.

On the basis of the evidence provided above, the eastern Australian biological stock of Pink Ling is classified as an **undefined stock**.

Table 2: Pink Ling biology^{4,5}

Longevity and maximum size	25–30 years; 1600–1750 mm TL
Maturity (50%)	7–12 years; 700–1000 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Pink Ling in Australian waters, 2013 (calendar year)

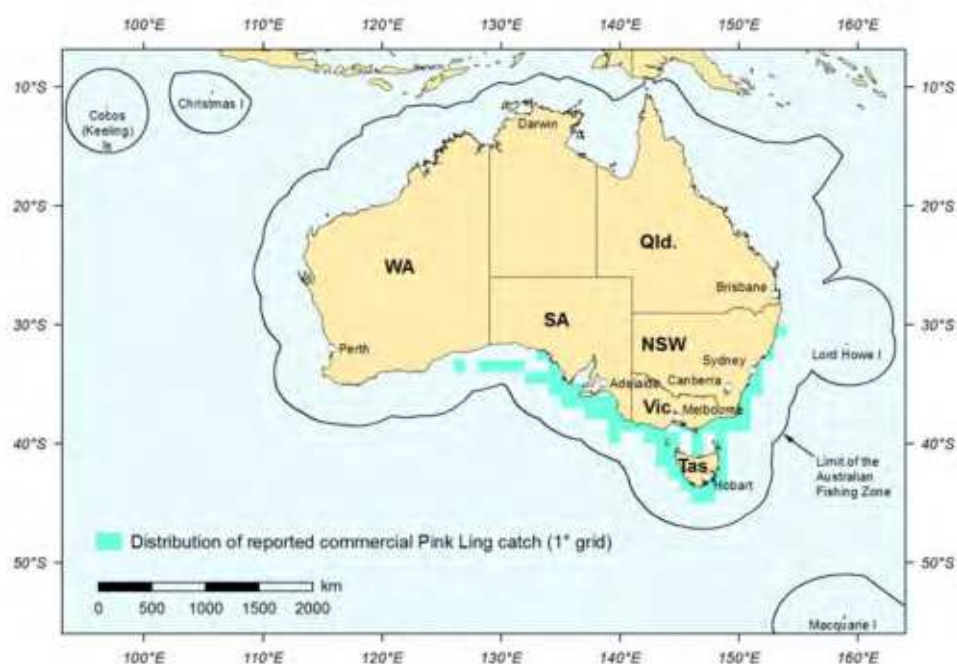


Table 3: Main features and statistics for Pink Ling fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth	New South Wales
Fishing methods		
Commercial		
Demersal trawl	✓	
Autoline hook	✓	
Bottom longline hook	✓	✓
Recreational ^a		
		Unknown
Indigenous ^b		
		Unknown
Management methods		
Commercial		
Limited entry	✓	✓
Total allowable catch	✓	
Spatial closures	✓	

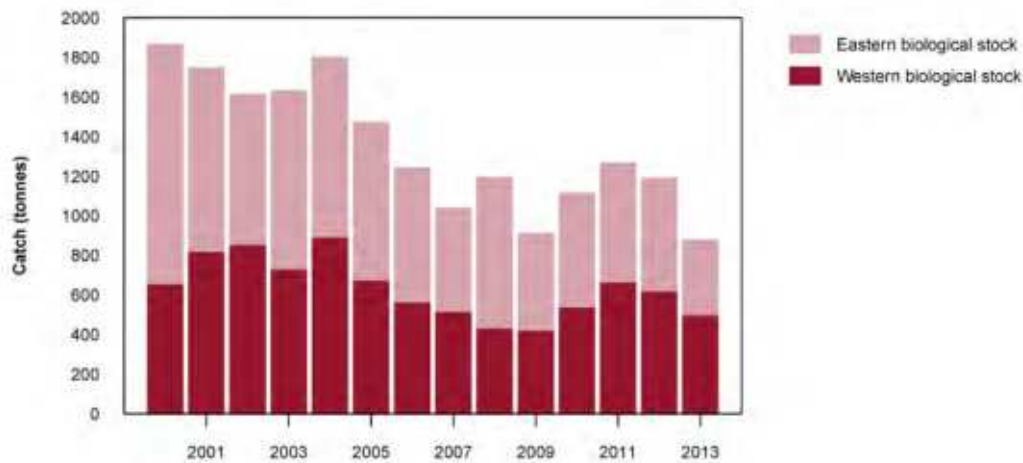
Jurisdiction	Commonwealth	New South Wales
Recreational ^a		
		None
Indigenous ^b		
		None
Active vessels		
	42 in CTS 4 in GAB 16 in GHT	18 in OTL
Catch		
Commercial	564 t in CTS 8 t in GABTS 254 t in GHaTS	49 t in OTL
Recreational ^a		Unknown
Indigenous ^b		Unknown
Markets		
Domestic	✓	✓
Export	✓	

CTS = Commonwealth Trawl Fishery; GABTS = Great Australian Bight Trawl Sector (Commonwealth); GHaTS = Gillnet, Hook and Trap Sector (Commonwealth); OTL = Ocean Trap and Line (New South Wales)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

Figure 2: Commercial catch of Pink Ling in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- There can be a substantial level of bycatch in the fish trawl sector. In 2006, mandatory requirements for otter trawls to use 90 mm square-mesh codend panels were introduced to reduce the catch of small species and juvenile fish⁶.
- Interactions also occur with animals protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), including marine mammals (dolphins, seals and sea lions), seabirds, some shark species and seahorses and pipefish (syngnathids). These interactions are reported quarterly by the Australian Fisheries Management Authority⁷ and on-board observer programs are used to validate the reporting in commercial logbooks.
- In 2007, the South East Trawl Fishing Industry Association 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 generally⁸. Operators have developed other mitigation protocols that have further reduced seal mortalities, including using breakaway ties that keep the net closed until it is below depths that seals regularly inhabit, adopting techniques to close the trawl opening during recovery to minimise opportunities for seals to enter the net, switching off gantry lights that are not required during night trawling to avoid attracting bait species and seals, and dumping offal only when the boat is not engaged in deploying or hauling gear⁸.
- In 2011, AFMA mandated individual vessel seabird management plans⁹. The seabird action plans are used in the Commonwealth Trawl Sector to mitigate the impacts of trawling on seabirds. Seabird mitigation measures include warp deflectors ('pinkys'), bird bafflers (a system of ropes and PVC piping that protects the warp cable) and seal excluder devices.
- The effects of trawl fishing on the marine environment are assessed through an environmental risk assessment and risk management framework and mitigated through spatial closures, and the implementation of bycatch and discard workplans in the Commonwealth Trawl Sector and Great Australian Bight Trawl Sector fisheries.

Environmental effects on Pink Ling

- Pink Ling is a deepwater species living in close association with the seabed at depths of 200–900 m¹⁰. The species is relatively nonmigratory and does not appear to move in response to changes in ocean currents

or water temperature. Stock assessments indicate that annual recruitment is usually somewhat variable, but occasional years of higher recruitment may be partly environmentally driven².

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41. Southern Garfish *Hyporhamphus melanochir*

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Table 1: Stock status determination for Southern Garfish

Jurisdiction	South Australia					
Stock	West coast (MSF)	Southern Spencer Gulf (MSF, NZRLF)	Northern Spencer Gulf (MSF)	Southern Gulf St Vincent (MSF, SZRLF)	Northern Gulf St Vincent (MSF, SZRLF)	South-east (MSF, SZRLF)
Stock status			↓		↓	
	Undefined	Undefined	Transitional–depleting	Undefined	Transitional–depleting	Undefined
Indicators	None	None	Harvest fraction, egg production, biomass	None	Harvest fraction, egg production, biomass	None

MSF = Marine Scalefish Fishery (South Australia); NZRLF = Northern Zone Rock Lobster Fishery (South Australia); SZRLF = Southern Zone Rock Lobster Fishery (South Australia)

Table 1 continued

Jurisdiction	Western Australia		Victoria	Tasmania
Stock	West coast (CSFNMF)	South coast (OA, SCEMF)	Victoria (CIF, OF, PPBF)	SF
Stock status				
	Undefined	Undefined	Sustainable	Undefined
Indicators	Catch, CPUE	None	Catch, effort, CPUE trends	Catch, effort, CPUE trends, age composition

CIF = Corner Inlet Fishery (Victoria); CPUE = catch per unit effort; CSFNMF = Cockburn Sound Fish Net Managed Fishery (Western Australia); OA = Open Access (Western Australia); OF = Ocean Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); SF = Scalefish Fishery (Tasmania)

Stock structure

Southern Garfish has a wide distribution in Australia, extending from Lancelin in Western Australia along the southern coast of mainland Australia and up the east coast to Eden in southern New South Wales, as well as the surrounding waters of Tasmania¹.

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^d Department of Fisheries, Western Australia

A multidisciplinary otolith-based study (otolith chemistry and morphometrics) identified at least five biological stocks in South Australia: west coast, northern Spencer Gulf, southern Spencer Gulf, northern Gulf St Vincent and southern Gulf St Vincent². Given the level of spatial separation of Southern Garfish observed within the gulfs, it was assumed that Southern Garfish from the south-east also comprised a distinct biological stock. From recent stock assessments, most of the biomass exists in the northern gulfs: northern Spencer Gulf and northern Gulf St Vincent. The remaining biological stocks have generally produced relatively low catches. For South Australia, status is reported at the level of the six individual biological stocks.

Differences in size and age composition between the north and east coasts of Tasmania suggest that there may be multiple biological stocks; however, no firm evidence exists at present, and current stock assessments assume a single statewide biological stock³. Status for Southern Garfish in Tasmania is reported at the level of this assumed single biological stock.

There has been no research into the stock structure for Western Australian populations of Southern Garfish. However, given the limited dispersal capabilities of Southern Garfish, and the large spatial separation between the west and south coasts of Western Australia, it is likely that the west and south coast host separate biological stocks of this species. Furthermore, the majority of west coast landings are from Cockburn Sound, and the majority of south coast landings are from Wilson Inlet. Garfish spawn within Wilson Inlet, thus maintaining a self-sustaining population within this estuary, which is usually separated from the ocean by a sand bar. Hence, status is reported at the level of the west and south coast biological stocks.

There has been no research into the stock structure for Victorian populations of Southern Garfish. Therefore, Southern Garfish in Victoria is assessed at the jurisdictional level.

Stock status

West coast (South Australia) biological stock

A negligible amount of Southern Garfish is landed by the commercial sector on the west coast of South Australia, with the contribution to the statewide catch rarely exceeding 2 per cent. Consequently, there is insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

Southern Spencer Gulf (South Australia) biological stock

Large areas of southern Spencer Gulf have been closed to commercial hauling-net fishing, with the most recent closure implemented in 2005. Consequently, the hauling-net sector has been effectively removed from this region, which is now mainly fished by commercial dab netters. The relative contribution of this region to the statewide catch has decreased to less than 5 per cent. Fishing effort has also substantially decreased (47 per cent) in the dab net sector over the past 4 years. Given the relatively small size of this regional fishery, it is difficult to access meaningful quantities of Southern Garfish to ascertain trends in the local population demography. Hence, there is insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

Northern Spencer Gulf (South Australia) biological stock

The northern Spencer Gulf biological stock has been the most productive for Southern Garfish in South Australia since 1983, typically contributing to more than half of the statewide catch. This stock is exclusively commercially fished by the hauling-net sector. The most recent assessment⁴ assessed three types of performance indicators: commercial catch rates; age-length frequency distributions; and model-based assessments of exploitation rate, egg production and fishable biomass. Catch rates have trended upwards since 1999. The composition of the commercial harvest is dominated by 1 year old plus and 2 year old plus Southern Garfish, indicating that the population structure has remained severely truncated as a result of sustained levels of high exploitation (higher than 65 per cent). Despite this, both fishable biomass and egg production remained relatively stable at moderate levels from 2003 to 2011. Consequently, the stock is not yet considered to be in a recruitment overfished state. However, the current level of fishing pressure has the potential to cause the stock to become recruitment overfished. New statewide harvest strategies have recently (2012) been implemented to promote the recovery of the stock, by reducing the harvest fraction and increasing egg production through a combination of effort (spatial closures) and gear-based (increased

hauling-net mesh size) restrictions. It is too early to assess the flow-on effects of these strategies. Proportional strategies are currently being developed for the recreational sector.

On the basis of the evidence provided above, the biological stock is classified as a **transitional–depleting stock**.

Southern Gulf St Vincent (South Australia) biological stock

Before 1993, the commercial catch of Southern Garfish from southern Gulf St Vincent was equally shared among the hauling-net and dab-net sectors. Since then, the hauling-net sector has declined, with a steady reduction in fishing effort, and, by 2006, dab nets had become the dominant gear type. This dominance was accelerated by the implementation of a voluntary net buy-back scheme and spatial netting closures in 2005. Before this management restructure, the commercial Southern Garfish catch from the region rarely exceeded 10 per cent of the statewide harvest; after its implementation, catch decreased to less than 5 per cent. Like southern Spencer Gulf, little is known about the size and age structures of the commercial catch of Southern Garfish in southern Gulf St Vincent, as it is difficult to access adequate biological samples from this relatively small regional fishery. Hence, there is insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

Northern Gulf St Vincent (South Australia) biological stock

Northern Gulf St Vincent has historically been the second most productive region in the state, accounting for an average of 35 per cent of South Australia's annual Southern Garfish catch. The most recent assessment⁴ used three types of performance indicators: commercial catch rates; age-length frequency distributions; and model-based assessments of exploitation rate, egg production and fishable biomass. Like the adjacent Northern Spencer Gulf biological stock, the Southern Garfish population in northern Gulf St Vincent is severely truncated as a result of sustained levels of exploitation (higher than 60 per cent). The recent trends in fishable biomass and egg production have remained relatively stable over the past decade, indicating that the stock is not yet considered to be recruitment overfished. However, this continued level of fishing pressure has the potential to cause the stock to become recruitment overfished. New statewide harvest strategies have recently (2012) been implemented to promote the recovery of the stock, by reducing the harvest fraction and increasing egg production through a combination of effort (spatial closures) and gear-based (increased hauling-net mesh size) restrictions. It is too early to assess the flow-on effects of these strategies. Proportional strategies are currently being developed for the recreational sector.

On the basis of the evidence provided above, the biological stock is classified as a **transitional–depleting stock**.

South-east (South Australia) biological stock

Very few Southern Garfish are landed by the commercial sector in the south-east; the statewide contribution rarely exceeds 0.3 per cent. Consequently, there is insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

West coast (Western Australia) biological stock

From 2009 to 2013, 87 per cent of west coast commercial landings of Southern Garfish were from Cockburn Sound. This represented 47 per cent of total Western Australian commercial landings of this species. The Southern Garfish catch and catch per unit effort (CPUE) in Cockburn Sound followed a declining trend from 2002 to 2013. Both catch and CPUE reached a historically low level in 2013 (that is, the lowest since the early 1970s, when the fishery commenced). Catch and CPUE indicators suggest that stock abundance is currently relatively low in Cockburn Sound. A new assessment, based on age-structure information, is under way to provide a better understanding of the status of this stock. Currently, insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

South coast (Western Australia) biological stock

From 2009 to 2013, 58 per cent of south coast commercial landings of Southern Garfish were from Wilson Inlet. This represented 27 per cent of total Western Australian commercial landings of this species. Over this period, the catch in this estuary ranged from 3 to 10 tonnes (t) per year. The remainder of south coast landings

each year comprised multiple small catches from other estuarine and coastal fisheries. From 2002 to 2013, the annual catch in Wilson Inlet followed an increasing trend, suggesting that the biomass has remained stable and that this stock is unlikely to be recruitment overfished. However, insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

Victoria

The commercial catch rate for Southern Garfish in Victoria has been relatively stable for the past 35 years. The majority (58 t) of the commercial catch of Southern Garfish comes from Corner Inlet, where catch rates vary annually but have been relatively stable since the early 1990s⁵. The majority of the recreational catch of Southern Garfish comes from Port Phillip Bay. In 2000–01, it was estimated that 25 t was taken by the Victorian recreational fishery, constituting 3.4 per cent of the statewide recreational catch in marine waters⁶. Recreational catch rates of Southern Garfish by avid and non-avid anglers in Port Phillip Bay have declined slightly since 2004⁵. Available fishery and scientific data indicate that the fishery is performing within its historical range, based on total annual catch and catch rate. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished and the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, Southern Garfish in Victoria is classified as a **sustainable stock**.

Scalefish Fishery (Tasmania) biological stock

From 1995–96 to 2005–06, commercial catches in the Scalefish Fishery (Tasmania) were stable and typically between 80 and 100 t. They have generally been less than 60 t in the past 6 years³. This coincides with a decline in average size and truncation of age classes of the catch, which may have resulted from heavy fishing pressure and/or a period of poor recruitment³. As a result, seasonal closures were introduced in 2009 to protect spawning fish. Since then, there has been an increase in the size of Southern Garfish captured, a greater variety of age classes present in the catch and increasing CPUE. This provides some evidence that the stock is recovering. At present, however, insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

Table 2: Southern Garfish biology⁷

<i>Longevity and maximum size</i>	South Australia: 10 years; 380 mm TL Tasmania: 9.5 years; 460 mm TL
<i>Maturity (50%)</i>	Western Australia: 19 months; 230 mm TL South Australia: 18 months; 190 mm TL Victoria: 19 months; 210 mm TL Tasmania: 22 months; 200 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Southern Garfish in Australian waters, 2013 (calendar year)

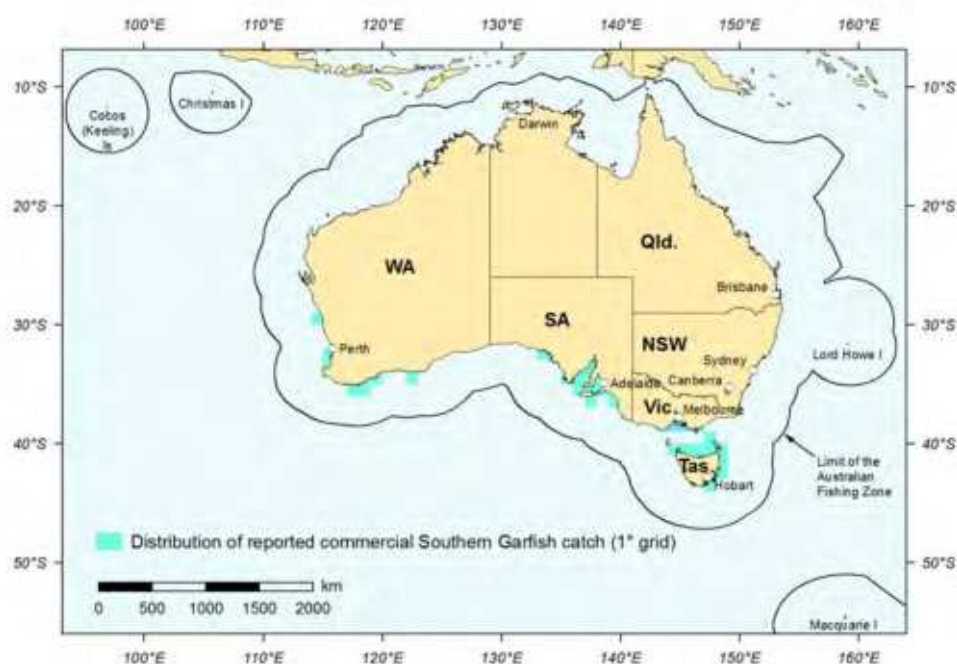


Table 3: Main features and statistics for Southern Garfish fisheries in Australia, 2013 (calendar year)

Jurisdiction	Western Australia	South Australia	Victoria	Tasmania
Fishing methods				
Commercial				
Hauling nets (seine)	✓	✓	✓	✓
Beach seine	✓			
Mesh (gill) net	✓		✓	
Dab (landing) nets	✓	✓		✓
Hand line	✓		✓	
Recreational				
Rod and line	✓	✓	✓	✓
Hand line	✓	✓	✓	✓
Dab (landing) nets	✓	✓	✓	✓
Beach seine				✓

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SOUTHERN GARFISH

Jurisdiction	Western Australia	South Australia	Victoria	Tasmania
Indigenous ^a				
Hand line	Unknown	✓		Unknown
Dab nets	Unknown	✓		Unknown
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Size limits		✓		✓
Gear restrictions	✓	✓	✓	✓
Vessel restrictions	✓			
Effort limits		✓	✓	
Spatial closures	✓	✓	✓	✓
Temporal closures		✓		✓
Recreational				
Licensing	✓		✓	
Bag limits	✓	✓	✓	✓
Size limits		✓		✓
Gear restrictions		✓		
Indigenous ^{a,b}				
Bag limits	✓	✓		✓
Size limits		✓		✓
Active commercial vessels				
	1 in CSFNMF 18 in OA 17 in SCEMF	91 in MSF 6 in NZRLF and SZRLF combined ^c	16 in CIF 2 in OF 23 in PPBF	22 in SF

Jurisdiction	Western Australia	South Australia	Victoria	Tasmania
Catch				
Commercial	4 t in CSFNMF 3 t in OA 11 t in SCEMF	249.7 t in MSF 0.7 t in NZRLF and SZRLF combined ^c	58 t in CIF Confidential in OF ^d 6 t in PPBF	48.8 t in SF
Recreational	2 t (vessel based only)	75 t (2007–08 survey)	21 t (2006– 07)	2 t (in 2007– 08 survey)
Indigenous ^a	Unknown	Unknown		Unknown
Markets				
Domestic	✓	✓	✓	✓
Export				

CIF = Corner Inlet Fishery (Victoria); CSFNMF = Cockburn Sound Fish Net Managed Fishery (Western Australia); MSF = Marine Scalefish Fishery (South Australia); NZRLF = Northern Zone Rock Lobster Fishery (South Australia); OA = Open Access (Western Australia); OF = Ocean Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); SF = Scalefish Fishery (Tasmania); SZRLF = Southern Zone Rock Lobster Fishery (South Australia)

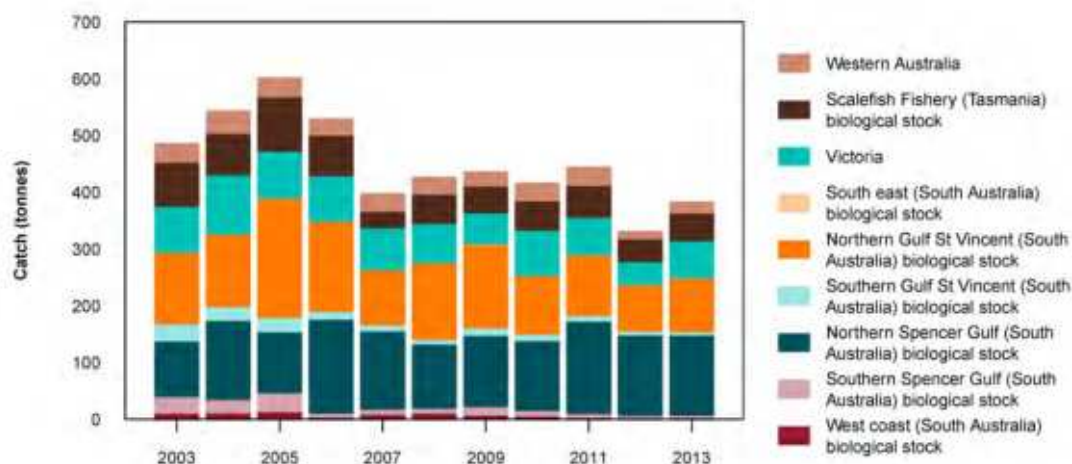
a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Southern Garfish.

b Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

c Data for the Northern Zone Rock Lobster Fishery (South Australia) and the Southern Zone Rock Lobster Fishery (South Australia) have been combined because of confidentiality requirements.

d To protect commercial confidentiality of data, the catch in the OF cannot be reported because there are fewer than five licence holders.

Figure 2: Commercial catch of Southern Garfish in Australian waters, 2003 to 2013 (calendar years)



Note: Western Australian data were not provided at the level of the individual stocks reported in the Southern Garfish chapter.

To protect commercial confidentiality of data, the catch in the OF (Victoria) cannot be reported because there are fewer than five licence holders.

Effects of fishing on the marine environment

- The hauling nets used to target Southern Garfish are typically lightweight, and consist of a 'pocket' end and lateral 'wings'. The wings, which generally have a smaller mesh size than the pocket, are specifically designed to herd fish inhabiting surface waters into the pocket of the net, rather than enmesh them throughout the entire water column. Fish that accumulate within the pocket are manually brailled out with a hand-held net, and are released or retained at the discretion of the fisher. The design and performance of these hauling nets ensures that post-release mortality of incidental bycatch is reduced, as nontargeted species can be released alive and in relatively good condition⁸. There is no indication that these lightweight nets adversely interrupt the normal ecological processes of fish and invertebrates that occupy shallow seagrass habitats⁹.

Environmental effects on Southern Garfish

- The impact of environmental factors on Southern Garfish stocks is unknown.

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42. Tailor *Pomatomus saltatrix*

Lenore Litherland^a, James Andrews^b, Paul Lewis^c and John Stewart^d

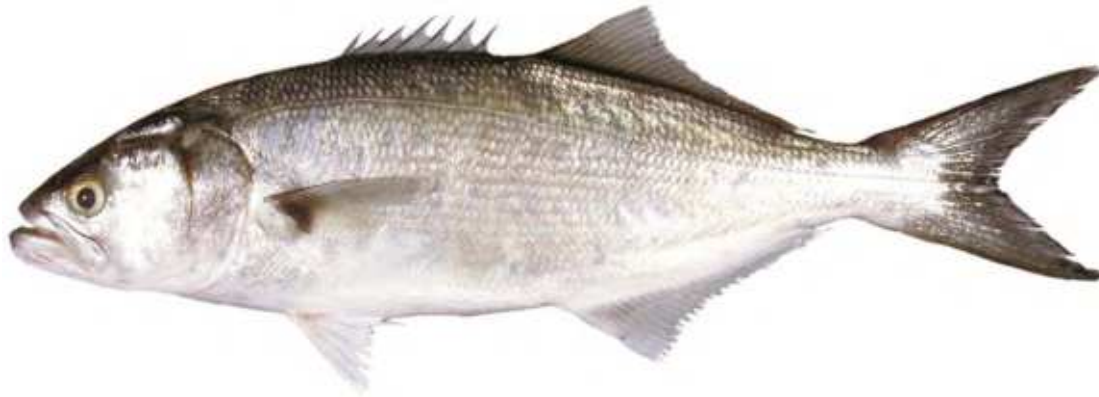


Table 1: Stock status determination for Tailor

Jurisdiction	Queensland, New South Wales, Victoria	Western Australia
Stock	Eastern Australian (CIF, ECIFFF, EGF, GLF, OHF, OPSF, OTLF, PPBF)	Western Australian (EF, GDSMF, OA, SBBSMNMF, SCEMF, WCDGDLIMF, WCDSIMF, WCEIMF)
Stock status		
	Sustainable	Sustainable
Indicators	Biomass, catch, effort, fishery-dependent length and age frequency, estimates of total mortality rate	Catch, juvenile index

CIF = Corner Inlet Fishery (Victoria); ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); EF = Estuaries Fisheries (Condition) (Western Australia); EGF = Estuary General Fishery (New South Wales); GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); GLF = Gippsland Lakes Fishery (Victoria); OA = Open Access (Western Australia); OHF = Ocean Haul Fishery (New South Wales); OPSF = Ocean Purse Seine Fishery (Victoria); OTLF = Ocean Trap and Line Fishery (New South Wales); PPBF = Port Phillip Bay Fishery (Victoria); SBBSMNMF = Shark Bay Beach Seine and Mesh Net Managed Fishery (Western Australia); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); WCDGDLIMF = West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (Western Australia); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia); WCEIMF = West Coast Estuarine (Interim) Managed Fishery (Western Australia)

Stock structure

Genetic evidence indicates that there are two biological stocks of Tailor in Australia, one along the east coast and a second along the west coast¹. The eastern Australian biological stock is distributed from Bundaberg in southern Queensland along the entire New South Wales coast and into eastern Bass Strait in Victoria². The western Australian biological stock is distributed along the western coastline of Australia from Exmouth to Esperance^{3,4}. Within each stock, multiple spawning groups may exist that spawn at different times and locations^{2,5,6}. However, several characteristics, such as the dispersal of pelagic eggs and larvae with prevailing currents, the movement of juveniles into sheltered near-shore or estuarine habitats in northern and southern areas of the species range, and the seasonal migration behaviour of adults, suggest that a genetically homogenous population occurs on each coast^{2,3,5-7}. The status for Tailor is reported here at the level of the two individual biological stocks.

a Department of Agriculture, Fisheries and Forestry, Queensland

b Department of Environment and Primary Industries, Victoria

c Department of Fisheries, Western Australia

d Department of Primary Industries, New South Wales

Stock status

Eastern Australian biological stock

Tailor is commonly fished throughout its distribution along the east coast of Australia. Queensland, New South Wales and Victoria each assess that part of the biological stock that occurs in their waters. The status presented here for the entire biological stock has been established using evidence from all three jurisdictions.

Tailor has a long history as a key fishery species for Indigenous, commercial and recreational fishers. Since the 1970s, the eastern Australian biological stock of Tailor has predominantly been targeted by the recreational fishery⁸. The most recent stock assessment^{8,9} indicated that the total recreational and commercial harvest of Tailor from Queensland and New South Wales peaked in the mid-1970s and again in the mid-1990s. These peaks coincided with periods of high recruitment to the fishery, when favourable environmental factors allowed larger numbers of young Tailor to thrive⁸. Since 2001, recruitment has been considered to be below average⁸. When assessed in 2008, the combined Queensland and New South Wales component of the stock was above 50 per cent of virgin biomass, and the total harvest was below the estimated maximum sustainable yield (MSY) of 1326 tonnes (t)^{8,10}. Since 2008, the commercial (Queensland and New South Wales) and recreational (Queensland) harvest of Tailor has decreased^{10,11}, suggesting that the total harvest has remained below MSY.

In Queensland, commercial landings and catch rates have decreased since 2010, reaching historically low levels in 2013. The decline reflects particularly low harvest from beach-seine netting following changes in management arrangements that have resulted in reduced nominal effort¹⁰. Fishery-dependent monitoring of length and age indicates a stable size composition of fish, and shows that older fish (4–7-year-olds) are present in the harvest. These are positive indicators of a stable population with continued recruitment. Fishery-dependent monitoring between 1999 and 2013 found no fish approaching the species' maximum age of 13¹⁰. On the whole, the data indicate that the biomass of the Queensland part of the stock is unlikely to be recruitment overfished.

In Queensland, management measures progressively introduced since 2002 have been effective in lowering fishing pressure¹⁰. Nominal effort in the commercial fishery in 2013 is the lowest in 5 years¹⁰. Recreational harvest estimates in 2011 were around one-third of the estimate in 2001, and there has been a reduction in the participation rate by recreational fishers in areas where Tailor are most commonly caught¹¹. The minimum legal size (35 cm total length) is set above the size at maturity¹², which reduces fishing pressure on the spawning stock and ensures that mature fish can spawn at least once. A seasonal closure also provides some protection of fish during the spawning period. Fishery-dependent age-frequency information shows evidence of continued recruitment, with 2–5-year-olds dominating the harvest¹⁰. Estimates of the total mortality rate from 2007 to 2013 are high, but are considered to be within an acceptable range for this species¹⁰. The data indicate that the current level of fishing pressure is unlikely to cause the Queensland component of the stock to become recruitment overfished.

In New South Wales, the length composition in commercial landings has remained consistent, typically ranging between 30 and 45 cm fork length. Nominal commercial catch rates (kilograms per day of line fishing) have increased steadily since the late 1990s. This evidence indicates that the biomass of the New South Wales part of the stock is unlikely to be recruitment overfished.

In New South Wales, the minimum legal size (30 cm total length) corresponds to the size at maturity. The recreational fishery is subject to the minimum legal length and a possession limit of 20 fish per person, which may do little to constrain harvest in this fishery sector. No recent estimate of the recreational harvest in New South Wales is available; historically, it has been substantially greater than the commercial harvest^{8,13}. Therefore, fishing pressure from the recreational sector could be high. Fishing pressure is considered adequately controlled in the commercial fishery through restrictive daily trip limits of 100 kg per day (ocean haul nets) or 50 kg per day (other netting methods). As a result, commercial landings have been relatively stable since the early 2000s. On the whole, the evidence indicates that the current level of fishing pressure is unlikely to cause the New South Wales component of the stock to become recruitment overfished.

In Victoria, most of the commercial catch of Tailor since 2007 has come from the Gippsland Lakes¹⁴. The most recent assessment¹⁵ for Tailor in the Gippsland Lakes used the commercial mesh-net catch rate (kg/km-lift) as an indicator. Despite a decrease in the 5-year moving average (11.06 kg/km-lift), the indicator in 2010 was above the long-term average (based on a 32-year time series of data), indicating that there was no evidence of

a long-term decline. This indicates that the biomass of the Victorian part of the stock is unlikely to be recruitment overfished.

In Victoria, the minimum legal size (23 cm total length) is below the size at maturity. The recreational fishery is subject to the minimum legal length and a bag/possession limit of 20 fish per person. Although there is no recent estimate of the recreational harvest of Tailor in Victoria, historically it was much less than in Queensland and New South Wales^{10,16}. Commercial landings show minor fluctuations since the early 2000s¹⁰, and the total catch in 2013 of 39.6 t was the second highest in 10 years. This indicates that fishing pressure is unlikely to cause the Victorian component of the stock to become recruitment overfished.

On the basis of the evidence provided above, the entire biological stock is classified as a **sustainable stock**.

Western Australian biological stock

The western Australian biological stock is accessed by one jurisdiction, Western Australia. Similar to the east coast, Tailor is predominantly a recreational species in Western Australia, with approximately 85 per cent taken by shore-based fishers^{4,17}. In the 1990s, there was a marked decline in size and numbers of Tailor caught along the west coast. Since then, management measures have been introduced⁴. The most recent stock assessment⁴ (2013) for the western Australian biological stock of Tailor used a weight-of-evidence approach. The assessment indicated that the stock had a low inherent vulnerability, and catch rates suggested that the current spawning stock abundance is high⁴. Annual recruitment by juvenile Tailor has been monitored in the Perth metropolitan area since 1996, and results suggest increasing recruitment since 2006. Increasing recreational catch rates of adult Tailor throughout the West Coast Bioregion in recent years are consistent with higher recruitment across the entire biological stock. Since 2001, the annual harvest and catch rates of Tailor in the main commercial fisheries (Shark Bay Beach Seine and Mesh Net Managed Fishery, and West Coast Estuarine [Interim] Managed Fishery) have been stable (combined 24–35 t) and are considered adequate, even though the Shark Bay Beach Seine and Mesh Net Managed Fishery catch is below the historical range as a result of local processing restrictions^{4,18}. The above evidence indicates that the biomass of the stock is unlikely to be recruitment overfished.

Management changes implemented in Western Australia between 1990 and 2009 (bag and size limits) have been effective in reducing the retained recreational harvest of Tailor. Although the current minimum legal size (30 cm total length) is just below the size at maturity, the maximum size possession limit (only two fish over 50 cm total length in the West Coast Bioregion) ensures protection for the breeding stock, and no additional management actions are expected to be implemented. The most recent stock assessment estimated a moderately high rate of natural mortality. However, the biological characteristics of fast growth rate and early maturity imply a low vulnerability of the stock to exploitation⁴. The above evidence indicates that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Tailor biology^{4,5,7,10,12}

Longevity and maximum size	11–13 years; 1200 mm TL
Maturity	Eastern Australian biological stock: 1–2 years; males 290 mm TL; females 310 mm TL Western Australian biological stock: 1–2 years; L_{50%} 320 mm TL

L_{50%} = length at which 50 percent of Tailor are mature; TL = total length

Figure 1: Distribution of reported commercial catch of Tailor in Australian waters, 2013 (calendar year)

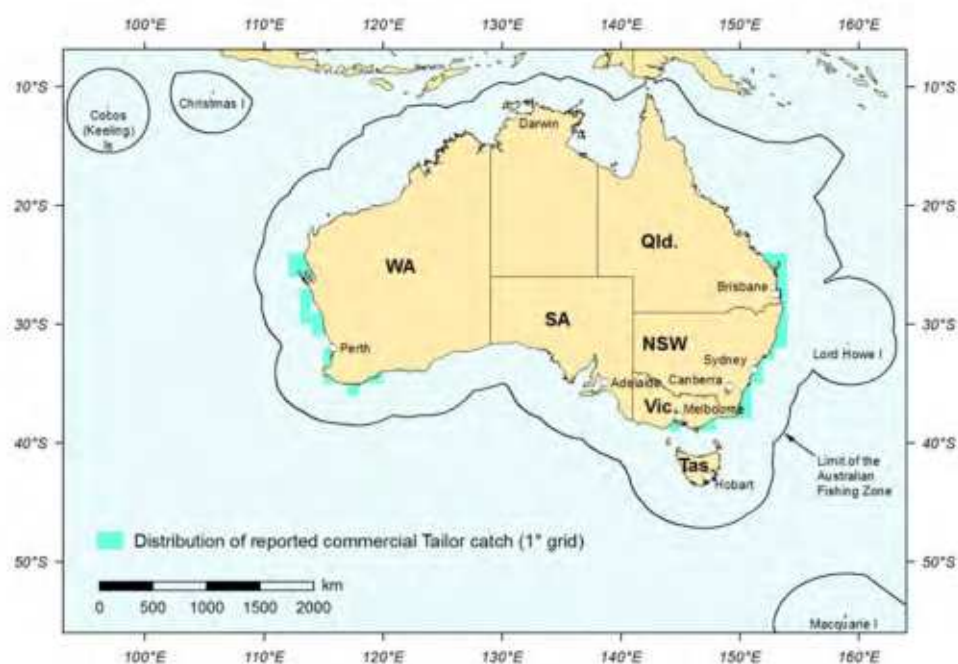


Table 3: Main features and statistics for Tailor fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland	New South Wales	Victoria	Western Australia
Fishing methods				
Commercial				
Gillnet	✓	✓	✓	✓
Beach seine	✓	✓	✓	✓
Haul net	✓	✓	✓	✓
Tunnel nets	✓			
Rod and line	✓	✓		✓
Purse seine			✓	
Dropline				✓
Hand line		✓		✓
Powered reel				✓

Jurisdiction	Queensland	New South Wales	Victoria	Western Australia
Recreational ^a				
Rod and line	✓	✓	✓	✓
Gillnet				✓
Haul nets				✓
Indigenous ^{b,c}				
Traditional apparatus	✓	✓		✓
Rod and line	✓	✓		
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Size limits	✓	✓	✓	✓
Gear restrictions	✓	✓	✓	✓
Vessel restrictions				✓
Total allowable catch	✓			
Total allowable effort				✓
Seasonal or spatial closures	✓	✓	✓	✓
Spatial zoning		✓		✓
Trip limits		✓		
Recreational ^a				
Bag limits		✓	✓	✓
Possession limits	✓	✓	✓	✓
Size limits	✓	✓	✓	✓
Seasonal or spatial closures	✓	✓	✓	✓
Licensing		✓	✓	✓
Limited entry (charter only)				✓
Spatial zoning (charter only)				✓

Jurisdiction	Queensland	New South Wales	Victoria	Western Australia
Passenger restrictions (charter only)				✓
Indigenous ^{a-e}				
Gear restrictions	✓	✓		✓
Bag limits		✓		
Size limits		✓		✓
Seasonal or spatial closures		✓		
Section 37(1)(c1), Aboriginal cultural fishing authority		✓		
Active vessels				
	112 in ECIFFF	209 in EGF 35 in OHF 81 in OTLF	10 in CIF 10 in GLF 2 in OPSF 4 in PPBF	1 in EF 2 in GDSMF 13 in OA 7 in SBBSMNMF 19 in SCEMF 1 in WCDGDLIMF 5 in WCDSIMF 9 in WCEIMF
Catch				
Commercial	37 t in ECIFFF	16 t in EGF 7 t in OHF 32 t in OTLF	<0.5 t in CIF 39 t in GLF <0.5 t in OPSF <0.1 t in PPBF	<0.5 t in EF <0.5 t in GDSMF 1 t in OA 15 t in SBBSMNMF 2 t in SCEMF <0.1 t in WCDGDLIMF <0.1 t in WCDSIMF 13 t in WCEIMF
Recreational	140 t (2011 ¹¹)	253 t (2001 ¹⁶)	Unknown	187 t (2001 ¹⁶) 16 t (2011, boat-based catch only ¹⁷ ; shore-based catches may account for 85% of recreational harvest ⁴)
Indigenous ^f	Unknown	Unknown	None	Unknown

Jurisdiction	Queensland	New South Wales	Victoria	Western Australia
Markets				
Domestic	✓	✓	✓	✓
Export				

CIF = Corner Inlet Fishery (Victoria); ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); EF = Estuaries Fisheries (Condition) (Western Australia); EGF = Estuary General Fishery (New South Wales); GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); GLF = Gippsland Lakes Fishery (Victoria); OA = Open Access (Western Australia); OHF = Ocean Haul Fishery (New South Wales); OPSF = Ocean Purse Seine Fishery (Victoria); OTLF = Ocean Trap and Line Fishery (New South Wales); PPBF = Port Phillip Bay Fishery (Victoria); SBBSMNMF = Shark Bay Beach Seine and Mesh Net Managed Fishery (Western Australia); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); WCDGDLIMF = West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (Western Australia); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia); WCEIMF = West Coast Estuarine (Interim) Managed Fishery (Western Australia)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

b In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Tailor.

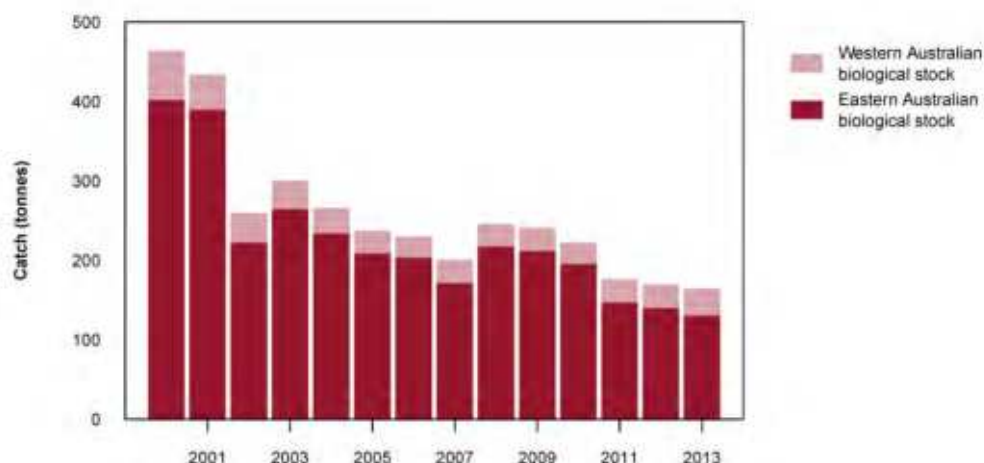
c Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

d The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

e The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

f Tailor is a culturally significant species for Indigenous groups along the eastern seaboard. However, statewide estimates of harvest are unknown. In northern New South Wales, Tailor is a dominant component of the Indigenous catch¹⁹.

Figure 2: Commercial catch of Tailor in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Commercial coastal-, river- and estuary-set gillnets have minimal impact on the environment and are quite selective in their harvest²⁰. In general, gill-, seine- and haul-net methods used by commercial fishers in near-shore and estuarine waters are deployed in a targeted manner and result in minimal bycatch relative to the harvest of the target species. Mesh size regulations help to ensure that target species caught by these methods are within an appropriate size range. Fishers using tunnel nets in Queensland operate under the industry code of best practice to minimise their environmental impacts²¹.
- Commercial gillnets can occasionally interact with threatened, endangered and protected species. The impact on populations of these species is unquantified. In most jurisdictions, commercial fishers are required to report all interactions with protected species.
- Discarded fishing tackle from recreational fishers poses a risk to seabirds and marine life, which can become entangled in or injured by discarded gear²². Programs to safely dispose of unwanted fishing tackle are in place in south-east Queensland, New South Wales and Western Australia²².
- Line-based fishing methods in near-shore and estuarine waters can result in the capture and release of a significant number of nontarget species and undersized fish. The rates of survival for released Tailor are high under some scenarios^{23,24}. However, levels of discard mortality should be quantified for line-caught fish captured and released in surf breaks.

Environmental effects on Tailor

- Near-shore habitats are important for this species, and Tailor populations are therefore vulnerable to any degradation in the quality of these habitats. Degradation may be from human causes (for example, pollution and habitat destruction) or natural causes (for example, floods), and has the potential to alter recruitment success of cohorts¹⁰.
- Changes in coastal currents and water temperatures associated with climate change have the potential to alter fish behaviours (for example, spawning activity and migration) and to affect the dispersal of eggs and larvae, which may influence the subsequent recruitment of Tailor into fisheries^{3,25,26}.

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43. Yellowtail Kingfish *Seriola lalandi*

Michael Lowry^a, Brett Molony^b, Malcom Keag^c and Andrew Penney^d



Table 1: Stock status determination for Yellowtail Kingfish

Jurisdiction	Commonwealth, New South Wales, Queensland, Commonwealth	Western Australia
Stock	Eastern Australian (CTS, GHaTS, HSN, OTLF, RRFFF)	Western Australian (JASDGLMF, OA, SCEMF, WCDSIMF)
Stock status		
	Undefined	Undefined
Indicators	Commercial catch rates, fishing mortality, yield per recruit analysis	Catch

CTS = Commonwealth Trawl Sector; GHaTS = Gillnet, Hook and Trap Sector (Commonwealth); HSN = High Seas Non-Trawl (Commonwealth); JASDGLMF = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Western Australia); OA = Open Access (Western Australia); OTLF = Ocean Trap and Line Fishery (New South Wales); RRFFF = Rocky Reef Fin Fish Fishery (Queensland); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia)

Stock structure

Yellowtail Kingfish is known to be a highly mobile and wide-ranging species, with a distribution extending throughout temperate waters of the Pacific and Indian Oceans¹. In Australian waters, they are distributed from southern Queensland to central Western Australia, including the east coast of Tasmania, and around Lord Howe and Norfolk Islands. Results from the New South Wales gamefish tagging program, which has operated since 1973, suggest that New South Wales and Queensland populations are genetically mixed²⁻⁵. Recaptured Yellowtail Kingfish have shown extensive movements along the north-east coast of Australia, and between Australia and New Zealand. The most recent genetic evaluation of stock structure studies⁴ provided definitive evidence of separate east and west coast populations, but noted the need for further work to identify finer-scale population structure in the eastern and central region. Stock status in this chapter is reported at the level of the eastern Australian and western Australian biological stocks.

a Department of Primary Industries, New South Wales

b Department of Fisheries, Western Australia

c Department of Agriculture, Fisheries and Forestry, Queensland

d Australian Bureau of Agricultural and Resource Economics and Sciences

Stock status

Eastern Australian biological stock

The cross-jurisdictional eastern Australian biological stock occurs throughout Commonwealth waters, New South Wales and Queensland. Each jurisdiction assesses the part of the biological stock that occurs in its waters. The status presented here for the entire biological stock has been established using evidence from the three jurisdictions.

Reported catch from the Queensland fishery is relatively minor, ranging from 3 to 11 tonnes (t) per year over the period 2004 to 2013. Recreational charter catch was estimated to be around 1 t, but limited information is available regarding the broader noncharter recreational catch.

Commonwealth fisheries comprise a relatively small catch of Yellowtail Kingfish across a number of fisheries. For the period 2000 to 2013, catch fluctuated between about 5 t and 64 t, averaging around 25 t per year. More than 80 per cent (23.6 t) of the catch in 2013 was taken using hook and line (dropline, autoline and bottom line) on the northern West Norfolk Rise, mainly when targetting Blue Eye Trevalla (*Hyperoglyphe antarctica*). A further 4.2 t (15 per cent of the catch in 2013) was caught as bycatch in the Commonwealth Trawl Sector, and less than 1 t was caught in the Commonwealth south-east Gillnet, Hook and Trap Sector. There are no specific management arrangements for Yellowtail Kingfish in Commonwealth fisheries. No data other than catch and effort are collected, and no Commonwealth assessment has been conducted for this stock.

Information on the eastern Australian stock is therefore primarily based on catch information from New South Wales. Catch rates and size compositions of commercial landings from the New South Wales component of the biological stock are assessed annually. Yellowtail Kingfish are currently assessed as being growth overfished in New South Wales waters, despite an increase in minimum legal length from 60 to 65 cm in 2007. However, New South Wales commercial landings in 2013 (around 83 t) are now substantially lower than the average during the late 1980s (more than 500 t per year). As well, commercial median catch rates (kilograms per day of line fishing) have increased from around 3 kg per day in the mid-1990s to an average of more than 22 kg per day since 2009. Although the fishery continues to be based largely on juveniles, the size composition in commercial landings has remained relatively stable since the 1990s, except for the effect of increasing the minimum legal length in 2007. The above evidence indicates that this stock is unlikely to be recruitment overfished.

However, there have been no age composition estimates since 2001⁶. This analysis, which used age data from 1998 to 2000, indicated that fishing mortality was likely to be greater than natural mortality, and the spawning potential ratio was likely to be below the 20 per cent limit reference point⁶. These estimates, which are based on data that are around 15 years old⁷, are outdated, but length composition data suggest that there have been no major changes to the fishery during the last 15 years. The limited information on the quantities or sizes of Yellowtail Kingfish harvested by the recreational fishery in New South Wales since 2000 results in considerable uncertainty around estimates of total fishing mortality. As a result of the conflicting evidence above, and the substantial uncertainty around total mortality levels, there is insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, the entire biological stock is classified as an **undefined stock**.

Western Australian biological stock

Yellowtail Kingfish are not commonly encountered in Western Australia. As a result, there is no commercial targeting of Yellowtail Kingfish and limited recreational effort focused on this species in Western Australia. Commercial catches of Yellowtail Kingfish have always been low (less than 1 t), and an estimated 11 t was reported from the state in 2013 (1 t commercial; 10 t recreational). As a result, insufficient information is available to classify the status of this stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

Table 2: Yellowtail Kingfish biology^{6,7}

Longevity and maximum size	20+ years; 1900 mm FL
Maturity (50%)	5–10 years; 800–1250 mm FL

FL = fork length

Figure 1: Distribution of reported commercial catch of Yellowtail Kingfish in Australian waters, 2013 (calendar year)

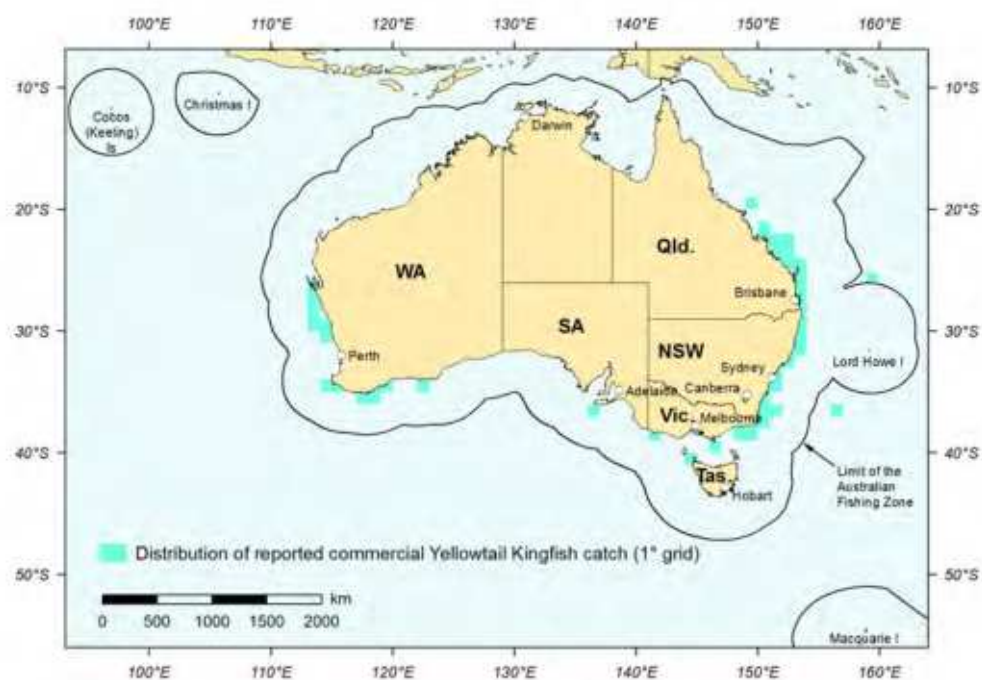


Table 3: Main features and statistics for Yellowtail Kingfish fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth	New South Wales	Queensland	Western Australia
Fishing methods				
Commercial				
Trolled baits		✓	✓	✓
Lures	✓	✓	✓	✓
Rod and line	✓	✓	✓	✓
Trawl	✓			

Jurisdiction	Commonwealth	New South Wales	Queensland	Western Australia
Recreational ^a				
Trolled baits		✓	✓	✓
Lures		✓	✓	✓
Rod and line		✓	✓	✓
Spearfishing		✓	✓	
Indigenous ^{b,c}				
Trolled baits		✓	✓	
Lures		✓	✓	
Rod and line		✓	✓	
Spearfishing		✓	✓	
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Size limits		✓	✓	✓
Vessel restrictions		✓	✓	✓
Spatial closures		✓	✓	
Recreational ^a				
Bag limits		✓	✓	✓
Size limits		✓	✓	✓
Spatial closures		✓	✓	
Gear restrictions		✓	✓	

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YELLOWTAIL KINGFISH

Jurisdiction	Commonwealth	New South Wales	Queensland	Western Australia
Indigenous ^{b,c,d,e}				
Bag limits		✓		
Size limits		✓		
Spatial closures		✓	✓	
Gear restrictions		✓	✓	
Section 37(1)(c1), Aboriginal cultural fishing authority		✓		
Active vessels				
	10 in CTS 7 in GHaTS 2 in HSN	148 in OTLF	58 in RRFFF	2 in JASDGLMF 11 in OA 1 in SCEMF 5 in WCDSIMF
Catch				
Commercial	4.2 t in CTS 0.7 t in GHaTS 23.6 t in HSN	83 t in OTLF	11 t in RRFFF	<0.1 t in JASDGLMF <0.1 t in OA <0.1 t in SCEMF <0.5 t in WCDSIMF
Recreational ^a		180 t (2000–01)	1 t	10 t
Indigenous ^b		Unknown	Unknown	Unknown
Markets				
Domestic	✓	✓	✓	✓
Export	✓			

CTS = Commonwealth Trawl Sector; GHaTS = Gillnet, Hook and Trap Sector (Commonwealth); HSN = High Seas Non-Trawl (Commonwealth); JASDGLMF = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (Western Australia); OA = Open Access (Western Australia); OTLF = Ocean Trap and Line Fishery (New South Wales); RRFFF = Rocky Reef Fin Fish Fishery (Queensland); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

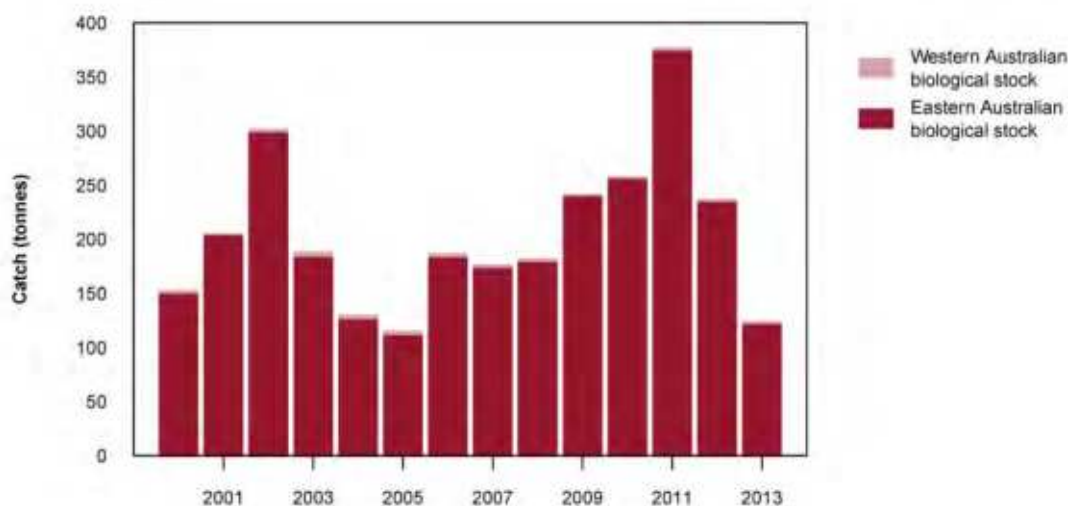
b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

c Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and bag limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

d The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

e The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Yellowtail Kingfish in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Beyond the removal of fish, there is little evidence to suggest that the fisheries targeting Yellowtail Kingfish impact significantly on benthic or pelagic ecological communities in the area as a whole.

Environmental effects on Yellowtail Kingfish

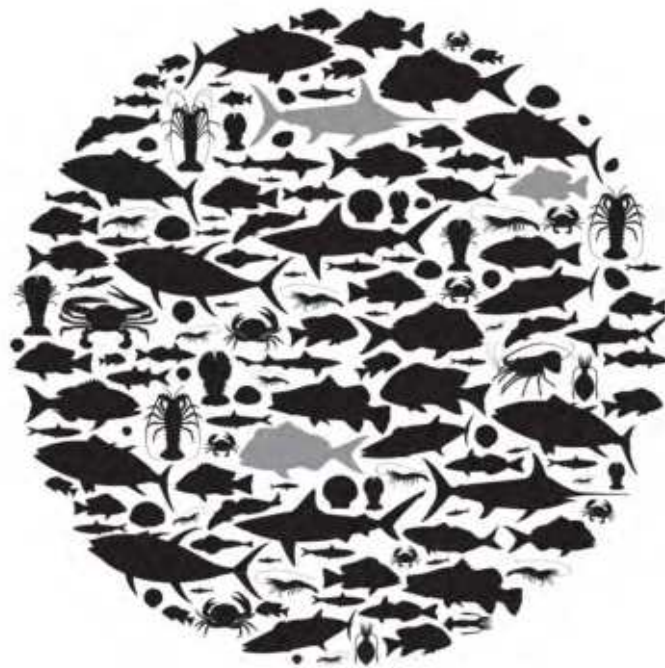
- Climate change and climate variability have the potential to impact fish stocks in a range of ways, including geographic distribution (for example, latitudinal shifts in distribution). Yellowtail Kingfish are known to respond rapidly to wind-induced shifts in current patterns. However, it is unclear how climate change may affect risks to sustainability of Yellowtail Kingfish.

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Finfish: *Flathead*



44. Deepwater Flathead *Neoplatycephalus conatus*

Andy Moore^a



Table 1: Stock status determination for Deepwater Flathead

Jurisdiction	Commonwealth
Stock	Great Australian Bight (CTS, GABTS)
Stock status	Sustainable
Indicators	Biomass, fishing mortality

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector (Commonwealth)

Stock structure

The biological stock structure of Deepwater Flathead is unknown; however, it is considered a single biological stock in the Southern and Eastern Scalefish and Shark Fishery for management purposes. Hence, stock status is reported at the level of the individual biological stock. Stock assessments for Deepwater Flathead have been completed only for the Great Australian Bight part of the biological stock¹. Because the Great Australian Bight Trawl Sector (Commonwealth) accounts for the majority of catch taken from this biological stock, the stock status for the entire biological stock is based on assessments and catch from this area.

Stock status

Great Australian Bight (Commonwealth) biological stock

The most recent quantitative assessment¹ estimated the spawning biomass at the start of 2014–15 to be 45 per cent of the unfished (1978) level. This assessment is generally consistent with previous assessments and fishery-independent surveys^{2,3}. The assessment estimated that the spawning biomass was progressively fished-down in the mid-2000s, but the biological stock had recovered by the start of 2010. This was most likely

a result of lower fishing pressure in recent years, combined with at least one substantial recruitment event. The biological stock is not considered to be recruitment overfished⁴

The biologically derived total allowable catch for the Great Australian Bight Trawl Sector (Commonwealth) for the 2013–14 fishing season was 1150 tonnes (t), which was adjusted to 1301 t to account for undercatch and overcatch. Landed catch of Deepwater Flathead from this fishery in the 2013–14 fishing season was 985 t. The Commonwealth Trawl Sector also landed 71 t, leading to a combined catch that was below the total allowable catch. The level of discards for this species is low¹. This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished⁴.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Deepwater Flathead biology^{3,5–8}

<i>Longevity and maximum size</i>	Females: ~26 years; 820 mm TL Males: ~19 years; 590 mm TL
<i>Maturity (50%)</i>	Females: 5–6 years; 430 mm TL Males: 4–5 years; 430 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Deepwater Flathead in Australian waters, 2013–14 (fishing season)

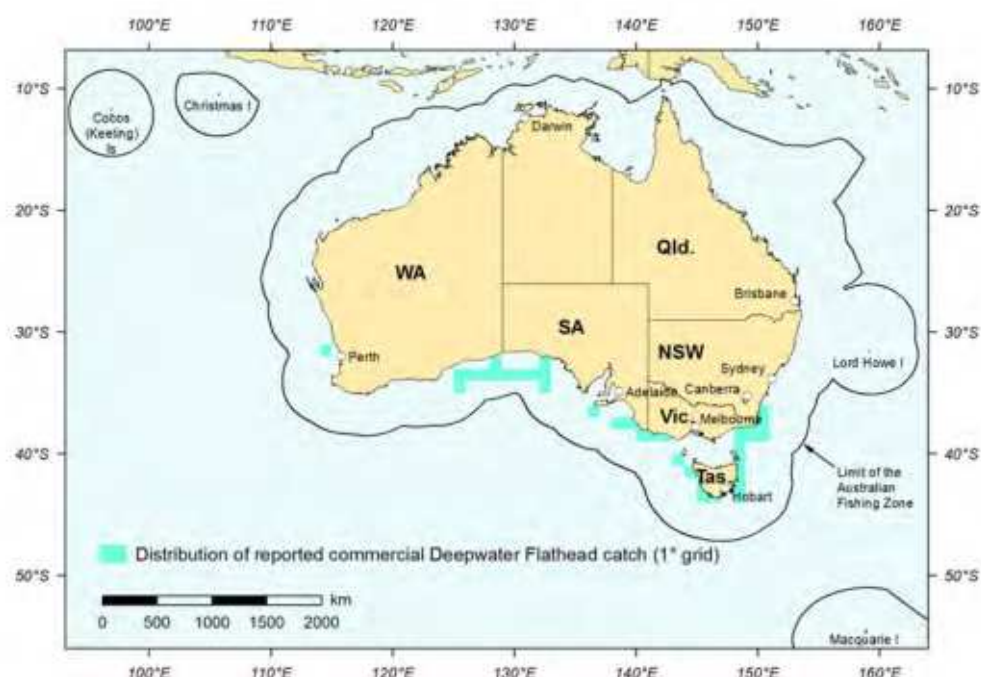


Table 3: Main features and statistics for Deepwater Flathead fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth
Fishing methods	
Commercial	
Demersal otter trawl	✓
Danish-seine	✓
Recreational ^a	
Indigenous ^b	
Management methods	
Commercial	
Limited entry	✓
Gear restrictions	✓
Spatial closures	✓
Total allowable catch	✓
Recreational ^a	
Indigenous ^b	
Active vessels	
	15 in CTS 6 in GABTS
Catch	
Commercial	72 t in CTS 975 t in GABTS
Recreational ^a	
Indigenous ^b	

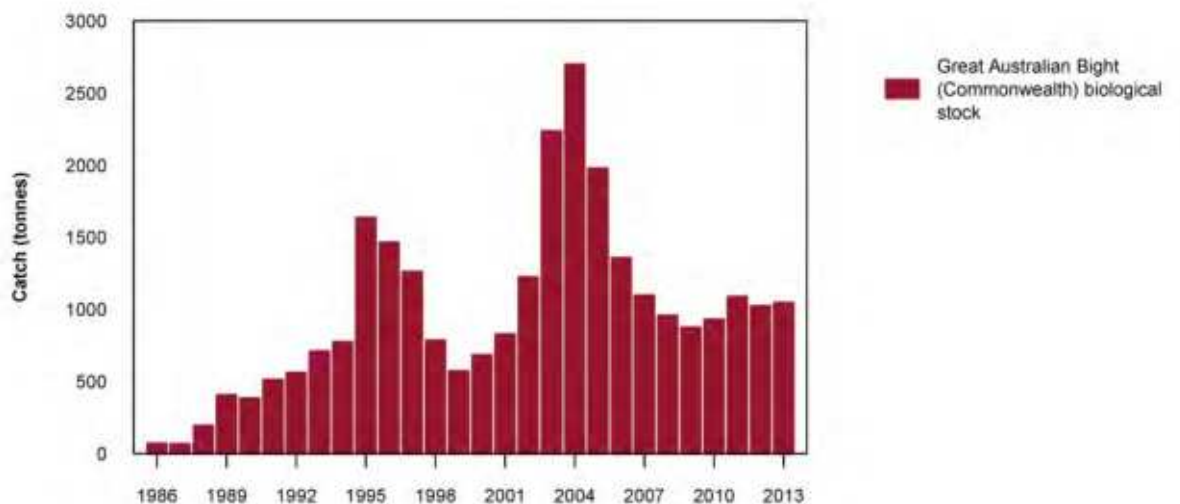
Jurisdiction	Commonwealth
Markets	
Domestic	✓
Export	

CTS = Commonwealth Trawl Sector; GABTS = Great Australian Bight Trawl Sector (Commonwealth)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

Figure 2: Commercial catch of Deepwater Flathead in Australian waters, 1986 to 2013 (calendar years)



Effects of fishing on the marine environment

- The Great Australian Bight Trawl Sector (Commonwealth) encounters nontarget species (bycatch). These fisheries have bycatch and discarding workplans or bycatch triggers in place to reduce interactions with nontarget species and minimise environmental impacts⁹⁻¹¹. Management and voluntary measures undertaken by the Great Australian Bight Trawl Sector (Commonwealth) to reduce impacts on the environment include spatial closures, use of T-90 square mesh net panels to reduce bycatch and implementation of seabird management plans.

Environmental effects on Deepwater Flathead

- Changes in ecosystem structure and function associated with changes in the climate may affect larval recruitment of Deepwater Flathead¹².

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45. Dusky Flathead *Platycephalus fuscus*

Jason McGilvray^a, Faith Doyle^b and Corey Green^c



Table 1: Stock status determination for Dusky Flathead

Jurisdiction	Queensland	New South Wales	Victoria
<i>Stock</i>	Queensland (ECIFFF)	New South Wales (EGF)	Victoria (GLF)
<i>Stock status</i>			
	Sustainable	Sustainable	Sustainable
<i>Indicators</i>	Commercial catch and CPUE, length and age composition, mortality rate (Z)	Commercial catch and CPUE, length and age composition, mortality rate (Z)	Commercial catch and CPUE, length frequency

CPUE = catch per unit effort; ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); EGF = Estuarine General Fishery (New South Wales); GLF = Gippsland Lakes Fishery (Victoria); Z = total instantaneous mortality rate

Stock structure

The biological stock structure of Dusky Flathead populations is unknown. However, the biological information on populations within each of the jurisdictions is well known and this coupled with the unknown stock structure dictates that assessments of Dusky Flathead stocks be completed at a jurisdictional level¹⁻⁵.

Stock status

Queensland

Nominal commercial catch rate has been stable since 1993⁶. Fishery-dependent monitoring from 2007 to 2013 indicates that both the commercial and recreational fishery sectors are harvesting Dusky Flathead across a spread of lengths and ages⁶. Fishery-dependent monitoring of length and age indicates that Dusky Flathead populations have variable recruitment, with no evidence of a decline through time⁶. The evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

^a Department of Agriculture, Fisheries and Forestry, Queensland

^b Department of Primary Industries, New South Wales

^c Department of Environment and Primary Industries, Victoria

In the commercial fishery, nominal effort continues to decrease (5408 days fished in 2009; 4100 days fished in 2013)⁶. Recreational anglers were estimated to have targeted Dusky Flathead on more days in 2013 (163 580 days) than in 2000 (147 580 days). Commercial and recreational fishers predominantly harvest female fish because of the minimum and maximum size limits that are in place. The minimum size protects most male fish, and the maximum size protects large female fish⁶. Possession limits are in place for the recreational sector. Mouth-hooked Dusky Flathead have high post-release survival⁷. Estimates of total mortality (from catch curves) are high—the fishing mortality rate (F) is greater than the natural mortality rate (M)—but show no clear trends upwards or downwards since 2007⁶. The estimates do not take into account older fish, which are known to exist in the population but are protected by the upper size limits in place. The current level of fishing effort is unlikely to cause this stock to become recruitment overfished.

On the basis of the evidence provided above, Dusky Flathead in Queensland is classified as a **sustainable stock**.

New South Wales

Median commercial catch rates (nominal) of Dusky Flathead in New South Wales have been relatively steady for the past 5 years, and slightly higher than those observed in the previous 11 years (1997 to 2013)⁸. There is some temporal and spatial variability in the length compositions of the landings for this species, which is indicative of a stock with variable recruitment. This pattern has been the same since the 1960s. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

Landings in New South Wales in 2013 (93.84 tonnes [t]) were lower than the long-term annual average (152.32 t). Summed across all methods in the Estuarine General Fishery, about 15 113 fisher-days were reported during 2013. This was the lowest annual effort for that fishery on record⁸. The size composition of fish measured during the 2012–13 financial year was similar to previous years, suggesting no large changes to the size frequency of the stock⁸. Although this species is likely to be primarily harvested by the recreational sector in New South Wales, recent estimates of recreational catch or effort are unavailable. The above evidence indicates that the current level of commercial fishing pressure is unlikely to cause this stock to become recruitment overfished, notwithstanding the unknown effects of recreational fishing pressure.

On the basis of the evidence provided above, Dusky Flathead in New South Wales is classified as a **sustainable stock**.

Victoria

Most Dusky Flathead caught in Victoria are taken from the Gippsland Lakes. The most recent assessment for Dusky Flathead in the Gippsland Lakes was undertaken in 2011. The assessment indicated that commercial and recreational catch rates for Dusky Flathead are highly variable, but there was no evidence of a long-term decline. Commercial mesh-net catch rates in 2009–10 were above both the long-term and the 10-year averages⁴. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

Commercial catches of Dusky Flathead dropped from 17 t in 2012 to 6 t in 2013; however, this level of annual catch is still double the size of commercial catches from the early 2000s. The trend in the 5-year moving average of recreational catch rates is stable⁴. Available recreational monitoring data (2005, 2006, 2009 and 2010) suggest that recreational fishers in the Gippsland Lakes rarely take Dusky Flathead greater than 50 cm total length⁴. In November 2013, Victoria introduced a slot limit for recreationally caught Dusky Flathead of 30–55 cm. The number of licensed commercial fishers in Victorian waters was reduced by two-thirds between 1986–87 and 2010–11. The majority of the licence removals occurred as a result of voluntary licence buyback schemes conducted in 1999–2000 and 2005–06. The above evidence suggests that the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, Dusky Flathead in Victoria is classified as a **sustainable stock**.

Table 2: Dusky Flathead biology ^{1,9}

Longevity and maximum size	Females: 16+ years; 1200 mm TL Males: 11+ years; 620 mm TL
Maturity (50%)	Females: 570 mm TL Males: 320 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Dusky Flathead in Australian waters, 2013 (calendar year)

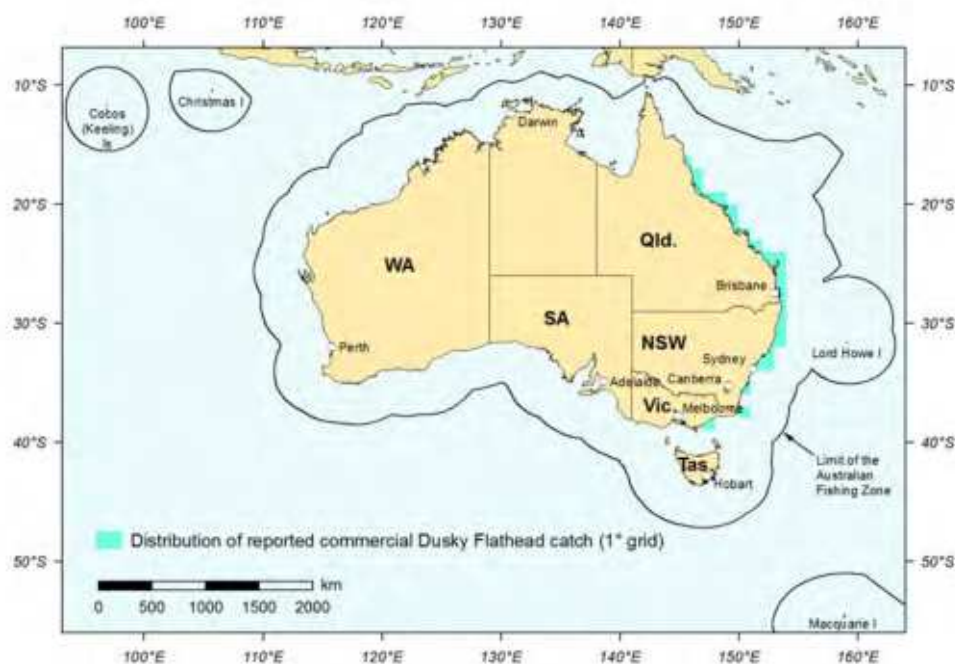


Table 3: Main features and statistics for Dusky Flathead fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland	New South Wales	Victoria
Fishing methods			
Commercial			
Gillnet	✓	✓	✓
Seine net	✓		✓
Tunnel net	✓		
Recreational			
Rod and line	✓	✓	✓
Spearfishing	✓	✓	

Jurisdiction	Queensland	New South Wales	Victoria
Indigenous ^{a,b,c}			
Management methods			
Commercial			
Limited entry	✓	✓	✓
Size limits	✓	✓	✓
Fishing gear and method restrictions	✓	✓	✓
Spatial closures	✓	✓	✓
Temporal closures	✓	✓	
Recreational			
Size limits	✓	✓	✓
Bag limits		✓	✓
Possession limits	✓	✓	✓
Fishing gear and method restrictions	✓	✓	✓
Spatial closures	✓	✓	✓
Licence		✓	✓
Indigenous ^{a,b,c}			
Active vessels			
	239 in ECIFFF	333 in EGF	10 in GLF
Catch			
Commercial	51 t in ECIFFF	93 t in EGF	<7 t in GLF
Recreational	149 t ¹⁰ (2010–11)	886 t ¹¹ (2000–01)	Unknown
Indigenous	Unknown	Unknown	Unknown

Jurisdiction	Queensland	New South Wales	Victoria
Markets			
Domestic	✓	✓	✓
Export			

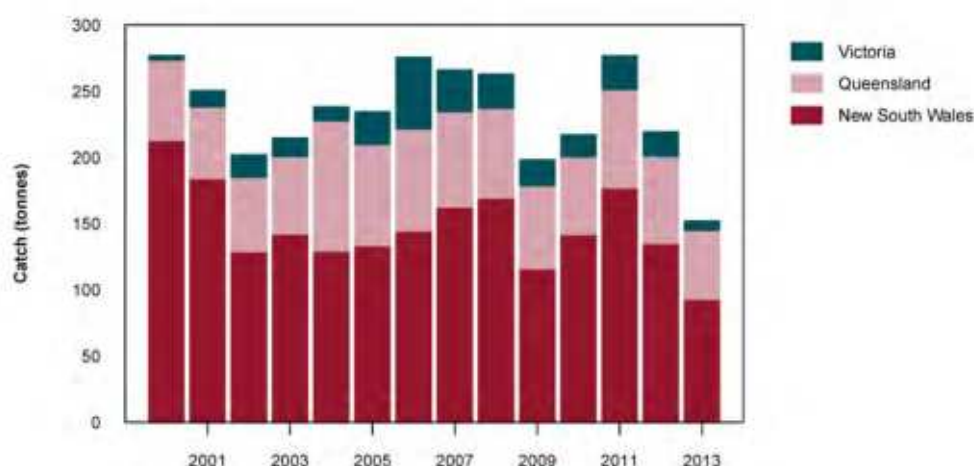
ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); EGF = Estuarine General Fishery (New South Wales); GLF = Gippsland Lakes Fishery (Victoria)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and bag limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

b In New South Wales, Indigenous fishers are able to use traditional and noncommercial apparatus to take double the recreational bag limit. Further exemptions to fishery regulations can be obtained through permits.

c In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Dusky Flathead.

Figure 2: Commercial catch of Dusky Flathead in Australian waters, 2000 to 2013 (calendar year)



Effects of fishing on the marine environment

- In Queensland, coastal-, river- and estuary-set gillnets have been shown to have minimal direct impact on the environment and are quite selective in their harvest¹². Levels of bycatch are generally low compared with the harvest of the target species¹². Fishers using tunnel nets operate under an industry-developed code of best-practice guidelines¹³. Marine turtles are released with minimal difficulty, and a high proportion of undersized or unwanted catch is returned to the water alive.
- In New South Wales estuaries, Dusky Flathead is targeted using gillnets, which also catch other species, including undersized individuals targeted in other key fisheries^{14–18}. These impacts can be minimised by using specifically designed Dusky Flathead gillnets that target fish above the minimum legal size¹⁶.
- In a similar manner to the tunnel net fishery in Queensland, the New South Wales estuarine beach-seine fishery operates in a manner that allows a proportion of nontarget species to be released alive¹⁹.

- Fishers in the Victorian Bays and Inlets Fisheries Association have adopted responsible fishing practices²⁰. It is likely that fishing activities have minimal direct impact on the environment.
- Seabirds and other marine life often become entangled in discarded recreational fishing tackle²¹. In south-east Queensland, a Fishing Line Recovery Bin program was instigated in 2012 to minimise the occurrence of discarded tackle at popular shore-based fishing locations.

Environmental effects on Dusky Flathead

- Dusky Flathead are dependent on estuarine and inshore coastal habitats throughout their life cycle. Variable recruitment has been observed in all three states, and is thought to be environmentally driven⁴. Physical impacts on coastal marine vegetation, subsurface topography and water quality are likely to influence the resilience and productivity of Dusky Flathead populations at local scales.

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46. Southern Sand Flathead *Platycephalus bassensis*

James Andrews^a, Jeremy Lyle^b, Justin Bell^b and Anthony Fowler^c



Table 1: Stock status determination for Southern Sand Flathead

Jurisdiction	Victoria	Tasmania	South Australia	Western Australia
<i>Stock</i>	Victoria (CIF, ITF, OF, PPBF)	Tasmania (SF)	South Australia	Western Australia
<i>Stock status</i>			Negligible ^a	Negligible ^b
	Undefined	Undefined		
<i>Indicators</i>	Catch, biomass, CPUE	Catch		

CIF = Corner Inlet Fishery (Victoria); CPUE = catch per unit effort; ITF = Inshore Trawl Fishery (Victoria); OF = Ocean Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SF = Scalefish Fishery (Tasmania)

a 'Negligible' means historically low catch; no stock status. The species is rare in South Australia; catch is unknown but very low, possibly zero. The catch history for all flathead combined was reviewed, and the annual catch has ranged from 1.5 to 5.7 tonnes over the past 13 years without apparent trend.

b 'Negligible' means historically low catch; no stock status. The species is rare in Western Australia; catch is unknown but very low, possibly zero.

Stock structure

Southern Sand Flathead (*Platycephalus bassensis*) is endemic to Australia and distributed from the central New South Wales coast, around Tasmania to South Australia, and to Bremer Bay in Western Australia¹. Southern Sand Flathead inhabit bays, inlets, estuaries and shallow coastal waters to a depth of about 100 metres². There is some evidence of regional differences in physical characteristics and growth rates for Southern Sand Flathead (for example, fish from Port Phillip bay are 30 per cent smaller than fish from Bass Strait and 20 per cent smaller than fish from south-east Tasmania)³, but the biological stock structure has not been studied. In the absence of information about stock structure, and because each of the jurisdictions has different management arrangements for Southern Sand Flathead, status is reported at the jurisdictional level.

a Department of Environment and Primary Industries, Victoria

b Institute for Marine and Antarctic Studies, University of Tasmania

c South Australian Research and Development Institute

Stock status

Victoria

Southern Sand Flathead historically comprised a significant component of the commercial catch in Victoria, with more than 200 tonnes (t) taken annually for several years until the 1950s from Port Phillip Bay². This species has also been an important component of the recreational fishery, with an estimated 322 t caught during 2000–01^{3,4}. Using three independent measures of abundance (biomass estimates from fishery-independent trawls, commercial longline catch per unit effort and recreational catch per unit effort), an 80–90 per cent decline in stock size was detected over the period 2000 to 2010³. By 2013, stocks had recovered to 30 per cent of 1990s levels, but the abundance of zero-plus aged fish has remained very low since 1994.

Very little is known about the catch of Southern Sand Flathead from Victorian waters outside of Port Phillip Bay, except that they are taken as bycatch and generally not targeted by commercial fishers. Some targeting offshore by recreational anglers is known to occur.

There is no formal management plan and no limit reference point for Victorian Southern Sand Flathead. Despite the substantial decline in biomass for the period 2000 to 2013 and the significant decline in recruitment for Port Phillip Bay populations³, there is no evidence that these trends are caused by the removal of catch. The above evidence indicates that the biomass of this stock has been deteriorating but is not likely to be recruitment overfished.

Recruitment in Port Phillip Bay is heavily influenced by climatic conditions^{2,3,5}, and for many years it was suggested that existing levels of fishing pressure had little influence on spawning success⁵. This is partly because a portion of the population will not grow to a size at which they become vulnerable to fishing (that is, they will not reach the legal minimum size). A more recent study, undertaken in response to angler concerns about the decline in Southern Sand Flathead abundance, found that, despite the decline in abundance, stock exploitation levels between 2000–01 and 2006–07 remained stable, at 15–30 per cent of the stock biomass³. This study found that the magnitude of the decline was, however, unprecedented over the history of the fishery and that, under these circumstances, fishing pressure can contribute to a more rapid decline or potentially affect the recovery rate of the stock. Consequently, the study evaluated management options to assist the recovery of the fishery in Port Phillip Bay.

The current level of fishing pressure is considered to be relatively low from the commercial sector, and is unknown for the recreational sector. The proportion of the population that exceeds the current minimum legal size limit (27 cm) has steadily increased from 1990 to 2011. In the early 1990s, the percentage of legal sized fish was less than 10 per cent of the population. This proportion was more than 30 per cent by the early 2000s and remained above 20 per cent until 2011. The remaining 70–80 per cent of the population are too small to be harvested by recreational fishers. From the above evidence, it is not clear whether the current level of fishing pressure is likely to cause the stock to become recruitment overfished. Hence, there is insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, Southern Sand Flathead in Victoria is classified as an **undefined stock**.

Tasmania

In Tasmanian waters, Southern Sand Flathead are mainly landed commercially by hook-and-line fishers, with minor catches taken by gillnet and Danish-seine. Total landings are low, typically less than 15 t per year⁶. Recreational catches of Southern Sand Flathead are substantially higher (around 300 t); the species dominates the recreational fishery in terms of overall catch numbers and weight⁷. Catch-curve analysis suggests that exploitation rates of legal sized fish are highest in the south-east of the state, and there are anecdotal reports of declining catch rates in some areas. However, juvenile fish appear to be abundant, and the legal minimum length is set well above the size at maturity to prevent recruitment overfishing⁶. Because of a lack of quantitative commercial fishing data and uncertainty surrounding the activities of the recreational fishery, there is currently insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, Southern Sand Flathead in Tasmania is classified as an **undefined stock**.

Table 2: Southern Sand flathead biology^{8–10}

Longevity and maximum size	23 years (both sexes); males 370 mm TL; females 480 mm TL
Maturity (50%)	Males 2.5–3.5 years, 210 mm TL; females 2.6–5.2 years, 235 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Southern Sand Flathead in Australian waters, 2013 (calendar year)

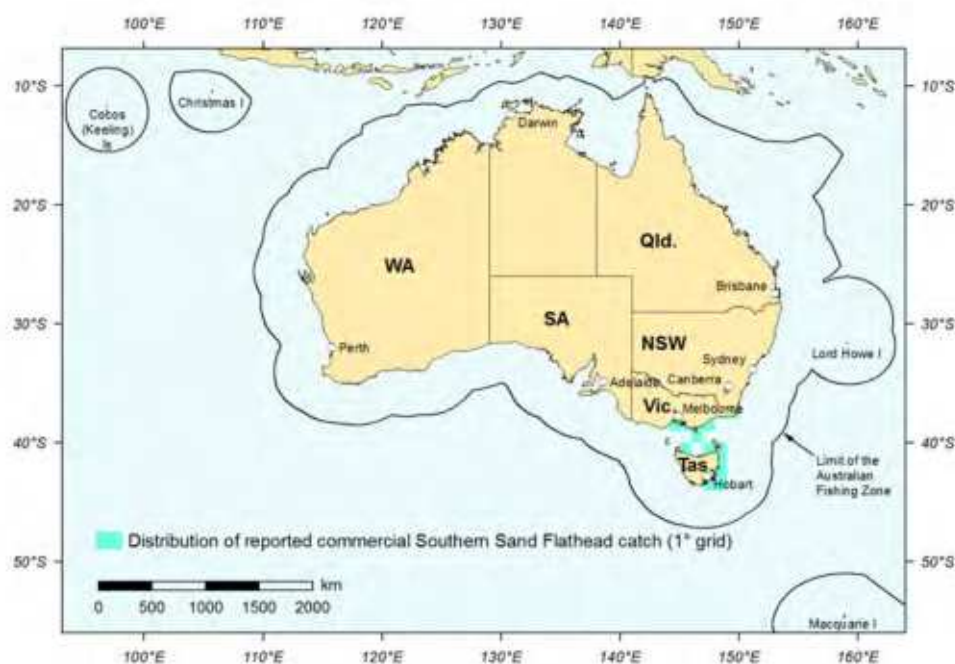


Table 3: Main features and statistics for Southern Sand Flathead fisheries in Australia, 2013 (calendar year)

Jurisdiction	Victoria	Tasmania
Fishing methods		
Commercial		
Gillnet	✓	✓
Haul seine	✓	✓
Trawl	✓	
Danish-seine		✓
Hand line	✓	✓
Longline	✓	

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SOUTHERN SAND FLATHEAD

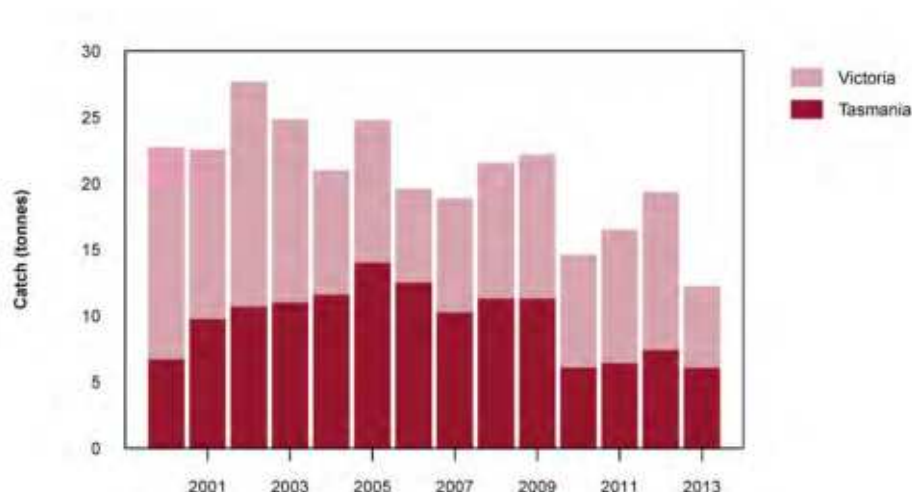
Jurisdiction	Victoria	Tasmania
Recreational		
Rod and line	✓	✓
Diving	✓	
Indigenous ^a		
Hand line	✓	✓
Management methods		
Commercial		
Limited entry	✓	✓
Vessel restrictions	✓	✓
Spatial closures	✓	✓
Size limits	✓	✓
Recreational		
Bag limits	✓	✓
Size limits	✓	✓
Indigenous ^a		
Bag limits	✓	✓
Size limits	✓	✓
Active vessels		
	4 in CIF 8 in ITF 1 in OF 15 in PPBF	55 in SF
Catch		
Commercial	<4.0 t in CIF 1.0 t in ITF <0.1 t in OF 1.3 t in PPBF	6.2 t in SF
Recreational	115 t (2006–07)	279 t (2007–08)
Indigenous	None	None

Jurisdiction	Victoria	Tasmania
Markets		
Domestic	✓	✓
Export		

CIF = Corner Inlet Fishery (Victoria); ITF = Inshore Trawl Fishery (Victoria); OF = Ocean Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SF = Scalefish Fishery (Tasmania)

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Southern Sand Flathead.

Figure 2: Commercial catch of Southern Sand Flathead in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Because most of the catch (95 per cent) is taken by recreational anglers using hand lines, and rods and reels, the effects of fishing on the marine environment are relatively low.

Environmental effects on Southern Sand Flathead

- A recent review concluded that declining recruitment from the mid-1990s onwards led to the decline of Southern Sand Flathead stocks in Port Phillip Bay from 2000 onwards. This decline in recruitment coincided with a prolonged drought in Victoria from 1997 to 2009, characterised by substantially lower rainfall and river flows³. The authors found that recruitment in Port Phillip Bay was significantly correlated with Yarra River flows during November and December, when the majority of Southern Sand Flathead larvae occur in the water column. It is suggested that climatic effects on this stage of the life cycle may be driving variations in recruitment.

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47. Tiger Flathead *Neoplatycephalus richardsoni*

Matthew Flood^a, Geoffrey Liggins^b, Justin Bell^c and James Andrews^d



Table 1: Stock status determination for Tiger Flathead

Jurisdiction	Commonwealth, New South Wales, Tasmania, Victoria
Stock	Southern Australian (ITF, OTF, SESSF [CTS], SF)
Stock status	Sustainable
Indicators	Spawning stock biomass, fishing mortality

ITF = Inshore Trawl Fishery (Victoria); OTF = Ocean Trawl Fishery (New South Wales); SESSF [CTS] = Southern and Eastern Scalefish and Shark Fishery (Commonwealth Trawl Sector); SF = Scalefish Fishery (Tasmania)

Stock structure

Tiger Flathead is endemic to Australia and distributed from northern New South Wales to western Victoria, including Tasmanian waters. There is some evidence of regional differences in physical characteristics, growth rates and spawning periods for Tiger Flathead, but biological stock structure has not been studied using genetic techniques. A single biological stock structure is assumed for management purposes¹ and stock status is reported at this level.

Stock status

Southern Australian biological stock

The most recent assessment² estimated spawning stock biomass in 2014 to be 11 572 tonnes (t) or 50 per cent of the unfished (1915) level. The spawning biomass that supports maximum sustainable yield of Tiger Flathead was estimated to be 32 per cent of the unfished biomass. The biological stock is not considered to be recruitment overfished³.

a Australian Bureau of Agricultural and Resource Economics and Sciences

b Department of Primary Industries, New South Wales

c Institute for Marine and Antarctic Studies, University of Tasmania

d Department of Environment and Primary Industries, Victoria

The assessment shows notable increases in spawning stock biomass in the past 4 years². In addition, the recommended biological catch (RBC) for Tiger Flathead for the 2011–12 fishing season was 3097 t⁴, and the total Australian commercial catch of Tiger Flathead in the 2012–13 fishing season was approximately 2976 t (2763 t Commonwealth; 181 t New South Wales; 31 t Tasmania; 1 t Victoria [financial year]). The RBC was not assessed for the 2012–13 fishing season³. This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished³.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Tiger Flathead biology⁵

Longevity and maximum size	20 years; males 500 mm SL, females 600 mm SL
Maturity (50%)	3 years; 300 mm SL

SL = standard length

Figure 1: Distribution of reported commercial catch of Tiger Flathead in Australian waters, 2013 (calendar year)

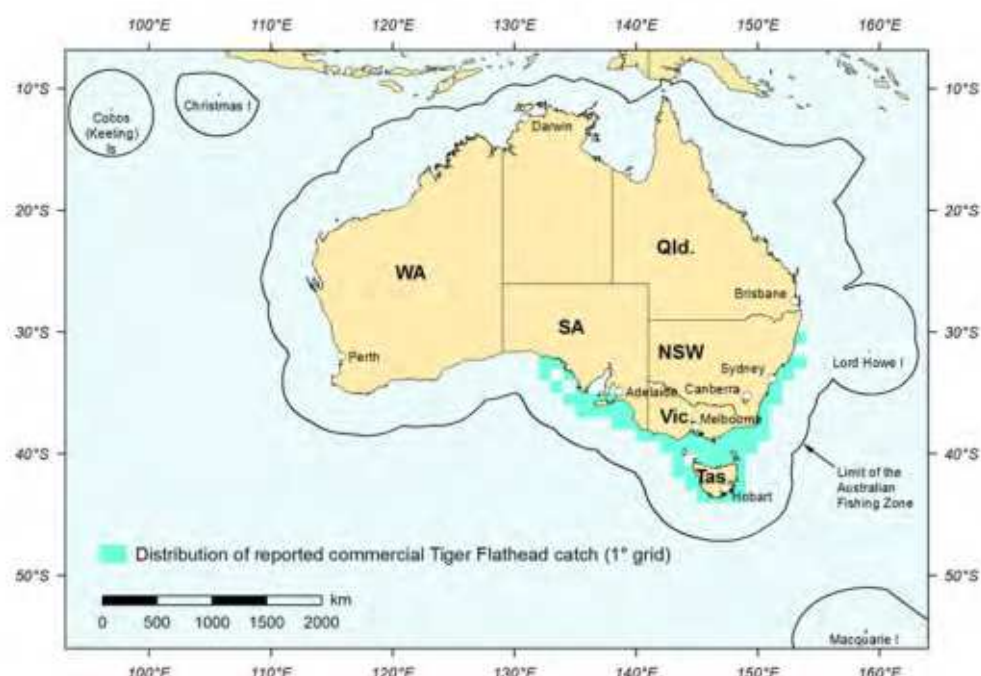


Table 3: Main features and statistics for Tiger Flathead fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth ^a	New South Wales ^a	Tasmania ^a	Victoria ^b
Fishing methods				
Commercial				
Danish-seine	✓	✓	✓	
Otter trawl	✓	✓		✓
Hand line			✓	
Recreational ^c				

Jurisdiction	Commonwealth ^a	New South Wales ^a	Tasmania ^a	Victoria ^b
Rod and line		✓	✓	✓
Indigenous ^d				
Rod and line		✓		
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Total allowable catch	✓			
Trip limit		✓		
Spatial closures	✓	✓	✓	✓
Gear restrictions	✓	✓	✓	✓
Recreational ^c				
Bag limits		✓	✓	✓
Size limits		✓	✓	✓
Spatial closures		✓	✓	✓
Gear restrictions		✓	✓	✓
Indigenous ^{d,e,f,g}				
Bag limits		✓		
Size limits		✓		
Spatial closures		✓		
Gear restrictions		✓		
Section 37(1)(c1) Aboriginal cultural fishing authority		✓		
Active vessels				
	57 in SESSF [CTS]	48 in OTF	4 in SF	6 in ITF
Catch				
Commercial	2763 t in SESSF [CTS]	181 t in OTF	31 t in SF	3 t in ITF
Recreational ^c		Unknown	14.7 t (2007–08) ⁶	Unknown
Indigenous ^d		Unknown	Unknown	None

Jurisdiction	Commonwealth ^a	New South Wales ^a	Tasmania ^a	Victoria ^b
Markets				
Domestic	✓	✓	✓	✓
Export	Unknown	Unknown	Unknown	Unknown

ITF = Inshore Trawl Fishery (Victoria); OTF = Ocean Trawl Fishery (New South Wales); SESSF [CTS] = Southern and Eastern Scalefish and Shark Fishery (Commonwealth Trawl Sector); SF = Scalefish Fishery (Tasmania)

a Data provided for the Commonwealth, New South Wales and Tasmania align with the Commonwealth Southern and Eastern Scalefish and Shark Fishery 2012–13 fishing season (1 May 2012 – 30 April 2013).

b Data provided for Victoria align with the 2013 calendar year.

c The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

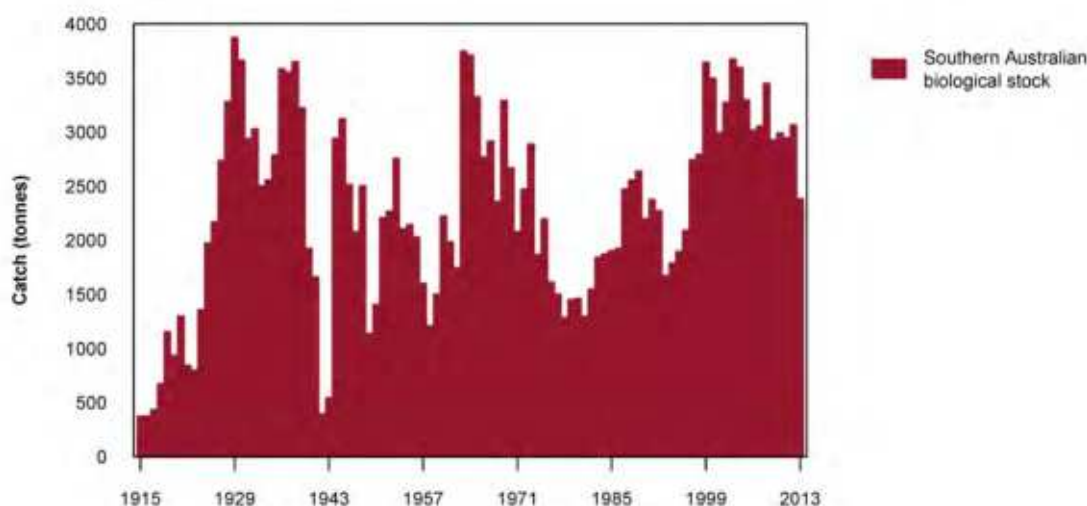
d The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

e In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (for example, different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Tiger Flathead.

f The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

g The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Tiger Flathead in Australian waters, 1915 to 2013 (calendar years)



Effects of fishing on the marine environment

- There can be a substantial level of bycatch in the fish trawl sector. In 2006, mandatory requirements for otter trawls to use 90 mm square-mesh codend panels were introduced to reduce the catch of small species and juvenile fish⁷.

- Interactions also occur with animals protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), including marine mammals (dolphins, seals and sea lions), seabirds, some shark species and seahorses and pipefish (syngnathids). These interactions are reported quarterly by the Australian Fisheries Management Authority⁸ and on-board observer programs are used to validate the reporting in commercial logbooks.
- In 2007, the South East Trawl Fishing Industry Association 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 generally⁹. Operators have developed other mitigation protocols that have further reduced seal mortalities, including using breakaway ties that keep the net closed until it is below depths that seals regularly inhabit, adopting techniques to close the trawl opening during recovery to minimise opportunities for seals to enter the net, switching off gantry lights that are not required during night trawling to avoid attracting bait species and seals, and dumping offal only when the boat is not engaged in deploying or hauling gear⁹.
- In 2011, AFMA mandated individual vessel seabird management plans¹⁰. The seabird action plans are used in the Commonwealth Trawl Sector to mitigate the impacts of trawling on seabirds. Seabird mitigation measures include warp deflectors ('pinkys'), bird bafflers (a system of ropes and PVC piping that protects the warp cable) and seal excluder devices.
- The effects of trawl fishing on the marine environment are assessed through an environmental risk assessment and risk management framework and mitigated through spatial closures, and the implementation of bycatch and discard workplans in the Commonwealth Trawl Sector and Great Australian Bight Trawl Sector fisheries.
- Danish-seine and otter trawl interact with a broad range of habitat types. However, an ecological risk assessment indicates that fishing operations on sandy substrates of the inner to mid shelf, where Tiger Flathead are targeted, do not present a high risk to habitats^{11,12}.
- Danish-seining has the potential to affect seahorses and pipefish (syngnathids) because Danish-seiners operate in relatively shallow waters and use nets with a small mesh size. An ecological risk assessment (ERA) indicated that the Spiny Pipehorse was at low risk because the fishery overlaps with only a small portion of the range of this species¹³.
- Discarding of quota species can be significant in some parts of the Commonwealth Trawl Sector. However, discard rates for Tiger Flathead are low, generally around 5 per cent¹.

Environmental effects on Tiger Flathead

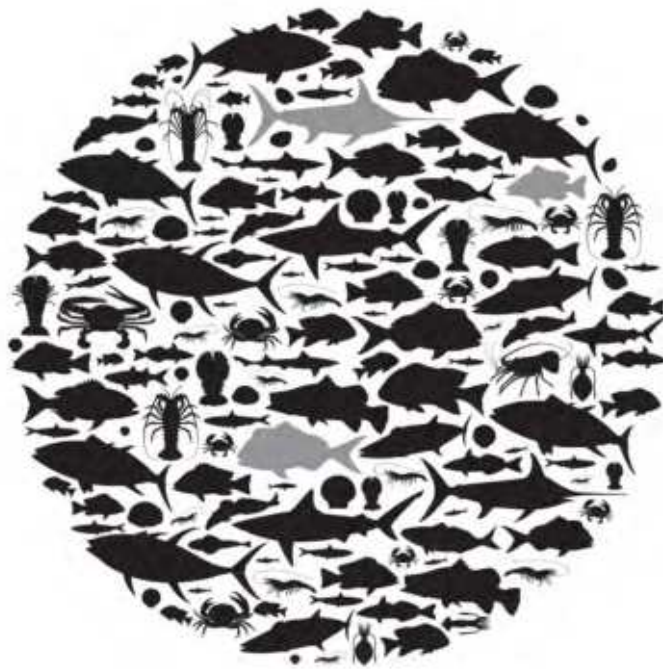
- There is some speculation that past peaks in abundance of Tiger Flathead may have been linked to favourable, but undetermined, environmental conditions¹⁴. Recent strong recruitment of small Tiger Flathead may have a similar environmental basis. However, the effect of long-term shifts in the marine environment, such as those associated with global climate change, cannot yet be predicted for the Tiger Flathead biological stock.

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Finfish: *Mackerel*



48. Common Jack Mackerel *Trachurus declivis*

Jeremy Lyle^a, Justin Bell^a, Anthony Moore^b and John Stewart^c

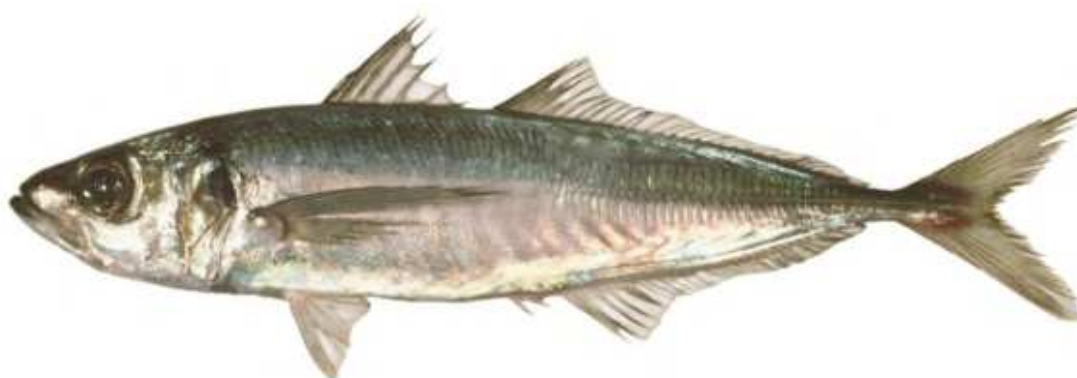


Table 1: Stock status determination for Common Jack Mackerel

Jurisdiction	Tasmania, New South Wales, Commonwealth	Tasmania, Commonwealth
Stock	Eastern stock (CTS, NSWCF, SF, SPF, VIT)	Western stock (CTS, GAB, SET, SF, SPF)
Stock status		
	Sustainable	Sustainable
Indicators	Catch, effort and CPUE trends, spawning biomass, ecosystem modelling	Catch, effort

CPUE = catch per unit effort; CTS = Commonwealth Trawl Sector; GAB = Great Australian Bight Trawl (Commonwealth); NSWCF = New South Wales Commercial Fishery; SF = Scalefish Fishery (Tasmania); SPF = Small Pelagic Fishery (Commonwealth); VIT = Victorian Inshore Trawl Fishery (Commonwealth)

Stock structure

There is evidence of at least two biological stocks of Common Jack Mackerel in Australian waters: one off eastern mainland Australia, including eastern Tasmania, and the other extending from western Tasmania through to southern Western Australia. A separate biological stock also exists in New Zealand waters. These conclusions are based on morphological and meristic differences between fish from the Great Australian Bight and eastern Australia¹, genetic differences between fish from the Great Australian Bight and New Zealand², and a lack of genetic difference between fish from eastern Tasmania and New South Wales³. While not conclusive, the above evidence was considered sufficient for the Common Jack Mackerel in the Small Pelagic Fishery (Commonwealth) to be managed as separate eastern and western biological stocks⁴, and they are assessed as such in this chapter.

Stock status

Eastern biological stock

Two studies have estimated the adult biomass of the eastern Common Jack Mackerel stock. The first, based on an ichthyoplankton survey conducted in 2002, used the daily egg production method and estimated the spawning biomass to be in the range 114 900–169 000 tonnes (t)⁵. The second study used two ecosystem-

^a Institute for Marine and Antarctic Studies, University of Tasmania

^b Australian Bureau of Agricultural and Resource Economics and Sciences

^c Department of Primary Industries, New South Wales

based modelling techniques to examine the plausible biomass required to support the shelf ecosystem of south-eastern Australia. These models estimated the biomass to be in the order of 130 000–170 000 t, and suggested that there would not be any broadscale restructuring of the marine ecosystem should the total allowable catch (TAC) for the Small Pelagic Fishery (Commonwealth) eastern stock (10 000 t in the 2012–13 fishing season) be taken⁶.

The low market value of this species, reduced demand for fish meal, and a recent moratorium on the operation of large-scale factory trawlers has meant that fishing activity has been minimal, and the TAC has not been taken in recent years. The most recent stock assessment for the eastern biological stock of Common Jack Mackerel⁴ reported that, since 2011, catches in all fisheries have been at historically low levels and collectively less than 100 t. Further, there has been a general decline in the number of vessels operating within the eastern zone of the Small Pelagic Fishery (Commonwealth) over the past 15 years⁴. The above evidence indicates that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished⁷. Relatively high biomass estimates⁶ and voluntary decreases in fishing effort, unrelated to Common Jack Mackerel abundance, also indicate that the biomass of the stock is unlikely to be recruitment overfished^{4,7}.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Western biological stock

No daily egg production method survey or estimate of spawning biomass has been conducted for the western Common Jack Mackerel stock. Aerial surveys in the 1970s suggested a biomass off western Tasmania of at least 80 000 t⁸. Catches peaked in 2006–07, when they were less than 1 per cent of the biomass estimate and 9 per cent of the current TAC (5000 t) for the Small Pelagic Fishery (Commonwealth). Catches in recent years have been low; the current catch is close to zero. The above evidence indicates that the stock is unlikely to be recruitment overfished and that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Common Jack Mackerel biology^{9–11}

<i>Longevity and maximum size</i>	17 years; 470 mm FL
<i>Maturity (50%)</i>	5–6 years; 315 mm FL

FL = fork length

Figure 1: Distribution of reported commercial catch of Common Jack Mackerel in Australian waters, 2013 (calendar year)

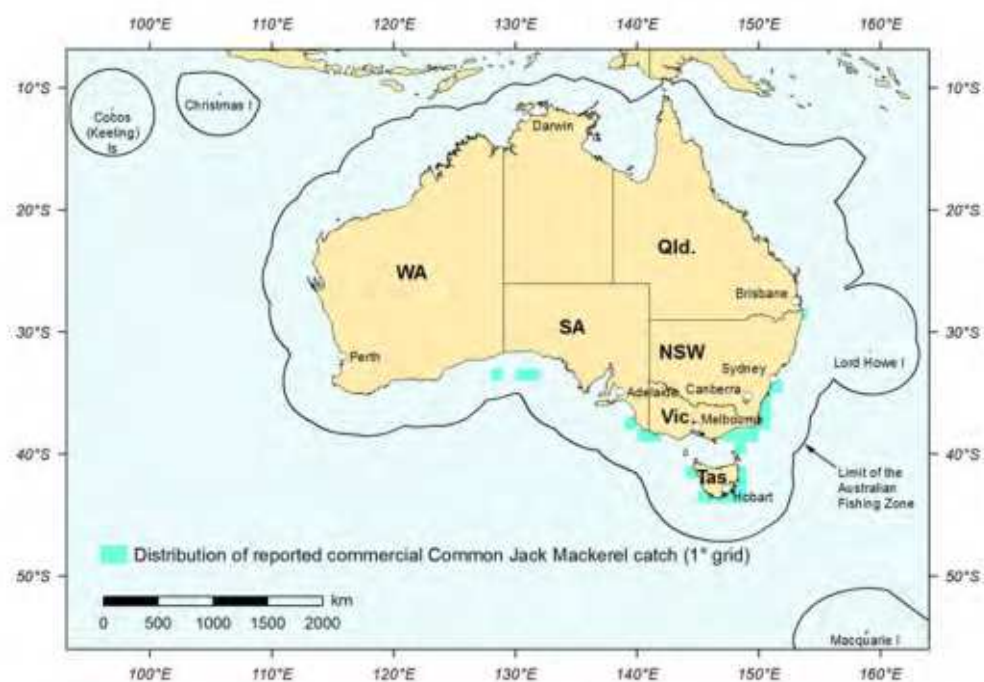


Table 3: Main features and statistics for Common Jack Mackerel fisheries in Australia, 2013 (calendar year)

Jurisdiction	Tasmania	New South Wales	Commonwealth
Fishing methods			
Commercial			
Purse seine	✓	✓	✓
Midwater trawl			✓
Beach seine	✓		
Gillnet	✓		
Demersal otter trawl		✓	✓
Recreational ^a			
Gillnet	✓		
Rod and line	✓	✓	

Jurisdiction	Tasmania	New South Wales	Commonwealth
Indigenous ^b			
Rod and line		✓	
Unknown	✓		
Management methods			
Commercial			
Limited entry	✓	✓	✓
Vessel restrictions	✓	✓	✓ ^c
Catch limits	✓		✓
Mesh size regulations	✓	✓	
Spatial closures	✓	✓	
Recreational ^a			
Bag limits	✓	✓	
Spatial closures	✓	✓	
Indigenous ^{b,d,e}			
Bag limits	✓	✓	
Spatial closures		✓	
Section 37(1)(c1), Aboriginal cultural fishing authority		✓	
Active vessels			
	5 in SF	<6 in NSWCF	2 in GAB 23 in CTS 3 in SPF 2 in VIT

Jurisdiction	Tasmania	New South Wales	Commonwealth
Catch			
Commercial	0.25 t in SF	Confidential ^f in NSWCF	0.1 t in GAB 36.1 t in CTS 0 t in SPF 0.3 t in VIT
Recreational ^b	1 t (2007–08)	Unknown	
Indigenous ^c	Unknown	Unknown	
Markets			
Domestic	✓	✓	✓
Export			

CTS = Commonwealth Trawl Sector; GAB = Great Australian Bight Trawl (Commonwealth); NSWCF = New South Wales Commercial Fishery; SF = Scalefish Fishery (Tasmania); SPF = Small Pelagic Fishery (Commonwealth); VIT = Victorian Inshore Trawl Fishery (Commonwealth)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

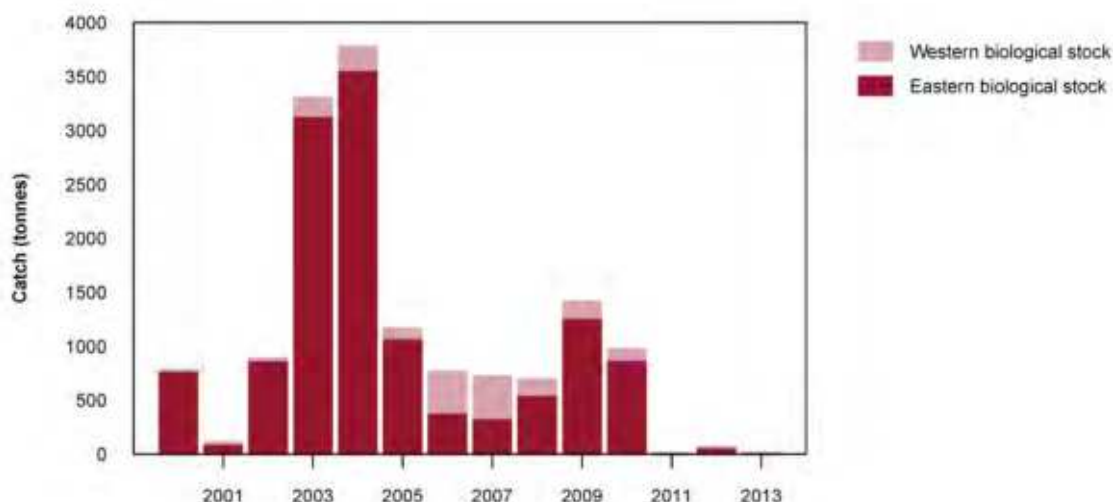
c Historically, no restrictions on vessel hold capacity have been in place in the Small Pelagic Fishery (Commonwealth). However, in 2012, an interim declaration was made to prevent factory trawlers greater than 130 metres in length with on-board fish processing facilities, and storage capacity for fish or fish products in excess of 2000 t, from entering this fishery for a 2-year period.

d The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

e The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

f Confidentiality clauses prevent reporting of fishery statistics for fewer than six vessels in New South Wales.

Figure 2: Commercial catch of Common Jack Mackerel in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Of the three main fishing methods used to target Common Jack Mackerel (purse seine, midwater trawl and beach seine), only beach seine interacts with the benthos. Studies in New South Wales have shown that purse-seine nets have a negligible impact on seagrass habitats¹². Both purse-seine and midwater trawl fisheries interact with marine mammals, including seals and dolphins. Purse-seine nets remain open to the surface. Studies in the Northern Hemisphere have shown that, although interactions with dolphins (Bottlenose and Common dolphins occur in Australia) can be common, these species are rarely caught by purse seine and, when caught, usually survive¹³. Mortalities of both seals and dolphins have been recorded during midwater trawl operations in this fishery¹⁴. Dolphin encounters appear to be very rare; however, underwater cameras have revealed that seals commonly enter and forage in midwater trawl gear, with some mortalities¹⁴. Seal excluder devices in the trawl nets have had some success in reducing, but not eliminating, lethal interactions¹⁴.
- Common Jack Mackerel play a role in the pelagic food chain as a link between primary and secondary producers and top predators, including tunas, sharks, marine mammals and seabirds. Recognising this important ecological role, the harvest strategy adopted in the Small Pelagic Fishery (Commonwealth) restricts catches to conservative levels of below 20 per cent of current spawning biomass estimates. These are consistent with levels internationally recommended for the sustainable management of forage fisheries¹⁵.

Environmental effects on Common Jack Mackerel

- A decrease in the presence and size of surface schools of Common Jack Mackerel in Tasmanian waters during the 1990s was initially considered to be due to the effects of heavy fishing pressure during the 1980s and 1990s by the Tasmanian Jack Mackerel (purse seine) Fishery. However, there is evidence that strengthening of the East Australian Current has altered the swarming behaviour and abundance of Australian krill (*Nyctiphanes australis*), a major prey for Common Jack Mackerel, and this contributed to the reduction in surface schools¹⁶. Associated with this ocean warming has been an apparent increase in the abundance of Redbait (*Emmelichthys nitidus*), a species that predominantly preys on small copepods¹⁷, which may have increased in abundance with the strengthening of the East Australian Current¹⁸.

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49. Grey Mackerel *Scomberomorus semifasciatus*

Anthony Roelofs^a, Grant Johnson^b and Stephen Newman^c



Table 1: Stock status determination for Grey Mackerel

Jurisdiction	Queensland		Queensland, Northern Territory	Northern Territory	Western Australia
Stock	Central east Queensland (ECIFFF)	North-east Queensland (ECIFFF)	Gulf of Carpentaria (GOCIFF, ONLF)	North-west Northern Territory (ONLF)	Western Australian (MMF)
Stock status					
	Sustainable	Sustainable	Sustainable	Sustainable	Sustainable
Indicators	Quantitative stock assessment, biomass, fishing mortality, catch, catch rate	Quantitative stock assessment, biomass, fishing mortality, catch, catch rate	Stock reduction analysis, fishing mortality, catch, catch rate	Stock reduction analysis, fishing mortality, catch, catch rate	Catch, population dynamics, catch rate

ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); GOCIFF = Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland); MMF = Mackerel Managed Fishery (Western Australia); ONLF = Offshore Net and Line Fishery (Northern Territory)

Stock structure

There are at least five Grey Mackerel biological stocks across northern Australia, with a possible additional stock in the north-east Gulf of Carpentaria^{1–5}. The five biological stocks are Western Australia, north-west Northern Territory (Timor/Arafura), Gulf of Carpentaria, north-east Queensland and central east Queensland. The status of Grey Mackerel has been determined at the level of these five biological stocks.

Stock status

Central-east Queensland biological stock

The central east Queensland biological stock is managed as part of a Queensland east coast-wide fishery. The most recent stock assessment⁶ did not detect any trend in east coast Grey Mackerel abundance that might indicate overfishing at the east coast-wide level, or find evidence to advocate against the current fishery-wide total allowable commercial catch (TACC) of 250 tonnes (t). The stock assessment (2011 data) for the central

a Department of Agriculture, Fisheries and Forestry, Queensland

b Department of Primary Industry and Fisheries, Northern Territory

c Department of Fisheries, Western Australia

east Queensland stock estimated the maximum sustainable yield (MSY) at approximately 90 t (80 per cent confidence interval: 70 to 130 t) and recommended a TACC of 70 t. Grey Mackerel is primarily a commercial net-caught species⁶; an average of 3 per cent of catches each year since 2003 have been taken by line fishing. The stock assessment estimated that the biomass of the central east Queensland stock in 2011 was equal to the biomass associated with MSY (B_{MSY}). Harvest levels for the commercial net fishery since 2011 (57 t in 2012; 53 t in 2013) were lower than the estimated MSY and the recommended TACC. Given this evidence, the biomass of the stock is not considered to be recruitment overfished.

Fishing pressure (days fished) on the central east coast has been low in recent years following the introduction of the current fishery-wide TACC of 250 t (an average of 93 net-fishing days from 2003 to 2009, and 61 days from 2010 to 2013). Fishery-dependent biological monitoring of central east Queensland Grey Mackerel indicates consistent recruitment in the fishery, with stable length and age frequencies^{6,7}. Estimates of fishing mortality are below natural mortality. This suggests stable levels of fishing pressure since 2008⁶. This level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

North-east Queensland biological stock

The north-east Queensland biological stock is managed as part of a Queensland east coast-wide fishery. The most recent stock assessment⁶ did not detect any trend in east coast Grey Mackerel abundance that might indicate overfishing at the east coast-wide level and found no evidence to advocate against the current fishery-wide TACC. However, uncertainty in the model outputs, particularly for the north-east Queensland stock, prompted the authors to suggest a conservative approach to sustainable yield estimates and subsequent TACC for this stock. The stock model estimated that MSY for the north-east Queensland stock ranged from 100 to 150 t and recommended a TACC of 100 t. The authors also indicated that there was flexibility in the proposed TACC, given the level of model uncertainty. The stock assessment estimated that the biomass of the north-east Queensland stock in 2011 was at levels close to B_{MSY} (noting the uncertainty in the model outputs). Commercial net harvest levels in 2013 (126 t) were above the recommended TACC but within the range of MSY, and average annual harvest levels since 2010 (113 t) of the north east Queensland biological stock have been close to the recommended TACC, following the introduction of the fishery-wide TACC of 250 t on 1 July 2009⁷. Given this evidence, the biomass of the stock is not considered to be recruitment overfished.

Fishery-dependent biological monitoring indicates that length and age frequencies in the north-east stock have been stable since monitoring commenced in 2008⁶. Estimates of total mortality have been below the threshold (double the natural mortality) since 2009. This suggests stable levels of fishing pressure since 2008⁶, and it is unlikely that the current level of fishing pressure will cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Gulf of Carpentaria biological stock

Grey Mackerel in the Gulf of Carpentaria is primarily a commercial net-caught species. Queensland and the Northern Territory share management of the Gulf of Carpentaria biological stock through the Queensland Fisheries Joint Authority. Queensland takes the majority of the commercial harvest (average 80–95 per cent).

There has been a rising trend in commercial catch rate since targeted fishing of Grey Mackerel began in the Gulf of Carpentaria in the late 1990s. Queensland catches and catch rates reached record levels in 2010 and 2012, respectively. Although the Queensland catch rate dropped in 2013, the rate (54 kg/100-m net) was still above the previous 10-year average (52 kg/100-m net)⁷. A stock reduction analysis of Grey Mackerel in the Gulf of Carpentaria, using Queensland and Northern Territory catches, concluded that the biomass in 2011 was at 74 per cent of the unfished biomass, and the harvest rate was 26 per cent of that required to achieve MSY⁸. The biomass of this stock is not considered to be recruitment overfished.

Queensland introduced changes to the net fishery at the beginning of the 2012 season to reduce pressure on Grey Mackerel. The measures decreased the total length of available net for the Queensland component of the stock by two-thirds, from 27 km to 9 km, in the offshore component of the fishery. Changes to the Queensland inshore fishery (within 7 nautical mile of the coast) also reduced the capacity for boats to target Grey Mackerel. Commercial catches and catch rates in 2013 were below the 5-year average for the Queensland component of the Gulf of Carpentaria stock. Given this evidence, the current allowable level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

North-west Northern Territory biological stock

Grey Mackerel has been assessed at the jurisdictional level for the north-west Northern Territory stock⁸. Assessments indicate that Grey Mackerel stocks in the Northern Territory declined substantially as a result of high Taiwanese catches in the 1970s and 1980s, but have since recovered, with the cessation of foreign fishing and more stringent management of the domestic fishery. In 2010, egg production was estimated at 74 per cent of unfished levels, which is well within sustainable limits for productive species such as Grey Mackerel⁸. Supporting this assessment is that catch per unit effort has increased over the past 10 years, while catches have remained relatively consistent^{8–10}. Grey Mackerel in the north-west Northern Territory stock is not considered to be recruitment overfished, and the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Western Australian biological stock

Grey Mackerel is exploited as a component of the Mackerel Managed Fishery of Western Australia⁵. The primary target species of the Mackerel Managed Fishery is Spanish Mackerel (*Scomberomorus commerson*). Grey Mackerel is therefore assessed on the basis of the status of the indicator species (Spanish Mackerel), which represents the pelagic suite of species. A stock assessment of Spanish Mackerel—examining catch-and-effort data, biological information, biomass and yield per recruit modelling—indicated that this stock is sustainable¹¹. In addition, Grey Mackerel are fast growing and have a young age at sexual maturity (less than 2 years)^{4,12,13}, indicating some resilience to fishing pressure.

Grey Mackerel catch levels in the Mackerel Managed Fishery from 2000 to 2013 have been relatively low and stable, ranging between 10 and 24 t, with catches reported from only a small area of the Grey Mackerel range¹¹. This level of catch is well below the TACC (60 t for each of the three management areas) for Grey Mackerel. The low levels of catch are likely to reflect the gear limitations (line only) that apply to the fishery. The biomass of the stock is not considered to be recruitment overfished, and the level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Grey Mackerel biology^{4,12,13}

Longevity and Maximum size	12 years; 1200 mm TL
Maturity (50%)	Females: 2 years; 700 mm TL Males: 1–2 years; 660 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Grey Mackerel in Australian waters, 2013 (calendar year)

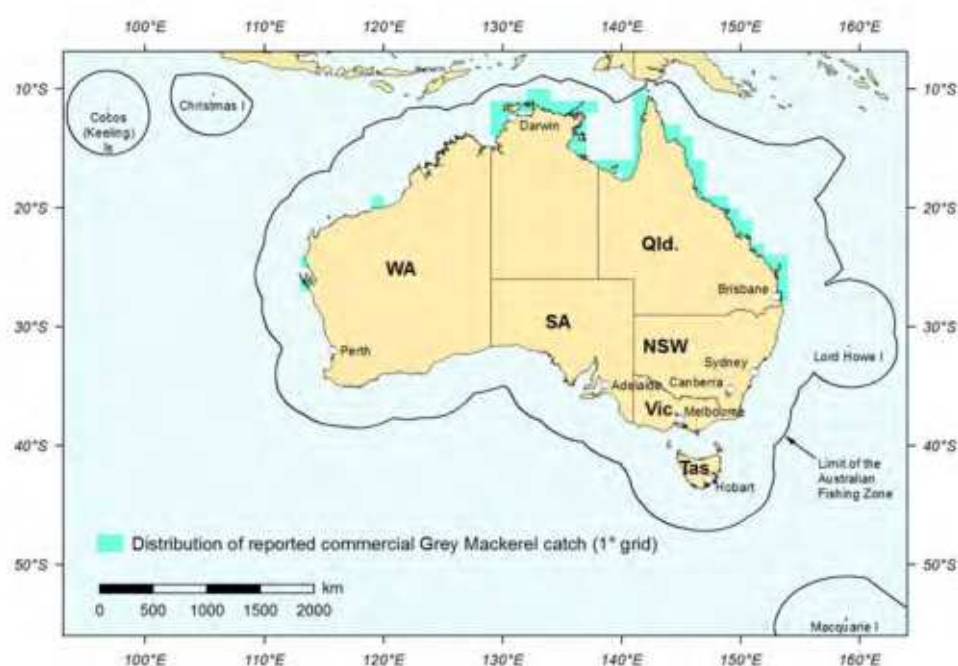


Table 3: Main features and statistics for Grey Mackerel fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland	Northern Territory	Western Australia
Fishing methods			
Commercial			
Nets	✓	✓	
Hand line	✓		✓
Rod and line	✓		✓
Recreational			
Hand line	✓	✓	✓
Rod and line	✓	✓	✓
Spearfishing	✓		✓
Indigenous ^{a,b}			
Hand line	✓	✓	✓
Rod and line	✓	✓	✓
Spearfishing	✓		✓

Jurisdiction	Queensland	Northern Territory	Western Australia
Management methods			
Commercial			
Limited entry	✓	✓	✓
Size limits	✓		✓
Gear restrictions	✓	✓	✓
Vessel restrictions	✓	✓	✓
Total allowable catch ^b	✓		✓
Fishery spatial closures	✓	✓	
Marine park closures	✓		
Spatial zoning	✓	✓	✓
Total allowable effort		✓	
Recreational			
Licensing			✓
Possession limits	✓	✓	✓
Bag limits			✓
Size limits	✓		✓
Gear restrictions	✓	✓	
Marine park closures	✓		
Spatial zoning	✓		
Charter			
Limited entry			✓
Passenger restrictions			✓
Possession limits	✓	✓	✓
Bag limits			✓
Size limits	✓		✓
Marine park closures	✓	✓	

Jurisdiction	Queensland	Northern Territory	Western Australia
Spatial zoning	✓		✓
Indigenous ^{a,b}			
No limits on customary catch		✓	
Laws of general application			✓
Active vessels			
	86 net and 20 line in ECIFFF 24 net in GOCIFFF	7 in ONLF	4 in MMF
Catch			
Commercial	194 t in ECIFFF ^{c,d} 485 t in GOCIFFF	355 t in ONLF	11 t in MMF
Recreational	Unknown ¹⁴	~10 t ¹⁵	Unknown ¹⁶
Charter	Unknown	173 fish (<1 t)	64 fish (<0.4 t)
Indigenous	Unknown	Unknown	Unknown
Markets			
Domestic	✓	✓	✓
Export			

ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); GOCIFFF = Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland); MMF = Mackerel Managed Fishery (Western Australia); ONLF = Offshore Net and Line Fishery (Northern Territory)

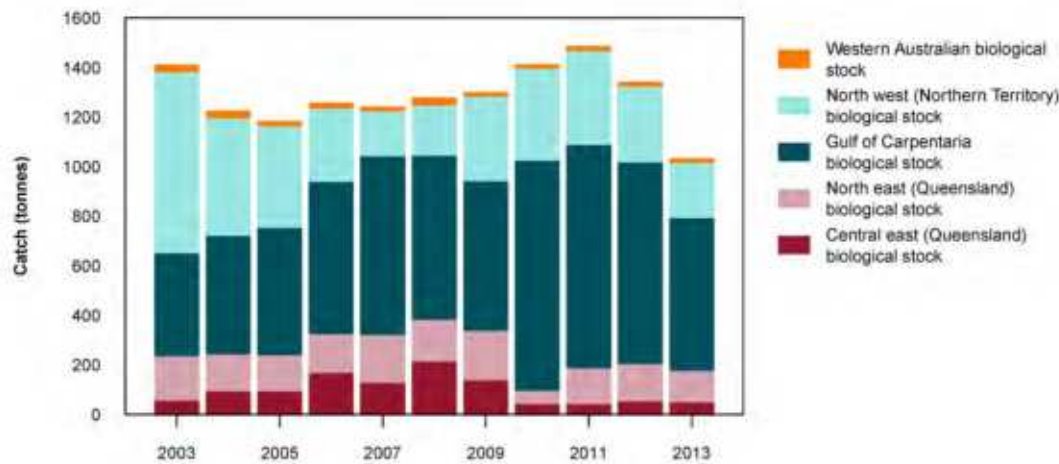
a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

b Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

c Limits apply to the combined catch of the two Queensland east coast stocks.

d Includes minor levels of catch from the Bowen region, which is not considered part of the north-east Queensland and central east Queensland biological stocks.

Figure 2: Commercial catch of Grey Mackerel in Australian waters, 2003 to 2013 (calendar years)



Effects of fishing on the marine environment

- Commercial gillnets have almost no impact on coastal habitat and are quite selective, with bycatch making up only a small proportion of the catch¹⁷. However, commercial gillnets do interact with threatened, endangered and protected species. Although reported interactions are low, the impact on the populations of these species is unknown.

Environmental effects on Grey Mackerel

- The duration and magnitude of the wet season is likely to affect the overall biomass of coastal stocks such as Grey Mackerel that are dependent on near-shore waters for breeding and feeding^{18,19}. A widespread drought in the Gulf of Carpentaria region in 2013 is thought to have affected the abundance of a number of commercially important species, including Grey Mackerel. Low rainfall in the southern Gulf of Carpentaria resulted in decreased freshwater flows, turbidity and primary productivity in near-shore areas, which are critical to Grey Mackerel larval survival and juvenile/adult feeding¹⁹. For other species, research has shown that large wet seasons result in higher recruitment than smaller wet seasons^{20,21}. The fine-scale stock structure evident on the Queensland east coast may limit the adaptability of Grey Mackerel to changing environmental conditions if stocks are unable to move in response to changing conditions¹⁹.

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50. Spanish Mackerel *Scomberomorus commerson*

Joanne Langstreth^a, Nic Marton^b, Thor Saunders^c and Brett Molony^d



Table 1: Stock status determination for Spanish Mackerel

Jurisdiction	Commonwealth	Queensland		Northern Territory	Western Australia
<i>Stock</i>	Torres Strait (TSSMF)	East coast (ECSMF)	Gulf of Carpentaria (GOCIFFF, GOCLF)	Northern Territory (DF, NTSMF, ONLF)	Western Australia (MMF)
<i>Stock status</i>					
	Sustainable	Sustainable	Sustainable	Sustainable	Sustainable
<i>Indicators</i>	Biomass, fishing mortality, catch and effort	Biomass, fishing mortality, catch and catch rate, length and age structure, TAC, performance indicators	Catch, catch rate, performance indicators, length and age structure	Catch rate, egg production	Catch, TAC, population dynamics, performance indicators

DF = Demersal Fishery (Northern Territory); ECSMF = East Coast Spanish Mackerel Fishery (Queensland); GOCIFFF = Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); MMF = Mackerel Managed Fishery (Western Australia); NTSMF = Northern Territory Spanish Mackerel Fishery (Northern Territory); ONLF = Offshore Net and Line Fishery (Northern Territory); TAC = total allowable catch; TSSMF = Torres Strait Spanish Mackerel Fishery (Commonwealth)

Stock structure

Genetic evidence indicates that there are three biological stocks of Spanish Mackerel across northern Australia¹; however, evidence from otolith microchemistry, parasite analysis and limited adult movement (at scales greater than 100 km) indicates that there are likely to be a number of smaller biological stocks with limited interaction¹⁻³. Although each jurisdiction is likely to have multiple biological stocks within its boundaries, the difficulty in obtaining relevant biological and catch-and-effort information to assess each stock individually has meant that Spanish Mackerel has been grouped into two biological stocks (Torres Strait and east coast [Queensland]), two management units (Gulf of Carpentaria [Queensland] and Mackerel Managed Fishery [Western Australia]) and one jurisdiction (Northern Territory). The assessments that are not undertaken at the biological stock level are based on the populations that receive the highest harvest rates; their status can be assumed to be representative of the highest level of exploitation that occurs on any population within each management unit or jurisdiction.

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Stock status

Torres Strait (Commonwealth) biological stock

A formal stock assessment of Spanish Mackerel in the Torres Strait Spanish Mackerel Fishery (Commonwealth) was conducted in 2006, informed by data to 2003⁴. The assessment uses a sex-specific age-structured population dynamics model to estimate biomass. A range of biological and effort reference points were assessed to evaluate various potential management strategies for the fishery. The assessment estimated that biomass in 2006 was 37 per cent (range 26–67 per cent) of the unfished level. Results of the assessment indicated that the base-case maximum sustainable yield (MSY) for Spanish Mackerel in the Torres Strait was 169 tonnes (t) per year, and annual catches of around 150 t per year would achieve a fishing mortality target of half natural mortality. The stock assessment concluded that the stock was likely to be harvested at levels near or exceeding MSY up to 2003. Catches since 2007–08 have been below both the base-case (169 t) and lower risk estimates of MSY⁵. The stock is therefore not considered to be recruitment overfished⁶, and the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished⁶.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

East coast (Queensland) biological stock

The east coast biological stock extends from Cape York in Queensland waters to its southern extent in northern New South Wales⁷, although New South Wales catches are limited⁸. The most recent stock assessment⁹ indicated that the 2009 estimate of biomass ranged from 36 to 54 per cent of the unfished level. Recent research, using commercial catch-and-effort data, describes a contraction in the spatial and temporal presence of spawning aggregations on the main commercial fishing grounds¹⁰, which may be a result of the vulnerable nature of transient spawning aggregations that form each year¹¹. Potential serial depletion of these spawning aggregations may be a concern for the reproductive potential and size of the stock. However, the overall evidence indicates that the biological stock is unlikely to be recruitment overfished.

Total landings for the combined commercial and recreational catch for Queensland and New South Wales over the past few years have been below the lowest sustainable yield estimate (yield that sustains $1.2B_{MSY}$ in the hyperstable model case) of 956 t, as well as below the lowest risk management yield estimate of 715 t⁹. In Queensland, introduction in 2004 of a total allowable catch and individual transferable quotas for the commercial fishery substantially reduced participation; in 2013, fishing effort was around the lowest level recorded in the past 25 years. Fishery-dependent monitoring data indicate a varied but continuous pattern of recruitment, and the estimate of total mortality rate in 2012–13 is less than twice the natural mortality rate¹². This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished. However, given the proximity of stock levels to relevant reference points, the fact that an average of only 51 per cent of available quota has been harvested in the past 9 years, and uncertainty around the levels of recreational harvest, future harvests will need to be closely monitored.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Gulf of Carpentaria (Queensland) management unit

The Gulf of Carpentaria (Queensland) management unit has a line and net component—the Gulf of Carpentaria Line Fishery and the Gulf of Carpentaria Inshore Fin Fish Fishery, respectively. Catch rates for both fisheries have continued to increase since the mid-1990s. Age-composition data from routine monitoring of line catches since 2007 are now available. The data indicate relatively consistent recruitment and age composition in the fishery, with the majority of line catches since 2007 comprising fish between 2 and 6 years of age. This evidence indicates that the biomass of the stock is unlikely to be recruitment overfished.

Total commercial landings are within historical harvest levels (238 t in 2013), with the majority taken by the line fishery (76 per cent in 2013). Landings in the line fishery have been relatively stable over the last 2 years; there have been stable catches in the net fishery over the past 4 years. Fishing effort in the line fishery has decreased substantially to a historical low in 2013. This evidence indicates that the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Northern Territory

Spanish Mackerel stocks have been assessed at a territory-wide level, including information up to 2011. The results indicated that stocks declined substantially because of high Taiwanese catches in the 1970s and 1980s, but have since recovered as a result of more stringent management. In 2011, egg production was estimated at around 85 per cent of unfished levels, which is well within sustainable limits for a species such as Spanish Mackerel, and it was suggested that increases in catch could occur^{13,14}. This assessment is supported by increased catch rates over the past 10 years, with the 2012 value being the highest recorded in the fishery¹⁵. The evidence provided indicates that the biomass of this management unit is unlikely to be recruitment overfished and the current level of fishing mortality is unlikely to cause this management unit to become recruitment overfished.

On the basis of the evidence provided above, Spanish Mackerel in the Northern Territory is classified as a **sustainable stock**.

Mackerel Managed Fishery (Western Australia) management unit

Fishing effort throughout the Mackerel Managed Fishery (Western Australia) has been relatively stable since 2006, following reductions due to management changes. The high catch rates for the two main fishery areas, both near record levels, indicate a relatively high abundance of Spanish Mackerel in these management areas. Catch rates in other areas have remained stable at relatively high levels since 2007. As the minimum legal size for Spanish Mackerel is 900 mm total length, which is similar to the size at maturity for this species¹⁶, the spawning stock is essentially the same as the exploited stock. Therefore, the status of the Spanish Mackerel spawning stock is measured using the catch rates for each area of the fishery. Catch rates are either continuing to increase or are stable at relatively high levels within each management area, suggesting that the overall spawning stock is increasing. Additionally, the total catches of Spanish Mackerel remain within the target range. Spanish Mackerel in Western Australia is not considered to be recruitment overfished, and the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

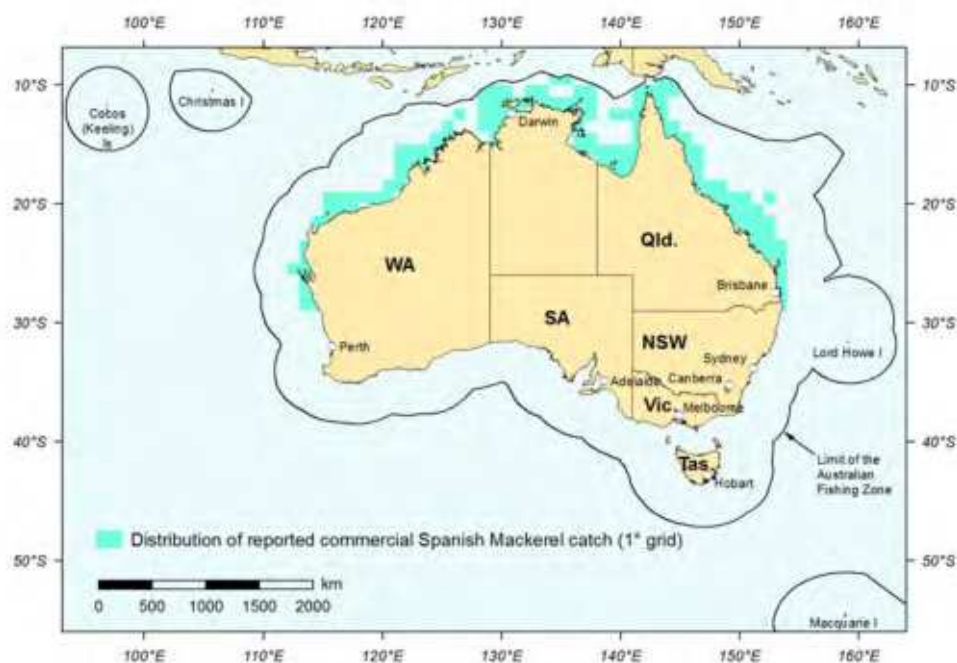
On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Table 2: Spanish Mackerel biology^{17–19}

Longevity and maximum size	26 years; 2400 mm FL
Maturity (50%)	~2 years; 800 mm FL

FL = fork length

Figure 1: Distribution of reported commercial catch of Spanish Mackerel in Australian waters, 2013 (calendar year)



Note: Commercial catch data for the east coast (Queensland) and Torres Strait biological stocks are for the financial year (2012–13).

Table 3: Main features and statistics for Spanish Mackerel fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth (Torres Strait) ^a	Queensland ^a	Northern Territory	Western Australia
Fishing methods				
Commercial				
Trolled baits	✓	✓	✓	✓
Lures	✓	✓	✓	✓
Hand line	✓	✓	✓	✓
Gillnet		✓	✓	
Trawl			✓	

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SPANISH MACKEREL

Jurisdiction	Commonwealth (Torres Strait) ^a	Queensland ^a	Northern Territory	Western Australia
Recreational ^b				
Trolled baits		✓	✓	✓
Lures		✓	✓	✓
Hand line		✓	✓	✓
Spearfishing		✓	✓	✓
Indigenous ^{c-e}				
Trolled baits		✓		✓
Lures		✓		✓
Hand line		✓	✓	✓
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Size limits	✓	✓		✓
Vessel restrictions	✓	✓	✓	✓
Catch restrictions	✓	✓	✓	✓
Effort limits			✓	
Spatial closures	✓	✓		✓
Recreational ^b				
Size limits		✓		✓
Bag limits				✓
Possession limits		✓	✓	✓
Spatial closures		✓	✓	✓
Gear restrictions		✓	✓	
Licensing				✓

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
SPANISH MACKEREL

Jurisdiction	Commonwealth (Torres Strait) ^a	Queensland ^a	Northern Territory	Western Australia
Charter ^b				
Licensing		✓ (vessel)		✓
Spatial zoning			✓	✓
Spatial closures		✓	✓	✓
Size limits		✓		✓
Bag limits				✓
Possession limits		✓	✓	✓
Indigenous ^{c-e}				
			None	None
Active vessels				
	135 Traditional Inhabitant (TIB) ^f 5 non-TIB in TSSMF	169 in ECSMF 22 in GOCIFFF 15 in GOCLF	6 in DF 11 in NTSMF 12 in ONLF	11 in MMF
Catch				
Commercial	83 t in TSSMF (2012–13)	261 t in ECSMF (2012–13) 57 t in GOCIFFF 181 t in GOCLF	0.2 t in DF 205 t in NTSMF 17 t in ONLF	277 t in MMF
Recreational ^b		272 t (2010)	27 t (2010) plus 4 t by FTO	89 t (2011–12)
Indigenous ^{c,d}		Negligible	Unknown	Unknown
Markets				
Domestic	✓	✓	✓	✓
Export	✓		✓	

DF = Demersal Fishery (Northern Territory); ECSMF = East Coast Spanish Mackerel Fishery (Queensland); FTO = Fishing Tour Operators (Northern Territory); GOCIFFF = Gulf of Carpentaria Inshore Fin Fish Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); MMF = Mackerel Managed Fishery (Western Australia); NTSMF = Northern Territory Spanish Mackerel Fishery (Northern Territory); ONLF = Offshore Net and Line Fishery (Northern Territory); TSSMF = Torres Strait Spanish Mackerel Fishery (Commonwealth)

a The reporting period for the Commonwealth (Torres Strait) and Queensland (east coast [Queensland]) is the 2012–13 financial year.

b The Australian Government does not manage recreational fishing, including charter fishing, in Commonwealth waters. Recreational and charter fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

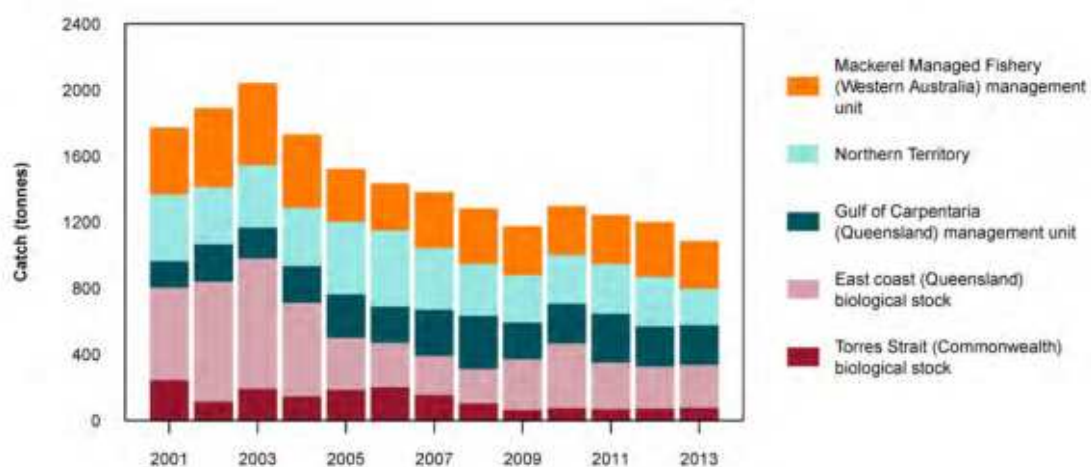
c The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters. In the Torres Strait, both commercial and noncommercial Indigenous fishing is managed by the Torres Strait Protected Zone Joint Authority (PZJA) through the Australian Fisheries Management Authority (Commonwealth); the Department of Agriculture, Fisheries and Forestry (Queensland); and the Torres Strait Regional Authority. The PZJA also manages non-Indigenous commercial fishing in the Torres Strait.

d Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

e Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

f Total number of TIB licences; this is not an indicator of licence activity.

Figure 2: Commercial catch of Spanish Mackerel in Australian waters, 2001 to 2013 (calendar years)



Note: Commercial catch for the east coast (Queensland) and Torres Strait biological stocks is reported by financial year, with data for the 2012–13 year plotted against 2013.

Effects of fishing on the marine environment

- Targeted fishing for all Spanish Mackerel in Western Australia and most Spanish Mackerel fishing in the other jurisdictions uses trolled lines. This method has almost no direct impact on the habitats where it is used and results in little bycatch^{15,20–23}.
- Commercial gillnets interact with threatened, endangered and protected species. Although reported interactions are low, the impact on the populations of these species is unknown.
- Commercial trawl gear used in the Northern Territory has the potential to impact on the benthic habitat. However, trawl nets in the Northern Territory have been designed to fish off the seabed, reducing interaction with benthic habitats²⁴. The trawl fishery in the Northern Territory comprises a small fleet and only fishes around 7 per cent of the available area²⁴.
- An analysis of community structure of finfish in the bioregions in Western Australia¹⁶ where mackerel fishing has been undertaken has found no evidence of any significant shift over the past 30 years²⁵.

Environmental effects on Spanish Mackerel

- Annual recruitment strength of Spanish Mackerel appears to be negatively correlated with spring sea surface temperature, with cooler years positively influencing recruitment on the Queensland east coast²⁶.

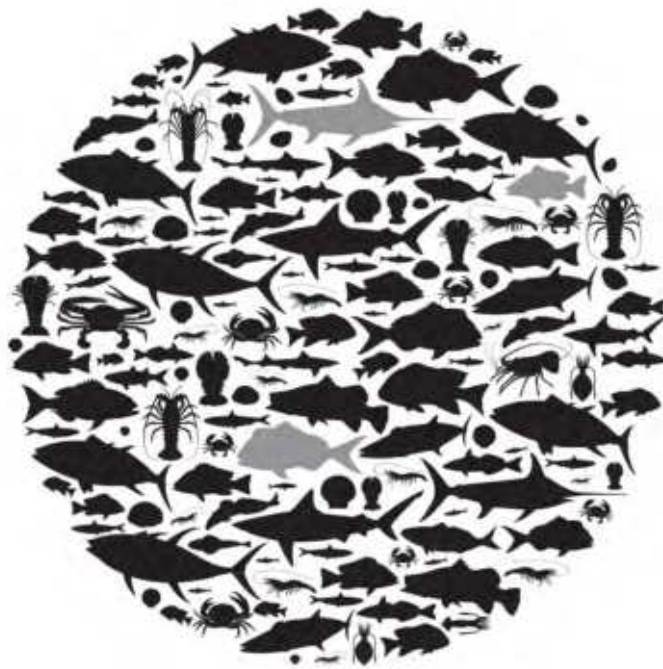
In addition, marine heatwave events in late 2010 and early 2011 off the south-western coast of Western Australia appear to have temporarily shifted Spanish Mackerel distribution southward²⁷. It is currently unclear if this is a one-off event or a longer-term regime shift in the system.

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Finfish: *Mullet*



51. Sea Mullet *Mugil cephalus*

John Stewart^a, Andrew Prosser^b and Kim Smith^c



Table 1: Stock status determination for Sea Mullet

Jurisdiction	New South Wales, Queensland	Western Australia
Stock	Eastern Australian (ECIFFF, EGF, OHF)	Western Australian (EF, EGBSMNMF, SBBSMNMF, SCEMF, WCBBFNMF, WCEIMF)
Stock status		
	Sustainable	Sustainable
Indicators	Catch, CPUE, length and age frequencies	Catch, CPUE

CPUE = catch per unit effort; ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); EF = Estuaries Fisheries (Condition) (Western Australia); EGBSMNMF = Exmouth Gulf Beach Seine and Mesh Net Managed Fishery (Western Australia); EGF = Estuary General Fishery (New South Wales); OHF = Ocean Hauling Fishery (New South Wales); SBBSMNMF = Shark Bay Beach Seine and Mesh Net Managed Fishery (Western Australia); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); WCBBFNMF = West Coast (Beach Bait Fish Net) Managed Fishery (Western Australia); WCEIMF = West Coast Estuarine (Interim) Managed Fishery (Western Australia)

Stock structure

Results of extensive tagging studies¹ suggest a single east coast biological stock of Sea Mullet, extending from central Queensland to eastern Victoria. The biological stock structure of Sea Mullet off Western Australia is likely to be complex, although limited tagging and genetic studies^{2,3} suggest mixing of fish throughout the lower west coast region, where the majority of the catch is taken. Therefore, a single Western Australian biological stock is assumed here. Stock status for Sea Mullet is reported at the level of individual biological stocks.

^a Department of Primary Industries, New South Wales

^b Department of Agriculture, Fisheries and Forestry, Queensland

^c Department of Fisheries, Western Australia

Stock status

Eastern Australian biological stock

The cross-jurisdictional eastern Australian biological stock has components in New South Wales and Queensland. Each jurisdiction assesses the part of the biological stock that occurs in its waters. The status presented here for the entire biological stock has been established using evidence from both jurisdictions.

The New South Wales component of the eastern Australian biological stock is assessed annually in terms of landings and catch rates in both the estuary and ocean fisheries⁴. The annual spawning run fishery on ocean beaches is assessed in terms of fish sizes and ages in landings. Commercial median catch rates have remained stable in the estuary fishery (kilograms per day of mesh netting) and increased slightly in the ocean fishery (kilograms per day of beach hauling) since the early 1980s. The size compositions of fish in ocean landings have remained stable, while the age composition of fish in this fishery is generally between 2 and 5 years, with some variations in year-class strength. The above evidence indicates that the biomass of this part of the stock is unlikely to be recruitment overfished.

Landings in New South Wales in 2013 (2133 tonnes [t]) were well below the long-term annual average (around 3000 t). The reported number of fisher-days in the ocean fishery in 2013 was at a historical low of approximately 650 days. Typical length-frequency compositions were found in landings in 2013. Age compositions in 2011 (the most recent year analysed for age compositions) suggest no large changes in the stock, with most fish being 3–5 years of age. The above evidence indicates that the current level of fishing pressure is unlikely to cause this part of the stock to become recruitment overfished.

The Queensland component of the eastern Australian biological stock has a long history of stable commercial landings. In 2013, 2109 t was reported landed, which is above the long-term average of around 2000 t. Length-frequency information from routine monitoring shows stable distributions of fish sizes harvested by the Queensland fishery. Age-frequency information shows that fish from 3 to 5 years of age dominate catches, but older fish are present. Recruitment has been consistent, with evidence of recent strong year-classes. The above evidence indicates that the biomass of the Queensland component of this stock is unlikely to be recruitment overfished.

Nominal effort in the Queensland component of the fishery has been stable at around 9000 days for the past 5 years, and the number of fishers reporting mullet (unspecified) catch has decreased from 319 fishers in 2009 to 285 fishers in 2013. This decline is expected to continue with planned net licence buy-backs. Length-frequency information shows stable patterns, and catch is well above minimum legal size. Age-frequency information shows continued recruitment to the fishery and evidence of strong year-classes. Estimates of fishing mortality are high compared with estimates of natural mortality, but show a stable trend in combination with consistent catches. The above evidence indicates that the current level of fishing pressure is unlikely to cause the Queensland component of the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the entire biological stock is classified as a **sustainable stock**.

Western Australian biological stock

Sea Mullet occurs in all coastal regions of Western Australia, but commercial targeting of the species is mainly restricted to waters from Shark Bay southwards. Sea Mullet is managed separately in the four Western Australian bioregions, although the level of connectivity between the different populations is unknown⁵. The total catch of Sea Mullet in Western Australia has declined since the 1990s, as a consequence of commercial effort reductions in coastal and estuarine areas, attributable to licence buy-backs and spatial closures. The above evidence indicates that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

The assessment for Sea Mullet is based on trends in catches and catch rates in the three main fisheries (Shark Bay Beach Seine and Mesh Net Managed Fishery, South Coast Estuarine Managed Fishery, and West Coast Estuarine [Interim] Managed Fishery) that capture around 80 per cent of the total commercial catch. Catch rates in these fisheries were relatively stable over the period 1980 to 2000, and have increased since 2000. These trends suggest long-term stability in Sea Mullet abundance in each bioregion, with a slight increase in recent years. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Sea Mullet biology⁶⁻⁹

Longevity and maximum size	Eastern Australia: 16 years; 640 mm FL Western Australia: males 8 years, females 12 years, 790 mm FL
Maturity (50%)	Eastern Australia: males 330 mm FL, females 370 mm FL Western Australia: both sexes 370 mm TL

FL = fork length; TL = total length

Figure 1: Distribution of reported commercial catch of Sea Mullet in Australian waters, 2013 (calendar year)

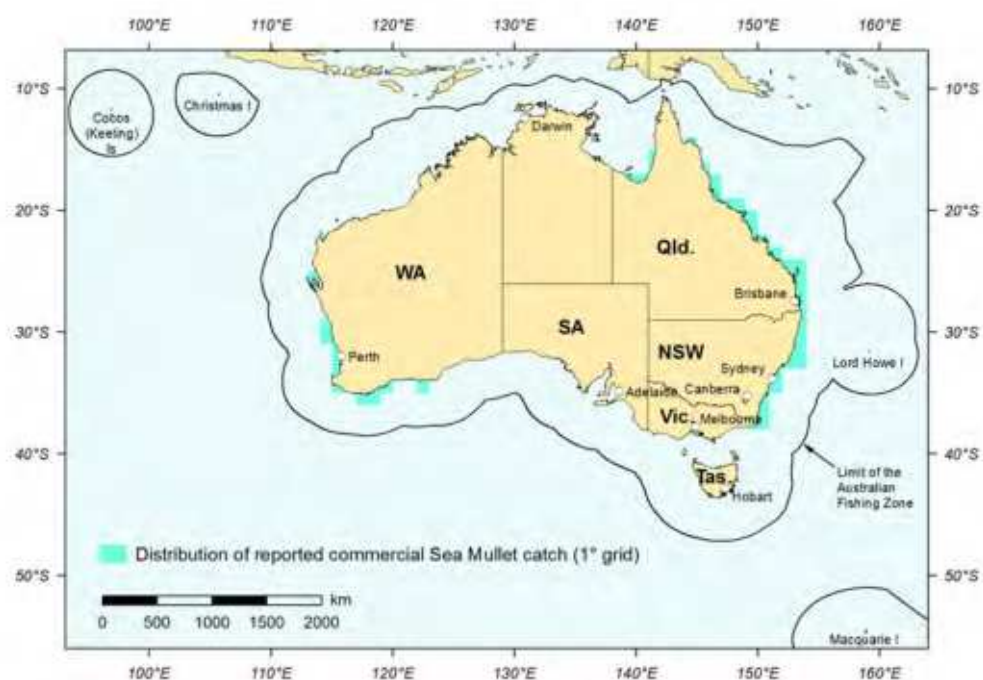


Table 3: Main features and statistics for Sea Mullet fisheries in Australia, 2013 (calendar year)

Jurisdiction	New South Wales	Queensland	Western Australia
Fishing methods			
Commercial			
Gillnet	✓	✓	✓
Beach-seine net	✓	✓	✓
Tunnel net		✓	
Haul net	✓		✓

Jurisdiction	New South Wales	Queensland	Western Australia
Recreational			
Rod and line	✓		✓
Bait trap	✓		
Nets			✓
Cast netting		✓	
Bait (seine) netting		✓	
Indigenous ^a			
Rod and line	✓		
Bait trap	✓		
Management methods			
Commercial			
Limited entry	✓	✓	✓
Size limits	✓	✓	
Gear restrictions	✓	✓	✓
Temporal closures	✓	✓	
Spatial closures	✓	✓	✓
Vessel restrictions	✓		✓
Recreational			
Bag limits	✓		✓
Possession limits	✓	✓	
Size limits	✓	✓	
Licensing			✓
Gear restrictions	✓		✓
Spatial closures	✓		

Jurisdiction	New South Wales	Queensland	Western Australia
Indigenous ^{b,c,d}			
Bag limits	✓		✓
Size limits	✓		
Spatial closures	✓		
Section 37(1)(c1), Aboriginal cultural fishing authority	✓		
Gear restrictions ^a	✓	✓	
Active vessels			
	299 in EGF 53 in OHF	285 in ECIFFF	27 in open access 2 in EF 2 in EGBSMNMF 7 in SBBSMNMF 23 in SCEMF 1 in WCBBFNMF 10 in WCEIMF
Catch			
Commercial	1140 t in EGF 1000 t in OHF	2109 t in ECIFFF	30 t in open access 4 t in EF <1 t in EGBSMNMF 32 t in SBBSMNMF 32 t in SCEMF <0.5 t in WCBBFNMF 68 t in WCEIMF
Recreational	Negligible	Negligible	<0.5 t
Indigenous	Unknown	Unknown	Unknown
Markets			
Domestic	✓	✓	✓
Export	✓	✓	

ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); EF = Estuaries Fisheries (Condition) (Western Australia); EGBSMNMF = Exmouth Gulf Beach Seine and Mesh Net Managed Fishery (Western Australia); EGF = Estuary General Fishery (New South Wales); OHF = Ocean Hauling Fishery (New South Wales); SBBSMNMF = Shark Bay Beach Seine and Mesh Net Managed Fishery (Western Australia); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); WCBBFNMF = West Coast (Beach Bait Fish Net) Managed Fishery (Western Australia); WCEIMF = West Coast Estuarine (Interim) Managed Fishery (Western Australia)

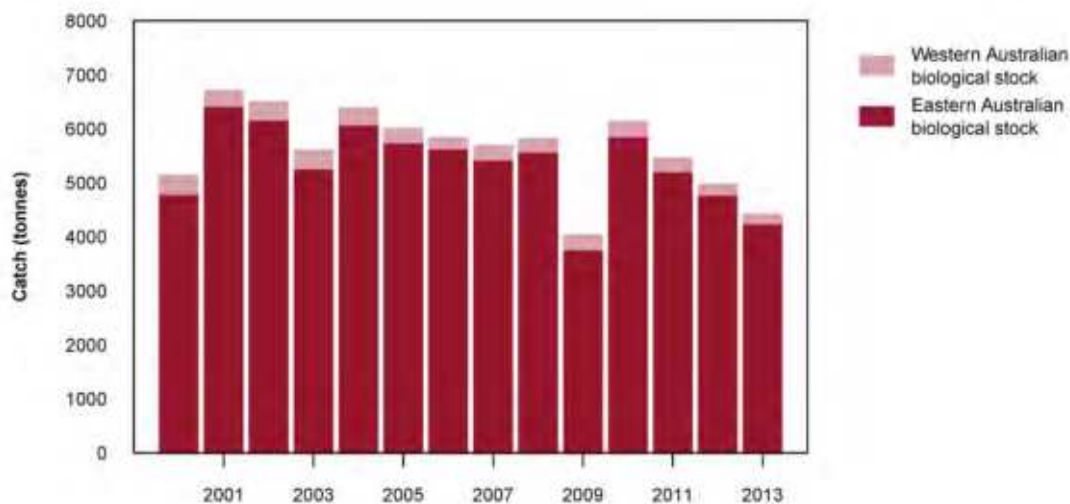
a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

b The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

c The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

d Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catch of Sea Mullet in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- The main fisheries for Sea Mullet use beach seining. This fishing method is highly targeted and, as a result, there is very little bycatch in these fisheries¹⁰. In Queensland, byproduct caught in estuarine gillnets in the Sea Mullet fishery comprises less than 20 per cent by number, and much of this is retained and marketed¹¹.

Environmental effects on Sea Mullet

- Sea Mullet penetrate far up rivers, often into fresh water, and barriers to fish passage (such as weirs and dams) can reduce the amount of habitat available to the species. Being highly dependent on riverine and estuarine habitats, Sea Mullet populations are vulnerable to fluctuations in water quality. Eutrophication and hypoxia can cause significant fish kills.

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52. Yelloweye Mullet *Aldrichetta forsteri*

Jason Earl^a, Kim Smith^b, Corey Green^c and Justin Bell^d



Table 1: Stock status determination for Yelloweye Mullet

Jurisdiction	Western Australia	South Australia		Victoria	Tasmania
Stock	Western Australia (SCEMF, SWBSF, WCEIMF)	LCF	MSF	Victoria (CIF, GLF, PPBF)	Tasmania (SF)
Stock status					
	Undefined	Sustainable	Sustainable	Undefined	Undefined
Indicators	Catch	Catch, CPUE, age structure	Catch, CPUE	Catch, CPUE	Catch

CIF = Corner Inlet Fishery (Victoria); CPUE = catch per unit effort; GLF = Gippsland Lakes Fishery (Victoria); LCF = Lakes and Coorong Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); PPBF = Port Phillip Bay Fishery (Victoria); SF = Scalefish Fishery (Tasmania); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); SWBSF = South-west Beach Seine Fishery (Western Australia); WCEIMF = West Coast Estuarine Interim Managed Fishery (Western Australia)

Stock structure

Yelloweye Mullet inhabit bays, estuaries and inshore waters along the southern coast of Australia, from Kalbarri in Western Australia, around Tasmania and to Newcastle in New South Wales, and in New Zealand¹. Throughout this broad distribution, Yelloweye Mullet typically occur in schools in inshore coastal waters, from the intertidal zone to depths of at least 20 metres, and can also be highly abundant in estuaries when conditions are favourable^{2,3}.

The biological stock structure of Yelloweye Mullet throughout its distribution is not well understood. It has been suggested that populations in Australia form two discrete biological stocks—western and eastern—based on morphological differences^{4,5}. However, further studies are required to confidently define biological stock delineation for this species. In the absence of definitive information on biological stock structure, status is reported on a jurisdictional basis for Western Australia, Victoria and Tasmania. For South Australia, status is reported for two functionally independent management units that reflect spatial patterns in commercial fishing.

^a South Australian Research and Development Institute

^b Department of Fisheries, Western Australia

^c Department of Environment and Primary Industries, Victoria

^d Institute for Marine and Antarctic Studies, University of Tasmania

Stock status

Western Australia

In Western Australia, commercial targeting of Yelloweye Mullet is mainly restricted to estuaries and embayments south of Perth. During the period 2003 to 2013, 78 per cent of the total catch in Western Australia was taken by the West Coast Estuarine Interim Managed Fishery in the Peel–Harvey Estuary, 12 per cent by the South Coast Estuarine Managed Fishery in several south coast estuaries, and 5 per cent by the South-west Beach Seine Fishery in Geographe Bay. The remainder was taken as minor catches in other fisheries.

Annual catches in each of the three main commercial fisheries have followed a similar trend. Catches peaked around 1980 and then gradually declined over the following two decades. A sharp drop in catch level occurred in each fishery around 2000. Subsequent catches have continued to decline gradually. The long-term decline in catch likely reflects reductions in fishing effort (due to licence buy-backs, for example) and reductions in targeted effort due to market demand. However, the catch decline is also believed to reflect a decline in stock abundance. Anecdotal reports from commercial and recreational fishers suggest that Yelloweye Mullet abundance in south-west Western Australia is low compared with historical levels. However, insufficient information is available to confidently classify the status of Yelloweye Mullet in this jurisdiction.

On the basis of the evidence provided above, Yelloweye Mullet in Western Australia is classified as an **undefined stock**.

Lakes and Coorong Fishery (South Australia) management unit

The Lakes and Coorong Fishery (South Australia) management unit has traditionally been the most important of the South Australian fisheries for Yelloweye Mullet, accounting for approximately 80 per cent of the state's total catch of this species since 2000. The most recent stock assessment for Yelloweye Mullet in this management unit considered that the stock was sustainable⁶. The 2013 catch of Yelloweye Mullet by the Lakes and Coorong Fishery of 227 tonnes (t) was 34 per cent higher than the average annual catch since 2000 (169 t). Over the past decade, annual catch rates for Yelloweye Mullet using small-mesh gillnets (the dominant gear used to target Yelloweye Mullet) have been among the highest recorded for the fishery. Age-structure analysis undertaken in 2012 revealed that numerous strong year-classes were present in the population and that there had been regular recruitment of young fish to the population over recent years⁶. The above evidence indicates that the biomass of Yelloweye Mullet exploited by the Lakes and Coorong Fishery (South Australia) management unit is unlikely to be recruitment overfished. Furthermore, the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Marine Scalefish Fishery (South Australia) management unit

The Marine Scalefish Fishery (South Australia) management unit has traditionally provided much lower catches than the Lakes and Coorong Fishery (South Australia). Since 2000, annual catches have progressively declined as a result of a decline in targeted fishing effort. Targeted effort of 78 days in 2012–13 was the lowest ever recorded in the fishery⁶. The long-term decline in targeted fishing effort likely relates to the relatively low value of Yelloweye Mullet on the local domestic market, rather than a declining biomass, because catch rates over recent years have been among the highest ever recorded in the fishery. The above evidence indicates that the biomass of Yelloweye Mullet exploited by the Marine Scalefish Fishery (South Australia) management unit is unlikely to be recruitment overfished. Furthermore, the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Victoria

In Victoria, a total of 50 t of Yelloweye Mullet was caught in 2013 by commercial fishers operating in the Port Phillip Bay, Corner Inlet and Gippsland Lakes fisheries. This catch is within the previous 10-year catch range (37–68 t). The commercial catch in the Gippsland Lakes has declined over the past 30 years; however, similar declines for other species were reportedly market driven, and it is unknown whether there has also been a decline in relative abundance⁷. In the Gippsland Lakes Fishery, Yelloweye Mullet constituted around 6 per cent (10 t) of the total commercial catch in 2009–10⁷. For the Port Phillip Bay Fishery, the 10-year trend in catch and

catch per unit effort is relatively constant, although catch has shown a decline over the past 30 years⁸. During 2013, 58 per cent of the total statewide catch was taken using haul-seine nets, and the remainder was caught using multifilament mesh nets. Yelloweye Mullet are caught by recreational fishers, but recent catch quantities are unknown. The 2000–01 recreational fishing survey indicated that around 60 t of mullet (unspecified) was caught by the recreational sector⁹. Formal stock assessment has not been undertaken for Yelloweye Mullet in Victoria. Therefore, insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Yelloweye Mullet in Victoria is classified as an **undefined stock**.

Tasmania

In Tasmania, commercial catch peaked at 19 t in 1999, but has not exceeded 7 t since 2000, as a result of a decline in targeted fishing effort¹⁰. Recreational catches peaked at 6.5 t in 1996–97. Reductions in the maximum permitted length of gillnets and an overall decline in participation¹¹ led to a reduction in recreational catch to around 1.7 t in 2009–10¹⁰. Because this species has not been targeted heavily in recent years and catches have been historically low, there is insufficient catch-and-effort information available to confidently classify the status of this stock.

On the basis of the evidence provided above, Yelloweye Mullet in Tasmania is classified as an **undefined stock**.

Table 2: Yelloweye Mullet biology^{4,12,13}

Longevity and maximum size	10 years; 440 mm TL
Maturity (50%)	2–3 years; 200–260 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Yelloweye Mullet in Australian waters, 2013 (calendar year)

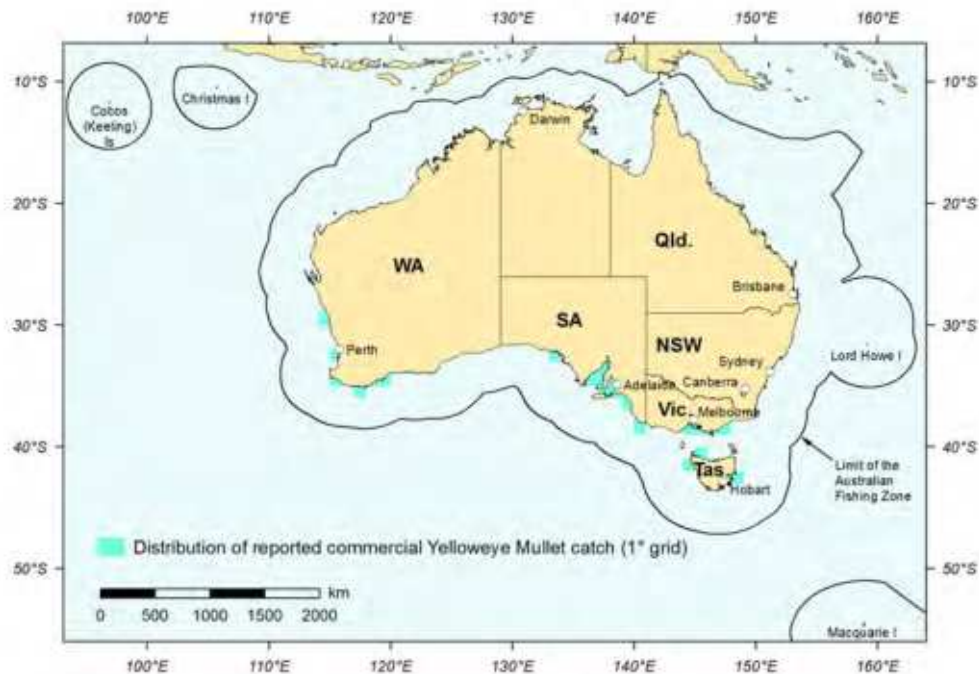


Table 3: Main features and statistics for Yelloweye Mullet fisheries in Australia, 2013 (calendar year)

Jurisdiction	Western Australia	South Australia	Victoria	Tasmania
Fishing methods				
Commercial				
Haul nets	✓	✓	✓	✓
Mesh (gill) nets	✓	✓	✓	✓
Beach-seine nets	✓		✓	✓
Ring nets		✓	✓	
Purse-seine nets				✓
Recreational				
Rod and line	✓	✓	✓	✓
Mesh (gill) nets	✓	✓		✓
Haul-seine nets				✓
Indigenous ^a				
Rod and line		✓		✓
Mesh (gill) nets		✓		✓
Traditional apparatus		✓		
Unknown	✓			
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Size limits		✓		✓
Gear restrictions	✓	✓	✓	✓
Spatial closures	✓	✓	✓	✓
Temporal closures		✓		
Vessel restrictions	✓			✓

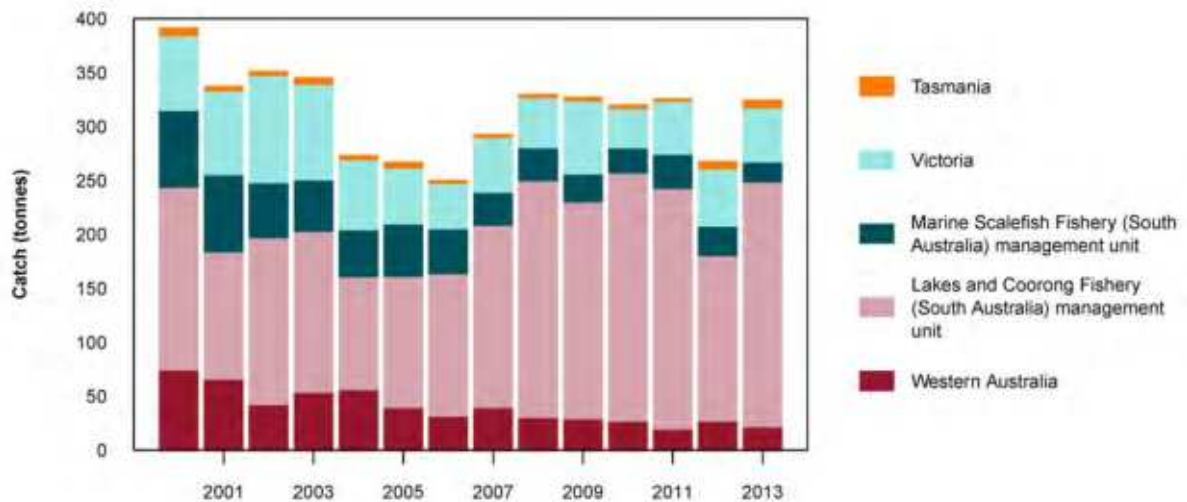
STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
YELLOW EYE MULLET

Jurisdiction	Western Australia	South Australia	Victoria	Tasmania
Recreational				
Gear restrictions		✓	✓	✓
Bag limits	✓	✓	✓	✓
Size limits		✓	✓	✓
Spatial closures		✓		
Temporal closures		✓		
Licences (boat-based sector)	✓			
Indigenous ^a				
Gear restrictions		✓		
Bag limits		✓		
Size limits		✓		
Spatial closures		✓		
Temporal closures		✓		
Active vessels				
	26 in SCEMF 10 in SWBSF 14 in WCEIMF	20 in LCF 40 in MSF	18 in CIF 9 in GLF 27 in PPBF	7 in SF
Catch				
Commercial	3 t in SCEMF 0 t in SWBSF 18 t in WCEIMF	227 t in LCF 19 t in MSF	18 t in CIF 15 t in GLF 16 t in PPBF	6 t in SF
Recreational	Negligible	28 t (2007–08)	Unknown	2 t (2010)
Indigenous	Unknown	Unknown	None	Unknown
Markets				
Domestic	✓	✓	✓	✓
Export				

CIF = Corner Inlet Fishery (Victoria); GLF = Gippsland Lakes Fishery (Victoria); LCF = Lakes and Coorong Fishery (South Australia); MSF = Marine Scalefish Fishery (South Australia); PPBF = Port Phillip Bay Fishery (Victoria); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); SF = Scalefish Fishery (Tasmania); SWBSF = South-west Beach Seine Fishery (Western Australia); WCEIMF = West Coast Estuarine Interim Managed Fishery (Western Australia)

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Yelloweye Mullet.

Figure 2: Commercial catch of Yelloweye Mullet in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Yelloweye Mullet are targeted by commercial fisheries using mainly gillnets and hauling nets. These activities are considered to pose a low risk to the physical environment (that is, substratum, benthic habitats)^{14,15}.
- Some bycatch may be expected from mesh (gill) nets used to target Yelloweye Mullet, including the capture of undersized individuals of some species¹⁶. However, these nets are relatively selective in their ability to capture target species¹⁴.

Environmental effects on Yelloweye Mullet

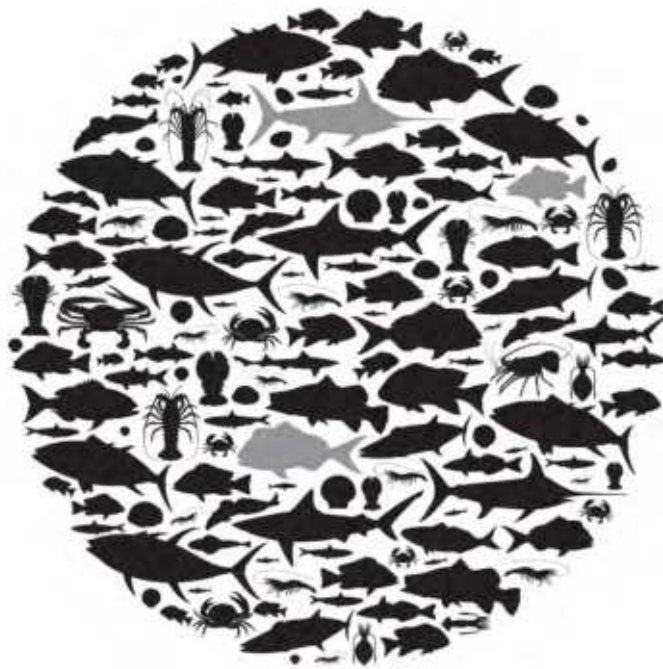
- Estuaries provide important habitat for Yelloweye Mullet through its life history. The availability of habitat and trophic resources for Yelloweye Mullet in estuaries is largely dependent on seasonal freshwater inflows from inland catchment areas.
- The impact of environmental factors on the spawning dynamics and recruitment of Yelloweye Mullet is unknown.

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Finfish: *Temperate Snapper & Bream*



53. Snapper *Chrysophrys auratus* (formerly *Pagrus auratus*)

Anthony Fowler^a, Paul Hamer^b, Gary Jackson^c, John Stewart^d and Stephen Wesche^e



Table 1: Stock status determination for Snapper

Jurisdiction	Queensland, New South Wales, Victoria	Victoria
Stock	East coast (CIF, ECIFFF, OF, OTLF, RRFFF)	Western Victorian (OF, PPBWPF)
Stock status		
	Undefined	Sustainable
Indicators	Catch, CPUE, fishing mortality, age composition	Catch, CPUE, pre-recruit surveys, age and length composition

CIF = Corner Inlet Fishery (Victoria); CPUE = catch per unit effort; ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); OF = Ocean Fishery (Victoria); OTLF = Ocean Trap and Line Fishery (New South Wales); PPBWPF = Port Phillip Bay and Western Port Fishery (Victoria); RRFFF = Rocky Reef Fin Fish Fishery (Queensland)

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c Department of Fisheries, Western Australia
d Department of Primary Industries, New South Wales
e Department of Agriculture, Fisheries and Forestry, Queensland

Table 1 continued

Jurisdiction	South Australia					
Stock	SEF	SGSVF	NGSVF	SSGF	NSGF	WCF
Stock status	↓	↓		↓	↓	
	Transitional–depleting	Transitional–depleting	Sustainable	Transitional–depleting	Transitional–depleting	Undefined
Indicators	Catch, CPUE, age structures	Catch, CPUE, age structures, biomass	Catch, CPUE, age structures, biomass	Catch, CPUE, age structures, biomass	Catch, CPUE, age structures, biomass	Catch, CPUE

CPUE = catch per unit effort; SGSVF = Northern Gulf St Vincent Fishery (South Australia); NSGF = Northern Spencer Gulf Fishery (South Australia); SEF = South East Fishery (South Australia); SGSVF = Southern Gulf St Vincent Fishery (South Australia); SSGF = Southern Spencer Gulf Fishery (South Australia); WCF = West Coast Fishery (South Australia)

Table 1 continued

Jurisdiction	Western Australia					
Stock	South coast (BBRF, JASDGLMF2, SCWLF)	Shark Bay oceanic (BBRF, GDSMF)	Shark Bay inshore—eastern gulf (BBRF)	Shark Bay inshore—Denham Sound (BBRF)	Shark Bay inshore—Freyinet Estuary (BBRF)	West coast (BBRF, JASDGLMF1, WCDGLF, WCDSF)
Stock status					↑	↑
	Undefined	Sustainable	Sustainable	Sustainable	Transitional–recovering	Transitional–recovering
Indicators	Catch	CPUE, biomass	Biomass	Biomass	Biomass	Catch, fishing mortality

BBRF = Boat Based Recreational Fishery (Western Australia); CPUE = catch per unit effort; GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); JASDGLMF1 = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery Zone 1 (Western Australia); JASDGLMF2 = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery Zone 2 (Western Australia); SCWLF = South Coast Wetline Fishery (Western Australia); WCDGLF = West Coast Demersal Gillnet and Longline Fishery (Western Australia); WCDSF = West Coast Demersal Scalefish Interim Managed Fishery (Western Australia)

Stock structure

Snapper has a wide distribution in Australia, from the Gascoyne region on the west coast of Western Australia, around the south of the continent, and up to northern Queensland around Hinchinbrook Island¹. Within this broad distribution, the biological stock structure is complex.

Snapper on the east coast of Australia, from Proserpine in north Queensland to around Wilsons Promontory (Victoria), show little genetic differentiation and are considered to represent a single genetic stock². Similarly, in Victoria, little genetic variation has been found for Snapper³. However, tagging and otolith chemistry data have indicated some separation between Snapper to the east of Wilsons Promontory (the 'east coast biological stock') and those in waters to the west, including Port Phillip Bay and Western Port ('western Victorian biological stock') and extending across western Victoria to near the Murray mouth in South Australia^{4,5}.

Despite the separation of the eastern and western stocks in Victorian waters, management of Snapper remains at a statewide level in Victoria, with specific management arrangements that govern commercial fishing in specific regions such as bays and inlets, and offshore waters. Input controls on the recreational Snapper fishery

are the same for the western and eastern stocks in Victorian waters. Management of the eastern stock from Victoria to Queensland is at a state jurisdictional level. Further research is required on the relationship between Snapper in western Victoria and beyond to inform the level of stock sharing between Victoria and South Australia.

Snapper in South Australia are divided into six management units. There is evidence of genetic differentiation between fish located in the South East Fishery and those in the remaining marine waters to the west of the Murray mouth⁶. The populations in these remaining five management units—the Southern Gulf St Vincent Fishery, Northern Gulf St Vincent Fishery, Southern Spencer Gulf Fishery, Northern Spencer Gulf Fishery and West Coast Fishery—are genetically homogeneous. Although there are some phenotypic differences between them, considerable uncertainty about adult movement patterns prevents determination of the location of possible stock boundaries^{7,8}. Further research is under way to better understand adult movement and stock structure.

In Western Australia, Snapper are divided into six management units, some at small geographic scales (for example, there are three separate biological stocks located inside Shark Bay) and others that cover greater areas of oceanic waters in the Gascoyne, west and south coast regions^{9–13}. The inshore Shark Bay biological stocks in the inner gulfs are predominantly fished by the recreational and charter sectors.

Because the biological stock structure for this species is known for several jurisdictions but is poorly understood for South Australia and oceanic waters in Western Australia, status is reported at the level of individual biological stocks or management units, as regionally appropriate.

Stock status

East coast biological stock

The cross-jurisdictional east coast biological stock has components in New South Wales, Queensland and Victoria. Each jurisdiction assesses and manages the part of the biological stock that occurs in its waters. The status presented here for the entire biological stock has been established using evidence from the three jurisdictions.

The New South Wales part of the biological stock is assessed annually in terms of commercial landings, catch rates and size composition. Periodic sampling of age compositions are used to generate mortality estimates. Snapper are currently assessed as being ‘growth overfished’ in New South Wales waters, despite an increase in minimum legal length from 28 to 30 cm in 2001. Since that time, commercial median catch rates (kilograms per day trapping) have nearly tripled, from approximately 9 kg/day to an average of more than 25 kg/day, between 2008 and 2013. The size compositions of Snapper in commercial landings have remained remarkably stable, with the average size being approximately 31–32 cm fork length each year since 2004. The most recent commercial age-composition samples in 2007–08 and 2010–11 showed that the fishery continues to be dominated by fish aged between 2 and 5 years, but with a slight increase in the proportion of fish aged more than 5 years in commercial landings. The above evidence indicates that the biomass of this part of the stock is unlikely to be recruitment overfished.

Commercial landings in the New South Wales part of the biological stock in 2013 (approximately 216 tonnes [t]) were the lowest since 2003 (noting that the catch records for 2013 may be incomplete at this time). The reported number of fisher-days per year in the trap fishery has approximately halved since 2001, from approximately 10 000 to 5000 days. Typical size compositions in 2013 suggest no large changes to the fishery. The above evidence indicates that the current level of fishing pressure is unlikely to cause this part of the stock to become recruitment overfished.

Queensland assessed its jurisdictional component of the east coast biological stock in 2009 using a sex-, age- and length-based stock analysis model¹⁴. The assessment indicated that exploitable biomass was approximately 35 per cent of unfished biomass and would continue to decline if fishing pressures remained unchanged. Based on this assessment, the Queensland Department of Agriculture, Fisheries and Forestry classified Snapper as an ‘overfished’ stock in 2009. Commercial and charter sector catches¹⁵ have declined since this stock assessment was completed, along with the commercial catch per unit effort (CPUE). Although there was a small improvement in commercial CPUE in 2013, measurable improvements in biomass are yet to be detected, and it is likely that the biomass of the Queensland part of the stock is still recruitment overfished. The number of commercial and charter licences accessing the fishery has declined, while fishing mortality

estimates remain high, exceeding natural mortality for the 2013 fishing year. The current level of fishing pressure is constrained by management to a level that should allow the stock to recover from its recruitment overfished state, but measurable improvements are yet to be detected.

An assessment of the status of the eastern biological stock of Snapper in waters adjacent to Victoria was undertaken in 2011¹⁶. The assessment found that insufficient data were available to adequately assess the Victorian part of the east coast biological stock. The catch of Snapper for this part of the state is much less than for Victoria's western biological stocks; for commercial fishers, Snapper in the Victorian part of the east coast biological stock has historically been considered a byproduct species.

A cross-jurisdictional east coast Snapper stock assessment is planned that should resolve the stock status classification for this stock in the future. However, conflicting signals and the fact that no stock assessment has been conducted on the biological stock as a whole, result in the east coast biological stock being classified as an **undefined stock**.

Western Victorian biological stock

The main indicators used for assessment of the western Victorian biological stock are CPUE from both the commercial and recreational sectors, fishery-independent annual surveys of pre-recruit (young-of-year) catch rates in Port Phillip Bay (the main spawning and nursery area for the western stock)⁴, and age-length composition of catches taken by both the recreational and commercial sectors.

The most recent stock assessment was in 2011¹⁶. This assessment indicated that the stock was in good condition. More recent review of commercial longline catch rates shows they have remained relatively stable since the 2011 assessment, after increasing from the late 1990s through to 2008. It appears that catch rates have stabilised after the full recruitment of the strong 2001, 2004 and 2005 year-classes to the adult fishery. The catch rates in the haul-seine fishery, which catches subadults, have also been stable since the 2011 assessment, consistent with recruitment of the three moderate year-classes detected by the 2008, 2009 and 2010 Port Phillip Bay pre-recruit surveys. Effort has remained relatively stable for both the longline (slight increase since 2011) and the haul-seine gear types, which account for most of the commercial catch. Recreational catch-rate data are consistent with the trends observed in the commercial data. Recent pre-recruit surveys in Port Phillip Bay have shown above-average (22-year time series) recruitment for the 2013 and 2014 year-classes.

The current high productivity of the Victorian western stock fishery may decline slightly over the coming 2–5 years as a result of the very poor juvenile recruitments in 2011 and 2012, but will increase again when the 2013 and 2014 strong year-classes enter the adult fishery in 6–7 years' time. The continued high catch rates of both subadult and adult Snapper, particularly in the Port Phillip Bay Fishery, and the recent strong recruitments of juvenile Snapper suggest that the western Victorian biological stock is not recruitment overfished.

The previous *Status of key Australian fish stocks reports* addressed the risk for the western Victorian biological stock associated with increasing catches from coastal waters. Recent data on fishery catches from both Commonwealth and state fisheries operating in offshore waters indicate that recent management measures have been successful in limiting catches. Based on this and the other evidence provided above, the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the western Victorian biological stock is classified as a **sustainable stock**.

South East Fishery (South Australia) management unit

The South East Fishery (South Australia) management unit has traditionally provided much lower catches than the gulf-based management units (Figure 2). Catches rose considerably through the mid- to late 2000s, as a result of substantial increases in longline fishing effort, reflecting the uptake of new longline fishing technology. This culminated in the region producing 25 per cent of South Australia's catch in 2010⁸. Furthermore, from 2003 to 2004, commercial longline CPUE increased, indicating an increase in biomass. This was related to recruitment of two strong year-classes in 2001 and 2004, evident in the population age structures⁸. Nevertheless, after 2010, both catch and CPUE decreased considerably, which is consistent with decreasing biomass due to depletion of the two strong year-classes. The biomass of this stock is not likely to be recruitment overfished, but the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

Significant changes were made to management arrangements in 2012 and 2013, including an extension to the closed season and introduction of daily commercial catch limits. The influence of these changes will take some time to manifest. Currently, given the decreasing levels of catch and CPUE, based on depletion of only a few strong year-classes in the age composition, this management unit is classified as a **transitional–depleting stock**.

Southern Gulf St Vincent Fishery (South Australia) management unit

The Southern Gulf St Vincent management unit has also traditionally provided lower catches than the other gulf-based management units (Figure 2). Nevertheless, longline catches and CPUE increased from 2008 to 2010, consistent with an increase in biomass⁸. This was associated with recruitment of two strong year-classes in 2001 and 2004, which are evident in the population age structures. However, catch and CPUE then decreased in 2011 and 2012, suggesting a decrease in biomass due to depletion of the two strong year-classes. The biomass of this stock is not likely to be recruitment overfished, but the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

Significant changes were made to management arrangements in 2012 and 2013, including an extension to the closed season, introduction of daily commercial catch limits and a further restriction on the number of commercial hooks that can be used on set lines. The influence of these changes will take some time to manifest. Currently, given the declining levels of catch and CPUE, based on depletion of only a few strong year-classes in the age composition, the management unit is classified as a **transitional–depleting stock**.

Northern Gulf St Vincent Fishery (South Australia) management unit

Since 2008, there has been a significant shift to new longline technology in the Northern Gulf St Vincent Fishery, which has become the dominant gear type in this management unit. As a result of this shift, dramatic increases in longline catch, effort and CPUE have culminated in this regional fishery becoming the dominant contributor to the state's Snapper catches⁸. The age structures show numerous strong year-classes recruiting to the population through the 2000s. As a consequence, the estimated fishable biomass increased by 80 per cent between 2000 and 2012. From 2008, catch, effort and CPUE all increased in response to the increase in fishable biomass. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished and that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

Significant changes were made to management arrangements in 2012 and 2013, including an extension to the closed season, introduction of a spatial closure to protect key spawning aggregation sites, introduction of daily commercial catch limits and a further restriction on the number of commercial hooks that can be used on set lines. The influence of these changes will take some time to manifest.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Southern Spencer Gulf Fishery (South Australia) management unit

From 2005, there was a substantial increase in commercial longline fishing effort for the regional Southern Spencer Gulf Fishery, which related to the uptake of new longline fishing technology⁸. This increased the effectiveness of fishers, culminating in dramatic increases in catches and CPUE. However, from 2009, CPUE declined dramatically, suggesting that the fishable biomass had become depleted. Age-composition data indicate that no strong year-classes have recruited to this region since 1999. The stock assessment integrated these data and suggested that fishable biomass had fallen each year between 2005 and 2012, by a total of 27 per cent⁸. Because recruitment for Snapper is highly variable and environmentally driven, the extent to which poor recent recruitment is related to overfishing is uncertain. The biomass of this stock is not likely to be recruitment overfished, but the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

Significant changes were made to management arrangements in 2012 and 2013, including an extension to the closed season, introduction of daily commercial catch limits and a further restriction on the number of commercial hooks that can be used on set lines. The influence of these changes will take some time to manifest.

On the basis of evidence provided above, the management unit is classified as a **transitional–depleting stock**.

Northern Spencer Gulf Fishery (South Australia) management unit

The regional Northern Spencer Gulf Fishery was traditionally the most significant in South Australia; up to 2004, it provided approximately 50 per cent of the state's total catch of Snapper⁸. However, since the mid-2000s, fishing effort has declined considerably, resulting in lower catches. By 2012, the fishery produced less than 10 per cent of the state's total catch. Although such results are consistent with declining fishable biomass, this was initially inconsistent with very high levels of CPUE. However, there was a dramatic decline in CPUE in 2012, which suggests that the earlier high values were artificially high as a consequence of hyperstability, reflecting the aggregative behaviour of Snapper and the experience of fishers in the region¹⁷. The suggestion of declining biomass through the mid- to late 2000s is consistent with the lack of recruitment of any strong year-classes to the population since 1999, as evident from population age structures. It is not clear whether the poor recent recruitment reflects recruitment overfishing or poor environmental conditions for recruitment. If recruitment remains poor, fishing mortality would cause further depletion of biomass. The biomass of this stock is not likely to be recruitment overfished, but the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

Significant changes were made to management arrangements in 2012 and 2013, including an extension to the closed season, introduction of several spatial closures to protect key spawning aggregation sites, introduction of daily commercial catch limits and a further restriction on the number of commercial hooks that can be used on set lines. The influence of these changes will take some time to manifest.

On the basis of evidence provided above, the management unit is classified as a **transitional–depleting stock**.

West Coast Fishery (South Australia) management unit

The West Coast regional fishery has traditionally provided much lower catches than the gulf-based management units described above. Catches were relatively high through the mid- to late 2000s, as a result of substantial increases in longline fishing effort, reflecting the uptake of new longline fishing technology⁸. However, since 2003–04, longline CPUE has declined, indicating possible declining fishable biomass. However, no size and age data are available for this region, which limits understanding of recruitment patterns that could otherwise confirm a trend of declining biomass. Significant changes were made to management arrangements in 2012 and 2013, including an extension to the closed season and introduction of daily commercial catch limits. The influence of these changes will take some time to manifest. There is currently insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

South coast management unit (Western Australia)

With a total annual catch (all sectors) of only approximately 30–40 t taken from such a large geographic area, the stock is very unlikely to be recruitment overfished. However, the south coast management unit has not been formally assessed, and insufficient information is available to confidently classify its status.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Shark Bay oceanic management unit (Western Australia)

The most recent model-based stock assessment (unpublished data from the Western Australian Department of Fisheries, 2014) indicated that spawning biomass in 2013 was just below 40 per cent of the unfished level, which is also the target level for this management unit. The biomass is estimated to have been increasing since a historical low of around 20 per cent in 2003, and is expected to reach the management target level by 2015–16. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

The total allowable commercial catch was reduced in 2007 to 277 t to further assist stock rebuilding to the target level of 40 per cent of the unfished level.

Approximately 235 t of Snapper was caught in 2013, and the level of fishing mortality is likely to be promoting rebuilding of this stock. The above evidence indicates that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the management unit is classified as a **sustainable stock**.

Shark Bay inshore—eastern gulf biological stock (Western Australia)

The most recent model-based stock assessment (unpublished data from the Western Australian Department of Fisheries, 2011) indicated that spawning biomass was approximately 60 per cent of the unfished level, which is well above the management target (40 per cent of unfished biomass) and the minimum threshold level (30 per cent of unfished biomass). The biological stock is not considered to be recruitment overfished.

There was no commercial catch of Snapper in the eastern gulf biological stock in 2013. As well, the recreational catch was likely to have been minor and within the target catch range (0–12 t). This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Shark Bay inshore—Denham Sound biological stock (Western Australia)

The most recent model-based stock assessment (unpublished data from the Western Australian Department of Fisheries, 2011) indicated that spawning biomass was approximately 42 per cent of the unfished level, which is above the management target (40 per cent of unfished biomass) and the minimum threshold level (30 per cent of unfished biomass). The biological stock is not considered to be recruitment overfished.

The total commercial catch of Snapper in the Denham Sound biological stock was less than 0.5 t in 2013. The recreational catch was likely to have been minor and within the target catch range (0–12 t). This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Shark Bay inshore—Freycinet Estuary biological stock (Western Australia)

The most recent model-based stock assessment (unpublished data from the Western Australian Department of Fisheries, 2011) indicated that spawning biomass was approximately 22 per cent of the unfished level. This level of biomass is below both the management target level (40 per cent of unfished biomass) and the minimum threshold level (30 per cent of unfished biomass). Modelled estimates indicate that the stock will continue to very slowly rebuild to around 25 per cent of the unfished biomass by 2015. The biological stock is considered to be recruitment overfished, based on the 30 per cent threshold.

There was no commercial catch of Snapper from the Freycinet Estuary biological stock in 2013. The recreational catch was assumed to have been within the target catch range (0–3.8 t) because of the conservative management regime that has been in place since 2003. This level of fishing mortality should allow the stock to recover from its recruitment overfished state.

On the basis of the evidence provided above, the biological stock is classified as a **transitional–recovering stock**.

West coast management unit (Western Australia)

Assessments completed in 2007, 2009 and 2013 showed that the fishing mortality in the west coast management unit of Western Australia exceeded the limit reference point of 1.5 times natural mortality^{18–20}. However, the most recent assessment indicated that fishing mortality had decreased, following the introduction of significant management changes, which provides evidence that recovery has begun. Based on agreed decision rules to decrease fishing mortality to a level that would allow the stock to recover, the total catch of Snapper by all sectors had to be reduced by at least 50 per cent—that is, to no more than 163 t. New management arrangements to achieve the required catch reductions have been successfully implemented for the commercial and recreational sectors. Although the current catch of Snapper by the West Coast Demersal Scalefish Interim Managed Fishery in this region has recently increased above the acceptable level of 120 t for the fishery, management action has been taken to reduce catch in 2015 to allow recovery to continue. The above evidence indicates that the stock is considered to be recruitment overfished but that the current level of fishing mortality should allow the stock to recover from its recruitment overfished state.

On the basis of the evidence provided above, the management unit is classified as a **transitional–recovering stock**.

Table 2: Snapper biology^(10,12,21–23)

Longevity and maximum size	30–40 years; 1300 mm TL
Maturity (50%)	2–7 years; 220–560 mm TL

TL = total length

Figure 1: Distribution of reported commercial catch of Snapper in Australian waters, 2013 (calendar year)

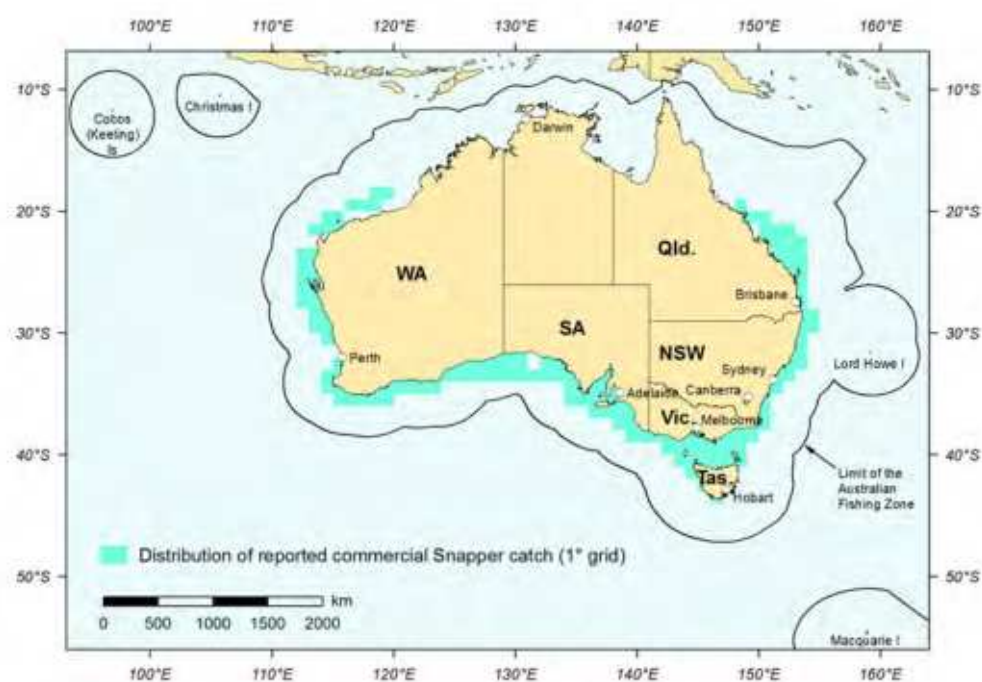


Table 3: Main features and statistics for Snapper fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland	New South Wales	Victoria	South Australia	Western Australia
Fishing methods					
Commercial					
Hand line		✓	✓	✓	✓
Rod and line	✓				
Demersal longline		✓	✓	✓	✓
Dropline				✓	✓
Demersal gillnet	✓		✓		✓
Demersal fish traps		✓	✓		
Seine net			✓		

Jurisdiction	Queensland	New South Wales	Victoria	South Australia	Western Australia
Recreational					
Hand line		✓	✓	✓	✓
Rod and line	✓	✓	✓	✓	✓
Spearfishing		✓	✓	✓	
Indigenous ^{a,b}					
Hand line		✓		✓	
Spearfishing		✓		✓	
Management methods					
Commercial					
Limited entry	✓	✓	✓	✓	✓
Size limits	✓	✓	✓	✓	✓
Catch limits			✓	✓	✓
Spatial closures	✓	✓	✓	✓	✓
Seasonal closures				✓	
Gear restrictions		✓	✓	✓	
Recreational					
Bag/boat limits		✓	✓	✓	✓
Possession limits	✓				
Size limits	✓	✓	✓	✓	✓
Catch limits ^c					✓
Spatial closures	✓	✓	✓	✓	✓
Seasonal closures				✓	✓
Gear restrictions		✓	✓	✓	✓
Indigenous ^{a,b,d,e}					
Bag limits		✓		✓	
Size limits		✓		✓	
Spatial closures		✓		✓	

Jurisdiction	Queensland	New South Wales	Victoria	South Australia	Western Australia
Section 37(1)(c1), Aboriginal cultural fishing authority		✓			
Active vessels					
	16 in ECIFFF 148 in RRFFF	256 in OTLF	8 in CIF 48 in OF 37 in PPBWPF	58 in NGSVF 36 in NSGF 24 in SEF 88 in SGSVF 64 in SSGF 44 in WCF	16 in GDSMF 5 in JASDGDLM F1 16 in JASDGDLM F2 41 in SCWLF 4 in WCDGDLF ~60 in WCDSF
Catch					
Commercial	7 t in ECIFFF 55 t in RRFFF	219 t in OTLF	0.5 t in CIF 4 t in OF 141 t in PPBWPF 15 t (Commonwe alth SESSF)	358 t in NGSVF 46 t in NSGF 50 t in SEF 22 t in SGSVF 25 t in SSGF 15 t in WCF	235 t in GDSMF 6 t in JASDGDLM F1 9 t in JASDGLMF2 17 t in SCWLF 3 t in WCDGDLF 185 t in WCDSF
Recreational	129 t (2010– 11)	246 t (2000– 01)	~600 t (2006–07) ²⁴	178 t (2007– 08) ²⁵	80–100 t (2012–13)
Indigenous	Unknown	Unknown	Unknown	Unknown	Unknown
Markets					
Domestic	✓	✓	✓	✓	✓
Export					

CIF = Corner Inlet Fishery (Victoria); ECIFFF = East Coast Inshore Fin Fish fishery (Queensland); GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); JASDGDLMF1 = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery Zone 1 (Western Australia); JASDGDLMF2 = Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery Zone 2 (Western Australia); NGSVF = Northern Gulf St Vincent Fishery (South Australia); NSGF = Northern Spencer Gulf Fishery (South Australia); OF = Ocean Fishery (Victoria); OTLF = Ocean Trap and Line Fishery (New South Wales); PPBWPF = Port Phillip Bay and Western Port Fishery (Victoria); SCWLF = South Coast Wetline Fishery (Western Australia); SESSF = Southern and Eastern Scalefish and Shark Fishery (Commonwealth); RRFFF = Rocky Reef Fin Fish Fishery (Queensland); SEF = South East Fishery (South Australia); SGSVF = Southern Gulf St Vincent Fishery (South Australia); SSGF = Southern Spencer Gulf Fishery (South Australia); WCF = West Coast Fishery (South Australia);

Australia); WCDGDLF = West Coast Demersal Gillnet and Longline Fishery (Western Australia); WCDSF = West Coast Demersal Scalefish Interim Managed Fishery (Western Australia)

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary permits to access Snapper.

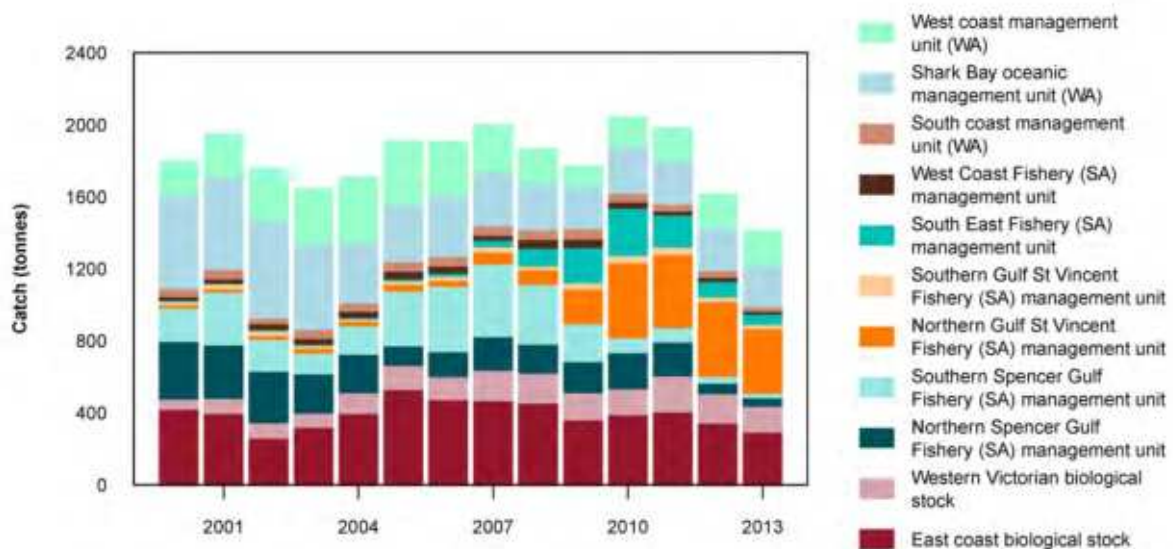
b Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

c In Western Australia, total recreational catch limits (that is, maximum catch limits) have been applied to stocks of Snapper in inner Shark Bay and the west coast, to aid recovery of stocks.

d The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

e The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Snapper in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Most of the fisheries that target adult Snapper use hook-and-line fishing techniques, which are likely to have little direct impact on benthic habitats. To date, limited research on the effects of fish traps on the benthic environment in New South Wales suggests only a minor influence (unpublished data from the New South Wales Department of Primary Industries).
- Snapper are generalist feeders and normally just one of a number of such species inhabiting continental shelf waters. Effects on the food chain from fishing for Snapper are considered to be low risk. This is supported by a recent study completed in the three Western Australian bioregions²⁶ where Snapper are captured, which found no evidence of material changes in finfish community structure over the past 30 years²⁷.

Environmental effects on Snapper

- A recent Fisheries Research and Development Corporation project identified two potential significant effects of climate change on Snapper populations²⁸. First, there is an optimal temperature range of 18–

22 °C for the production and survivorship of Snapper larvae. Furthermore, peak spawning times vary with latitude, resulting in peak production corresponding to the optimal temperature range. Warmer projected sea surface temperature regimes in the future will alter the timing and/or length of these optimal conditions for spawning and larval survivorship in different regions. This might restrict opportunities for successful spawning and recruitment in the northern fisheries, but provide enhanced opportunities for some southern fisheries, and the opportunity for establishing new populations and fisheries further south. Such environmental changes might also affect spawning and recruitment for the populations in South Australia's gulfs and Port Phillip Bay, Victoria.

- The second possible effect of climate change on Snapper populations is greater variation in recruitment of zero-plus-aged fish²⁸. Such variable recruitment already accounts for the population dynamics and variation in fishery productivity for a number of Australia's southern Snapper fisheries. Variation in recruitment is driven by the survivorship of the larvae. Larval survivorship depends on the overlap of the optimal temperature window with periods of high larval prey concentrations. The latter depends on nutrient input to marine environments. The effects of climate change on the dynamics of nutrient supply in Snapper spawning areas are difficult to predict because the sources of such nutrients vary from place to place. Furthermore, current understanding of nutrient supply and the dynamics of planktonic food chains is limited.

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54. Yellowfin Bream *Acanthopagrus australis*

Jason McGilvray^a, Faith Doyle^b and James Andrews^c



Table 1: Stock status determination for Yellowfin Bream

Jurisdiction	Queensland, New South Wales, Victoria
Stock	Eastern Australian (ECIFFF, EGF, GLF, OHF, OTLF)
Stock status	Sustainable
Indicators	Commercial catch and CPUE, length and age, mortality rate

CPUE = catch per unit effort; ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); EGF = Estuarine General Fishery (New South Wales); GLF = Gippsland Lakes Fishery (Victoria); OHF = Ocean Haul Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales)

Stock structure

The stock structure of Yellowfin Bream has been examined through tagging studies and genetic investigations. Two tagging studies—one in New South Wales¹ and one in Queensland²—have suggested the possibility of separate populations, based on a lack of significant movements between estuaries. However, a genetic investigation has shown that this species forms a single east coast population, with a general northward dispersal of adults and a southward dispersal of larvae³.

Towards the southern end of their distribution (southern New South Wales to East Gippsland), Yellowfin Bream are known to hybridise with Black Bream (*Acanthopagrus butcheri*), especially in areas where the two species are sympatric^{4–6}. Based on these findings, the stock status of Yellowfin Bream is reported at a biological stock level.

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^b Department of Primary Industries, New South Wales

^c Department of Environment and Primary Industries, Victoria

Stock status

Eastern Australian biological stock

The cross-jurisdictional eastern Australian stock has components in Queensland, New South Wales and Victoria. Each jurisdiction assesses that part of the biological stock that occurs in its waters. The status presented here for the entire biological stock has been established using evidence from all three jurisdictions.

In the Queensland part of the eastern Australian stock, the commercial catch and nominal catch rate of Yellowfin Bream are rebuilding after a change to the minimum legal size (2 cm longer), and an increase in areas protected from fishing in the Moreton Bay Marine Park in 2009; the catch and nominal catch rates were 107 tonnes (t) at 28 kg/day in 2010, and 153 t at 44 kg/day in 2013⁷. Length structures from fishery-dependent monitoring of Yellowfin Bream from 2007 onwards reflect this rebuilding catch trend. The fishery-dependent age structures indicate a stable population, with variable and continued recruitment⁷. The above evidence indicates that the biomass of the Queensland part of the biological stock is unlikely to be recruitment overfished.

Nominal effort in the Queensland commercial fishery in 2013 (3499 days fished) was much lower than in previous years (mean of 3944 days fished from 2009 to 2012), resulting in an improved commercial catch rate⁷. The number of recreational anglers in the south of the state, where Yellowfin Bream are most abundant, decreased between 2001 and 2010. Together with the introduction of a possession limit, this is likely to have reduced targeted fishing effort by recreational anglers⁷. The current minimum legal size (25 cm total length) for Yellowfin Bream in Queensland applies to both commercial and recreational fishers, and allows a proportion of mature fish to spawn for one or even several years before becoming available to the fishery. Total mortality estimates for Yellowfin Bream in Queensland decreased between 2007 and 2010, and have remained steady since (reflecting the change in minimum legal size and possession limit⁷). Estimates indicate that fishing mortality (F) has been lower than natural mortality (M) for the years 2007 to 2013. Yellowfin Bream have a moderate rate of survival (lower for gut-hooked fish) when released by recreational anglers, thus reducing impacts on this part of the stock⁸⁻¹¹. The above evidence indicates that the current level of fishing pressure is unlikely to cause the Queensland part of the biological stock to become recruitment overfished.

The commercial catch from New South Wales accounts for about two-thirds of the total catch of the eastern Australian Yellowfin Bream stock. Reported commercial landings of Yellowfin Bream in this state also include Black Bream and the hybrids formed by the two species. The median commercial catch rates of Yellowfin Bream in New South Wales have been relatively steady for the past 5 years and, for commercial fish trapping in particular, slightly higher than those observed in the previous 5 years¹². The length composition of the landings for this species has also been relatively stable since the 1950s. The above evidence indicates that the biomass of the New South Wales part of the biological stock is unlikely to be recruitment overfished.

In New South Wales, nominal effort in 2013 (number of fisher-days) in the Estuarine General Fishery (approximately 18 694 days, summed across methods), the Ocean Haul Fishery (approximately 539 days) and the Ocean Trap and Line Fishery (approximately 2940 days, summed across methods) was among the lowest ever reported, especially for the former two fisheries¹². Historically low nominal effort levels contributed to the 2013 New South Wales landings of 240 t being approximately 30 per cent less than the long-term annual average of 344 t¹². Recent size compositions in landings suggest no large changes in the stock. The minimum legal commercial and recreational length in New South Wales (22.5 cm fork length) provides an opportunity for Yellowfin Bream to spawn before recruiting to the fishery. Although this species is primarily harvested by the recreational sector in New South Wales, recent estimates of recreational fishing pressure are unavailable. The above evidence indicates that the current level of fishing pressure is unlikely to cause the New South Wales part of the biological stock to become recruitment overfished.

Compared with New South Wales and Queensland, the commercial catch of Yellowfin Bream from the Victorian part of the eastern Australian stock is very low (less than 1 per cent of the total catch). There is no commercial fishing in Mallacoota, and catches from the Gippsland Lakes are very small. The proportion of the eastern Australian Yellowfin Bream stock that inhabits Victorian waters is very small, and unlikely to significantly influence the stock dynamics of the eastern Australian stock¹³. The above evidence indicates that the biomass of the Victorian part of the biological stock is unlikely to be recruitment overfished.

The total annual catch of Yellowfin Bream by recreational fishers in Victoria has not been estimated. Recreational fishing effort is managed under regulations for bream (all species), using a minimum legal size (28 cm) and a bag/possession limit (maximum of 10 fish). Fish must be landed whole or in carcass. Less than five commercial fishers accessed the fishery in 2013. The above evidence indicates that the current level of fishing pressure is unlikely to cause the Victorian part of the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the entire biological stock is classified as a **sustainable stock**.

Table 2: Yellowfin Bream biology^{2,14}

Longevity and maximum size	~20 years; ~400 mm FL
Maturity (50%)	Males: 190 mm FL Females: 200–210 mm FL

FL = fork length

Figure 1: Distribution of reported commercial catch of Yellowfin Bream in Australian waters, 2013 (calendar year)

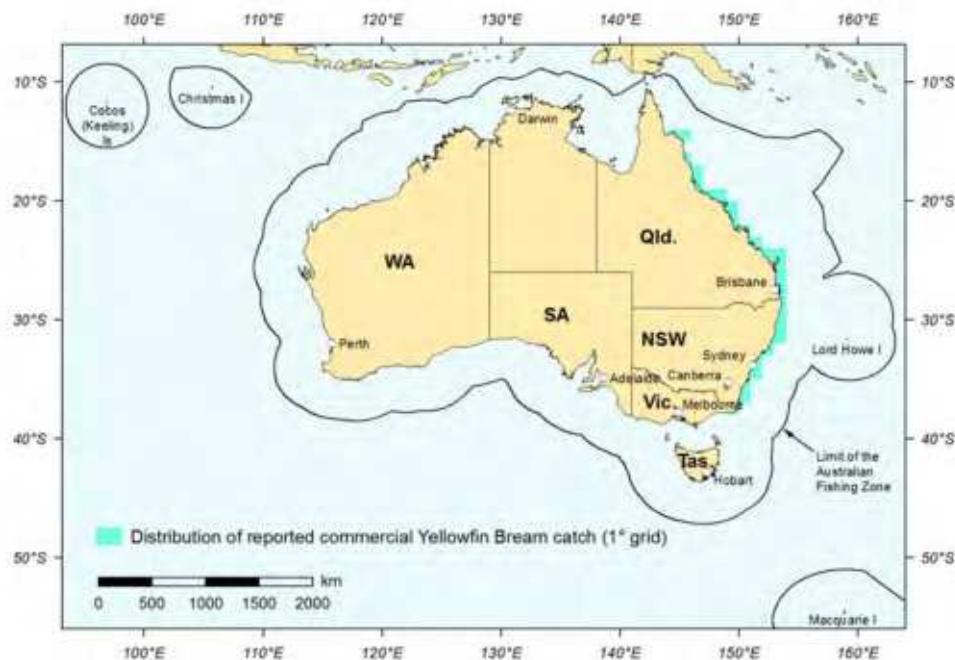


Table 3: Main features and statistics for Yellowfin Bream fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland	New South Wales	Victoria
Fishing methods			
Commercial			
Gillnet	✓	✓	✓
Seine net	✓	✓	✓
Tunnel net	✓		
Fish trap		✓	
Recreational			
Rod and line	✓	✓	✓
Spearfishing	✓	✓	✓
Indigenous ^{a,b,c}			
Management methods			
Commercial			
Limited entry	✓	✓	✓
Size limits	✓	✓	✓
Fishing gear and method restrictions	✓	✓	✓
Spatial closures	✓	✓	✓
Temporal closures	✓	✓	✓
Recreational			
Size limits	✓	✓	✓
Bag limits		✓	✓
Possession limits	✓	✓	✓
Fishing gear and method restrictions	✓	✓	✓
Spatial closures	✓	✓	✓
Indigenous ^{a,b,c}			

Jurisdiction	Queensland	New South Wales	Victoria
Active vessels			
	167 in ECIFFF	301 in EGF 39 in OHF 88 in OTLF	<5 in GLF
Catch			
Commercial	149 t in ECIFFF	189 t in EGF 25 t in OHF 12 t in OTLF	<1 t in GLF
Recreational	212 t ¹⁵ (2010–11)	728 t ¹⁶ (2000–01)	Unknown
Indigenous	Unknown	Unknown	None
Markets			
Domestic	✓	✓	✓
Export			

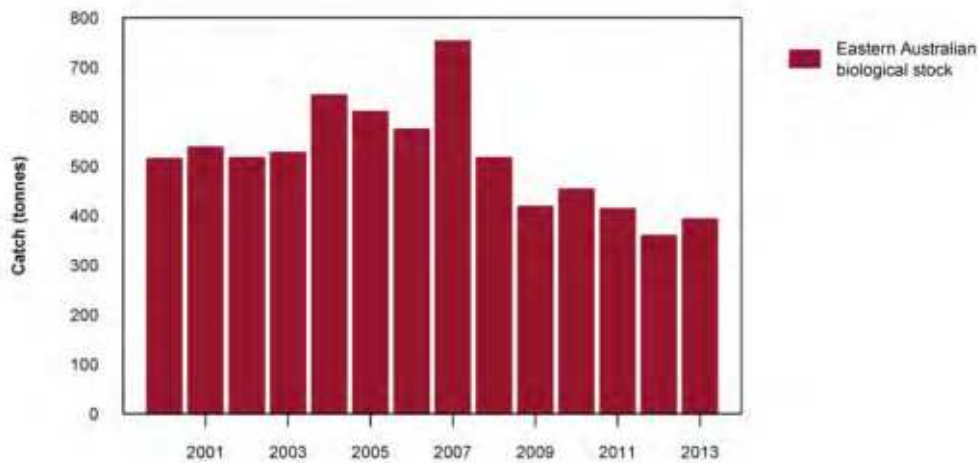
ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); EGF = Estuarine General Fishery (New South Wales); GLF = Gippsland Lakes Fishery (Victoria); OHF = Ocean Haul Fishery (New South Wales); OTLF = Ocean Trap and Line Fishery (New South Wales)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and bag limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

b In New South Wales, Indigenous fishers are able to use traditional and noncommercial apparatus to take double the recreational bag limit. Further exemptions to fishery regulations can be obtained through permits.

c In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Yellowfin Bream.

Figure 2: Commercial catch of Yellowfin Bream in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- In Queensland, coastal-, river- and estuary-set gillnets have been shown to have minimal impact on the environment and are quite selective in their harvest¹⁷. Bycatch is generally low compared with the harvest of the target species¹⁷. Fishers using tunnel nets operate under an industry-developed code of best practice¹⁸. Marine turtles are released with minimal difficulty, and undersized or unwanted catch is returned to the water alive.
- In New South Wales, seining in estuaries can incur large amounts of bycatch of undersized organisms and unwanted species, but the used of appropriately sized mesh can reduce mortalities of these species^{19–21}.
- Studies conducted in New South Wales indicate that gillnets used in estuaries can incur substantial amounts of bycatch, including the capture of undersized individuals of key species^{22,23}.
- Seabirds and other marine life often become entangled in discarded recreational fishing tackle²⁴. In south-east Queensland, a Fishing Line Recovery Bin program was instigated in 2012 to minimise the occurrence of discarded tackle at popular shore-based fishing locations.

Environmental effects on Yellowfin Bream

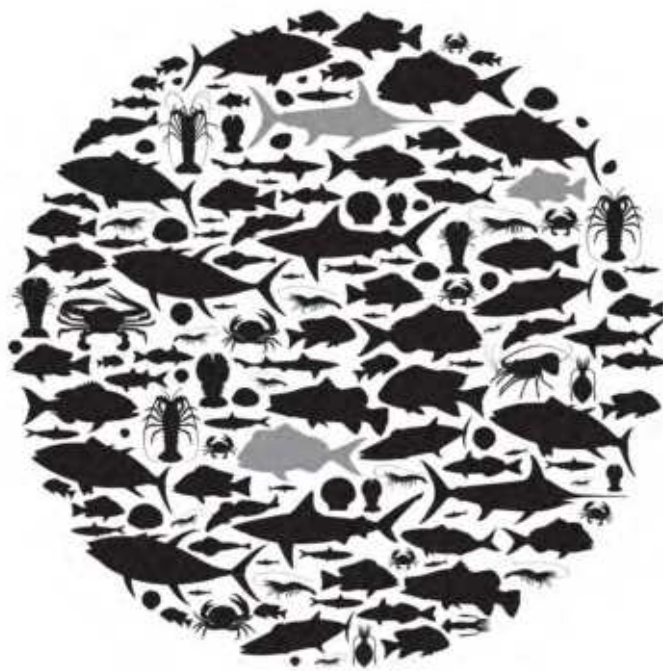
- Yellowfin Bream are dependent on estuarine and inshore coastal habitats throughout their life cycle^{25,26}. Physical impacts on coastal marine vegetation, subsurface topography and water quality are likely to influence the resilience and productivity of Yellowfin Bream populations at local scales.

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Finfish: *Tropical Snappers & Emperors*



55. Crimson Snapper *Lutjanus erythropterus*

Julie Martin^a, Malcolm Keag^b, Stephen Newman^c and Corey Wakefield^d



Table 1: Stock status determination for Crimson Snapper

Jurisdiction	Northern Territory, Queensland	Queensland	Western Australia
Stock	Northern Australian (DF, GOCDFFTF, GOCLF, TRF)	East coast Queensland (CRFFF, DWFFF)	North West Shelf (NDSMF, PFTIMF, PTMF)
Stock status			
	Sustainable	Undefined	Sustainable
Indicators	Catch, CPUE	Catch	Catch, CPUE

CPUE = catch per unit effort; CRFFF = Coral Reef Fin Fish Fishery (Queensland); DF = Demersal Fishery (Northern Territory); DWFFF = Deep Water Fin Fish Fishery (Queensland); GOCDFFTF = Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

Stock structure

Crimson Snapper (*Lutjanus erythropterus*) is a widespread Indo–Pacific species found throughout tropical Australian waters. Research on the biological stock structure of this species in Australian waters has only occurred in northern Australia, including the Timor Sea, the Arafura Sea and the Gulf of Carpentaria¹. A single genetic stock was found across this region. In addition to this northern Australian biological stock, it is considered that the species has a similar biological stock structure to Saddletail Snapper (*L. malabaricus*), with a North West Shelf biological stock and a biological stock off the east coast of Queensland¹.

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Stock status

Northern Australian biological stock

The cross-jurisdictional northern Australian biological stock has components in the Northern Territory and Queensland. Each jurisdiction assesses that part of the biological stock that occurs in its waters. The status presented here for the entire biological stock has been established using evidence from both jurisdictions.

The Northern Territory manages the commercial harvest of Crimson Snapper and Saddletail Snapper together as red snapper. Crimson Snapper has made up around 22 per cent of the red snapper catch for the past 15 years. Saddletail Snapper comprises the majority of red snapper catch (averaged 78 per cent of the annual red snapper catch over the past 10 years), and is used as an indicator for the combined red snapper group. Analysis of Saddletail Snapper in 2013 using a stochastic stock reduction analysis model estimated egg production to be around 80 per cent of that before the start of the fishery, well above conventional fishery targets². Therefore, this part of the Crimson Snapper biological stock is not considered to be recruitment overfished.

The combined Northern Territory total allowable commercial catch for red snappers is 3800 tonnes (t). The commercial catch of Crimson Snapper in 2013 was 327 t. The 2013 assessment confirmed that the current harvest rate of red snappers is well below that required to achieve maximum sustainable yield. The low level of fishing mortality, compared with the total allowable catch, is unlikely to cause this part of the biological stock to become recruitment overfished.

For the Queensland part of the biological stock, the commercial catch in 2013 was 12 t. This contrasts with catches of 150–350 t per year during the period 2004 to 2011, and is the lowest catch since 2001. Since no information is available on biomass, there is insufficient information to confidently classify the status of this part of the biological stock.

Since the Northern Territory part of the biological stock constituted the majority of the total catch in 2013, the status of this part of the biological stock is indicative of the entire biological stock.

On the basis of the evidence provided above, the entire biological stock is classified as a **sustainable stock**.

East coast Queensland biological stock

Crimson Snapper is taken in both the commercial and recreational sectors off eastern Queensland, probably in similar numbers by each sector.

Recreational harvest estimates group Saddletail and Crimson Snapper together because these two species are often not separately identified. The recreational harvest of these species was estimated to be approximately 65 000 fish in 2010³. The relative proportions of the two species in this catch are not known.

Since 2004, commercial harvest has dropped to around 20 t per year. At around the same time, there was an expansion of no-take marine reserves within the Great Barrier Reef Marine Park, and a quota management system for coral reef finfish species was introduced. Both factors are likely to have influenced commercial catch. Crimson Snapper is managed as part of the 'other species' quota category, which comprises many other coral reef finfish species. There is a cap on the total catch for the group, but no individual cap on any one species within the group. Although recreational fishing effort is not capped, the present level of combined fishing pressure is unlikely to cause the stock to become recruitment overfished.

Current biological information is unavailable, and no assessment has been completed for this stock. With no index of abundance, insufficient information is available to classify the status of this biological stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

North West Shelf biological stock

Crimson Snapper is caught primarily on the north-west coast of Western Australia as a component of the multispecies Pilbara Fish Trawl Interim Managed Fishery, Pilbara Trap Managed Fishery, and Northern Demersal Scalefish Managed Fishery (in the Kimberley region of Western Australia)³. Crimson Snapper is assessed on the basis of the status of several indicator species caught in association with it (including Red Emperor—*Lutjanus sebae*, and Goldband Snapper—*Pristipomoides multidens* in the Kimberley region) that represent the inshore demersal suite of species occurring at depths of 30–250 m. The major performance measures used for these indicator species are estimates of spawning stock levels. The target level of spawning

biomass is 40 per cent of the unfished level, and the limit level is 30 per cent of the unfished level. Data analysis using an integrated age-structured model determined that the spawning biomass levels of the indicator species were greater than 40 per cent of the unfished level in the Pilbara Fish Trawl Interim Managed Fishery, Pilbara Trap Managed Fishery and Northern Demersal Scalefish Managed Fishery in 2007⁴. The Crimson Snapper biological stock is therefore not considered to be recruitment overfished.

Fishing mortality (F)–based assessments⁵ indicated that the fishing levels on the indicator species were either lower than the target level, or between the target and threshold levels. These assessments use reference levels that are based on ratios of natural mortality (M) for each species, such that $F_{\text{target}} = 2/3M$, $F_{\text{threshold}} = M$ and $F_{\text{limit}} = 3/2M$. This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

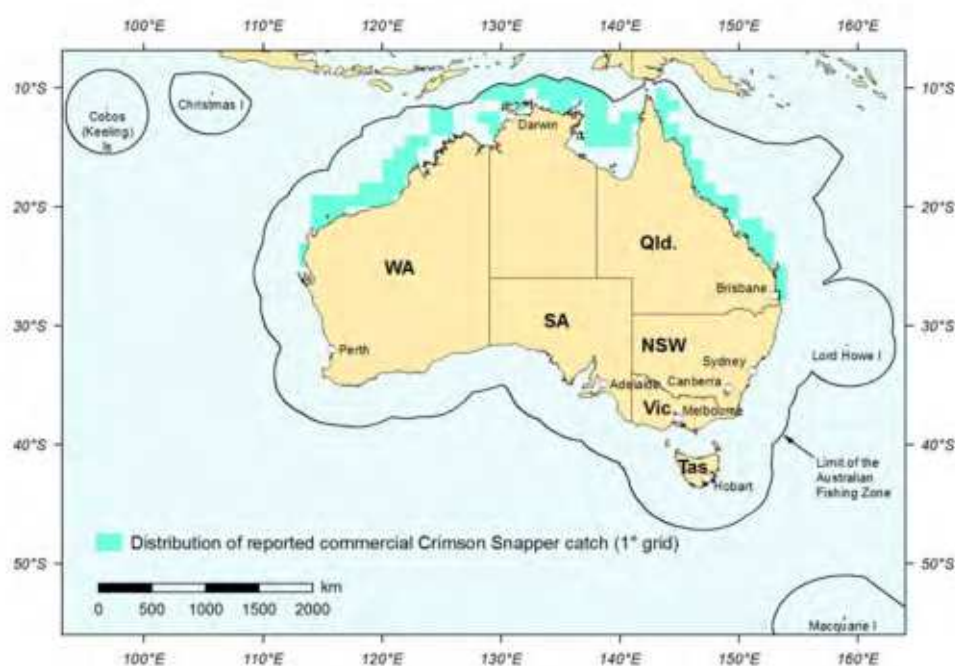
On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Crimson Snapper biology^{6,7}

Longevity and maximum size	42 years; 470 mm SL
Maturity (50%)	Males 270–280 mm SL, females 350–370 mm SL

SL = standard length

Figure 1: Distribution of reported commercial catch of Crimson Snapper in Australian waters, 2013 (calendar year)



Note: The reporting period for the Coral Reef Fin Fish Fishery (Queensland) and Deep Water Fin Fish Fishery (Queensland) is financial year (2012–13).

Table 3: Main features and statistics for Crimson Snapper fisheries in Australia, 2013 (calendar year)

Jurisdiction	Northern Territory	Queensland ^a	Western Australia
Fishing methods			
Commercial			
Hand line	✓ ^b	✓	✓
Rod and line	✓	✓	✓
Dropline	✓	✓	✓
Longline		✓	✓
Fish trap	✓		✓
Fish trawl	✓	✓	✓
Recreational (including charter)			
Hand line	✓	✓	✓
Rod and line	✓	✓	✓
Indigenous			
Hand line		✓	
Rod and line		✓	
Management methods			
Commercial			
Limited entry		✓	✓
Spatial zoning	✓		✓
Total allowable catch	✓	✓	
Total allowable effort			✓
Size limits		✓ (not in GOCDFFTF)	
Vessel restrictions		✓	✓
Gear restrictions	✓	✓	✓
Effort limits			✓
Spatial closures		✓	✓
Temporal closures		✓	

Jurisdiction	Northern Territory	Queensland ^a	Western Australia
Recreational			
Licensing (species/fishing from a boat/using specific gear)			✓
Possession limits	✓	✓	✓
Size limits		✓	
Spatial closures		✓	✓
Temporal closures		✓	
Charter			
Limited entry			✓
Spatial zoning			✓
Passenger restrictions			✓
Size limits		✓	
Bag limits			✓
Possession limits	✓	✓	
Spatial closures		✓	✓
Temporal closures		✓	
Indigenous ^{c-e}			
Laws of general application			✓
Active vessels			
	6 in DF 9 in TRF	81 in CRFFF 0 in DWFFF 1 in GOCDFFTF 0 in GOCLF	8 in NDSMF 3 in PFTIMF 2 in PTMF

Jurisdiction	Northern Territory	Queensland ^a	Western Australia
Catch			
Commercial	255 t in DF 72 t in TRF	23 t in CRFFF 0 t in DWFFF 12 t in GOCDFFTF 0 t in GOCLF	89 t in NDSMF 130 t in PFTIMF 32 t in PTMF
Recreational	55 t (2010) ^d	65 000 fish ^d	1494 fish (2011–12); ~3 t ^f
Charter	0 t (2012)	6 t	1447 fish; ~3 t
Indigenous	Unknown	Unknown	Unknown
Markets			
Domestic	✓	✓	✓
Export	✓		

CRFFF = Coral Reef Fin Fish Fishery (Queensland); DF = Demersal Fishery (Northern Territory); DWFFF = Deep Water Fin Fish Fishery (Queensland); GOCDFFTF = Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

a For Queensland, the reporting period for the CRFFF and DWFFF is financial year (2012–13).

b In the Northern Territory, hand lines, droplines, and rod and line together constituted less than 2 per cent of the total commercial catch.

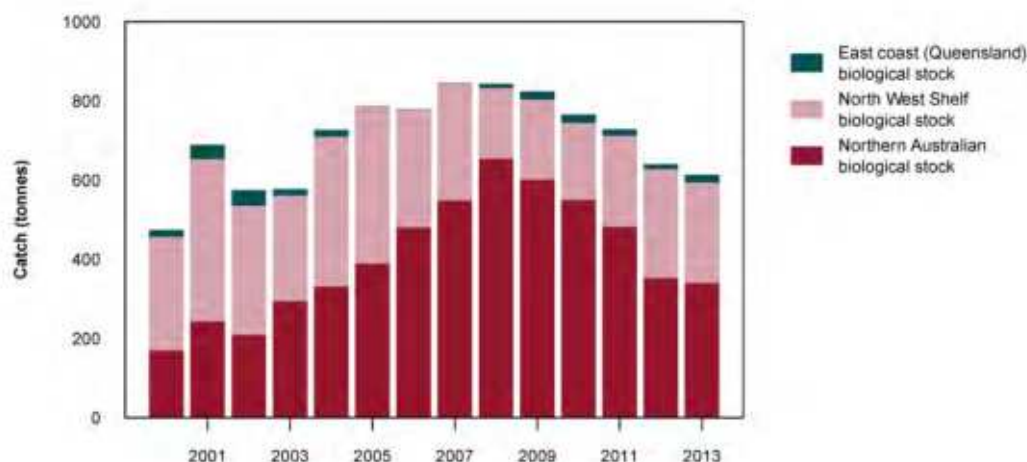
c Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

d Saddletail Snapper and Crimson Snapper catch were combined during the 2010 recreational fishing survey.

e Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

f Recreational catch is from a boat-based survey, which is considered to be representative of the total recreational catch.

Figure 2: Commercial catch of Crimson Snapper in Australian waters, 2000 to 2013 (calendar years)



Note: For Queensland, the reporting period for the Coral Reef Fin Fish Fishery and Deep Water Fin Fish Fishery is financial year (2012–13).

Effects of fishing on the marine environment

- Impacts on the benthic habitat of fishing activity for Crimson Snapper are limited to those of the trawl fisheries, which are restricted to around 7 per cent of the North West Shelf of Western Australia⁴, and parts of the Northern Territory and Queensland. Trawl nets in the Northern Territory have been designed to fish off the seabed, reducing interaction with benthic habitats⁸.
- There are few bycatch issues associated with trap- and line-based fishing. Bycatch of dolphins and turtles can occur in the fish trawls, but this has decreased significantly since turtle excluder devices were introduced in Western Australia in 2005 and the Northern Territory in 2006. Given the area of distribution and estimated population size of these protected species, the impact of the fish trawl fishery on their stocks is likely to be minimal. Gear and fishing modification continue to reduce this level of interaction^{4,9}.
- The Northern Territory fisheries that target Crimson Snapper have received full Export Exemption accreditation under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). The Western Australian and Queensland east coast fisheries that target Crimson Snapper have received Approved Wildlife Trade Operation Exemption accreditation under the Act (except for the Pilbara Trap Managed Fishery [Western Australia], which does not export fish). These assessments, subject to adherence to any accompanying conditions and recommendations, demonstrate that these fisheries are managed in a manner that does not lead to overfishing, and that fishing operations have a minimal impact on the structure, productivity, function and biological diversity of the ecosystem.

Environmental effects on Crimson Snapper

- Climate change and climate variability have the potential to impact fish stocks in a range of ways, including influencing their geographic distribution (for example, latitudinal shifts in distribution). However, it is unclear how climate change may affect risks to the sustainability of this species. Slow-growing and long-lived species such as Crimson Snapper are less likely to be affected by short-duration environmental changes (of one or a few years), because adult stocks comprise fish that have been recruited over many years.
- Changes in ocean chemistry such as ocean acidification have the potential to affect the replenishment rates of fish populations by affecting larval survival¹⁰, as well as individual growth rates and spawning output¹¹.

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56. Goldband Snapper *Pristipomoides multidens*

Julie Martin^a, Malcolm Keag^b, Stephen Newman^c and Corey Wakefield^c



Table 1: Stock status determination for Goldband Snapper

Jurisdiction	Northern Territory, Queensland	Queensland	Western Australia		
Stock	Northern Australian (DF, GOCDFTF, TRF)	East coast (CRFFF, DWFFF)	Kimberley (NDSMF)	Pilbara (PFTIMF, PLF, PTMF)	Gascoyne (GDSMF)
Stock status					
	Sustainable	Undefined	Sustainable	Sustainable	Sustainable
Indicators	Catch, CPUE, SRA	Catch, quota usage, performance indicators	Biomass, age structure, catch, CPUE	Age structure, catch, CPUE	Age structure, catch

CPUE = catch per unit effort; CRFFF = Coral Reef Fin Fish Fishery (Queensland); DF = Demersal Fishery (Northern Territory); DWFFF = Deep Water Fin Fish Fishery (Queensland); GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); GOCDFTF = Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PLF = Pilbara Line Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); SRA = stochastic stock reduction analysis; TRF = Timor Reef Fishery (Northern Territory)

Stock structure

Goldband Snapper is widely distributed throughout northern Australia and the tropical Indo–West Pacific. Analysis of otolith stable isotopes indicates separate biological stocks in each of the three management regions in Western Australia (Kimberley, Pilbara and Gascoyne), and across northern Australia¹. Separate biological stocks exist between Australia and Indonesia². The existence of multiple biological stocks across northern Australia and Western Australia suggests that several biological stocks may also be present on the east coast, although this remains to be determined. Because biological stock delineation is known for this species in the Northern Territory (including the Gulf of Carpentaria in Queensland), and Western Australia, stock status is reported at the level of individual biological stocks. On the east coast of Queensland, in the

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absence of information on biological stock boundaries, status is reported at the level of the Queensland east coast management unit.

Stock status

Northern Australian biological stock

The northern Australian Goldband Snapper biological stock was assessed in 2011 and 2013 using a stochastic stock reduction analysis (SRA) model^{3,4}. Egg production was estimated to be around 65 per cent of that before the start of the fishery, which is well above conventional target levels. For this reason, the biological stock is not considered to be recruitment overfished.

About 90 per cent of the catch is from the Timor Sea and western Arafura Sea. Catch from the Queensland Gulf of Carpentaria is negligible. The Northern Territory total allowable commercial catch for Goldband Snapper is 1300 tonnes (t): 900 t in the Timor Reef Fishery and 400 t in the Demersal Fishery. In 2013, the total commercial catch of Goldband Snapper in the Northern Territory was 684 t. In Queensland, 1 t was caught. The SRA assessments indicated that the current harvest rate is below that required to achieve maximum sustainable yield. This low level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

East coast (Queensland) management unit

No formal stock assessments have been undertaken to quantify biomass levels of Goldband Snapper on the east coast of Australia.

Species-level reporting in commercial logbooks began in 2007 and has helped to quantify catch as a measure of fishing pressure. Catch trends of Goldband Snapper are monitored annually, but more information is required on attributes such as age structure to better understand fishing pressure. Goldband Snapper is managed as part of the 'other species' quota category, which comprises many other coral reef finfish species. There is a cap on the total catch for the group, but no individual cap on any one species within the group.

Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Kimberley biological stock

Goldband Snapper is exploited in the North Coast and Gascoyne bioregions of Western Australia⁵. It is one of the indicator species used to assess the status of the demersal resources in the North Coast Bioregion.

The major performance measures for Goldband Snapper in the Kimberley biological stock are estimates of spawning stock levels in the Northern Demersal Scalefish Managed Fishery (Western Australia). The target level of spawning biomass is 40 per cent of the unfished (1980) level. The limit level is 30 per cent of the initial spawning biomass. The spawning biomass of Goldband Snapper was estimated to be greater than 40 per cent of the unfished level in the Kimberley biological stock in 2007 (the year the last integrated assessment was undertaken), using an integrated age-structured model⁶. The biological stock is therefore not considered to be recruitment overfished.

The fishing mortality (F)–based assessments indicated that the median fishing pressure on Goldband Snapper in this biological stock was below the target level in 2006, and between the target and the threshold in 2008⁶. These assessments use reference levels that are based on ratios of natural mortality (M) for each species, such that $F_{\text{target}} = 2/3M$, $F_{\text{threshold}} = M$ and $F_{\text{limit}} = 3/2M$. Goldband Snapper catches from the Northern Demersal Scalefish Managed Fishery (Kimberley biological stock) from 2006 to 2013 have ranged between 331 and 524 t⁶. Since 2008, catches of Goldband Snapper have been relatively stable, ranging between 457 and 524 t⁶. This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Pilbara biological stock

The stock assessment for Goldband Snapper in the Pilbara biological stock is based on an assessment of fishing mortality derived from catch-curve analysis of representative samples of the age structure in the Pilbara demersal fisheries (Pilbara Fish Trawl Interim Managed Fishery, Pilbara Line Fishery, Pilbara Trap Managed Fishery). These fishing mortality-based assessments use reference levels that are based on ratios of natural mortality for each species, such that $F_{\text{target}} = 2/3M$, $F_{\text{threshold}} = M$ and $F_{\text{limit}} = 3/2M$. The fishing mortality-based assessments indicated that the estimated fishing level on Goldband Snapper in this biological stock was either below the target level or between the target and threshold levels in 2008, depending on the area of the fisheries⁶. This indicates that fishing is not having an unacceptable impact on the age structure of the population. The biological stock is not considered to be recruitment overfished.

Goldband Snapper catches from the Pilbara demersal fisheries (Pilbara biological stock) from 2006 to 2013 have also been stable under current fishing pressure, ranging between 112 and 168 t⁶. This evidence indicates that the current level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Gascoyne biological stock

The stock assessment for Goldband Snapper in the Gascoyne biological stock is based on an assessment of fishing mortality derived from catch-curve analysis of representative samples of the age structure in the Gascoyne Demersal Scalefish Managed Fishery (Western Australia). These fishing mortality-based assessments use reference levels that are based on ratios of natural mortality for each species, such that $F_{\text{target}} = 2/3M$, $F_{\text{threshold}} = M$ and $F_{\text{limit}} = 3/2M$. The fishing mortality-based assessments indicated that the estimated fishing level on Goldband Snapper in this biological stock was below the target level in 2006 and 2008⁵. This indicates that fishing is not having an unacceptable impact on the age structure of the population. The biological stock is not considered to be recruitment overfished.

Goldband Snapper catches from the Gascoyne Demersal Scalefish Managed Fishery (Gascoyne biological stock) ranged from 240 to 311 t between 2002 and 2004⁵. Catch levels from 2005 to 2009 were lower, ranging between 105 and 144 t⁵. Catch levels since 2010 have been much reduced, ranging between 53 and 64 t⁵. Low catches, coupled with low fishing pressure, indicate that the current level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

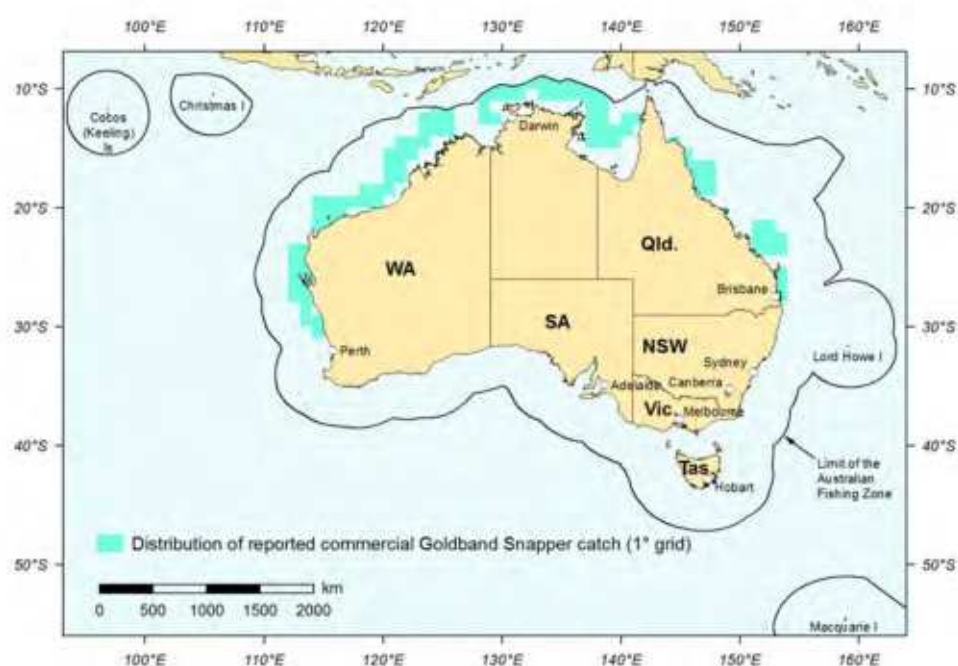
On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Goldband Snapper biology^{1,2,7,8}

Longevity and maximum size	30 years; 700 mm FL, 810 mm TL
Maturity (50%)	8 years; 470 mm FL, 550 mm TL

FL = fork length; TL = total length

Figure 1: Distribution of reported commercial catch of Goldband Snapper in Australian waters, 2013



Note: For Queensland, the reporting period for the Coral Reef Fin Fish Fishery and Deep Water Fin Fish Fishery is financial year (2012–13).

Table 3: Main features and statistics for Goldband Snapper fisheries in Australia, 2013

Jurisdiction	Northern Territory	Queensland ^a	Western Australia
Fishing methods			
Commercial			
Hand line	✓ ^b	✓	✓
Rod and line	✓	✓	✓
Longline		✓	✓
Dropline	✓	✓	
Fish trap	✓		✓
Fish trawl	✓	✓	✓
Recreational (including charter)			
Hand line	✓	✓	✓
Rod and line	✓	✓	✓

Jurisdiction	Northern Territory	Queensland ^a	Western Australia
Indigenous ^c			
Hand line		✓	
Rod and line		✓	
Management methods			
Commercial			
Limited entry		✓	✓
Spatial zoning	✓		✓
Total allowable catch	✓	✓	
Total allowable effort			✓
Size limits		✓ (not in GOCDFFTF)	
Vessel restrictions		✓	✓
Gear restrictions	✓	✓	✓
Effort limits			✓
Spatial closures		✓	✓
Temporal closures		✓	
Recreational			
Licensing			✓
Possession limits	✓	✓	✓
Bag limits			✓
Size limits		✓	✓
Spatial closures		✓	✓
Temporal closures		✓	
Charter			
Limited entry			✓
Spatial zoning			✓
Passenger restrictions			✓

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
GOLDBAND SNAPPER

Jurisdiction	Northern Territory	Queensland ^a	Western Australia
Size limits		✓	✓
Bag limits			✓
Possession limits	✓	✓	
Spatial closures		✓	✓
Temporal closures		✓	
Indigenous ^{c,d}			
Laws of general application			✓
Active vessels			
	6 in DF 9 in TRF	32 in CRFFF 0 in DWFFF 1 in GOCDFFTF	11 in GDSMF 8 in NDSMF 2 in PFTIMF 6 in PLF 2 in PTMF
Catch			
Commercial	332 t in DF 352 t in TRF	38 t in CRFFF 0 t in DWFFF 1 t in GOCDFFTF	53 t in GDSMF 490 t in NDSMF 78 t in PFTIMF 31 t in PLF 61 t in PTMF
Recreational	0.5 t (2010)	Unknown	2457 fish (2011–12); ~11 t ⁹
Charter	1 t (2012)	1 t	2341 fish; ~10 t
Indigenous	Negligible ¹⁰	Unknown	Unknown
Markets			
Domestic	✓	✓	✓
Export			

CRFFF = Coral Reef Fin Fish Fishery (Queensland); DF = Demersal Fishery (Northern Territory); DWFFF = Deep Water Fin Fish Fishery (Queensland); GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); GOCDFFTF = Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PLF = Pilbara Line Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

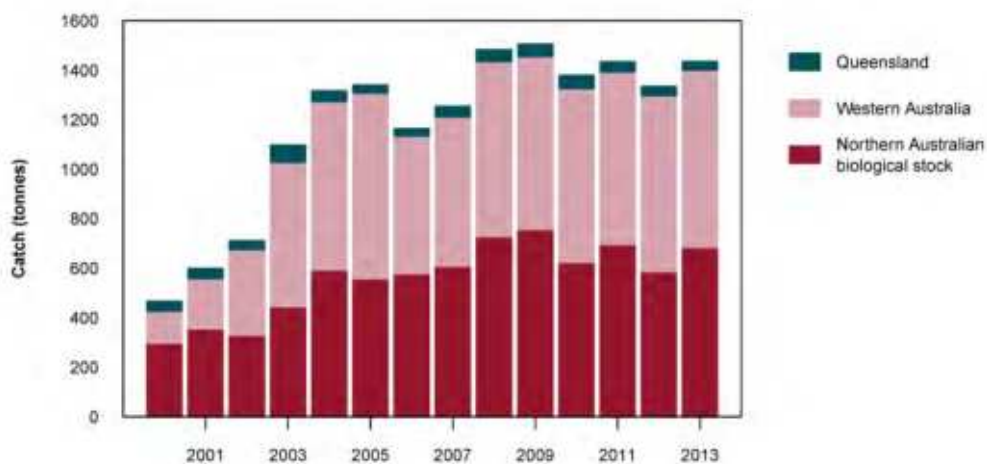
a For Queensland, the reporting period for the CRFFF and DWFFF is financial year (2012–13).

b In the Northern Territory, hand lines, droplines, and rod and line together constituted less than 3 per cent of the total commercial catch.

c Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

d Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

Figure 2: Commercial catch of Goldband Snapper in Australian waters, 2000 to 2013



Note: For Queensland, the reporting period for the Coral Reef Fin Fish Fishery and Deep Water Fin Fish Fishery is financial year. Western Australian data are combined because of confidentiality issues for one or more stocks in one or more years.

Effects of fishing on the marine environment

- The maintenance of high levels of adult biomass of Goldband Snapper in Western Australia, above biomass target levels, results in a low risk to the overall ecosystem from these fisheries. Furthermore, there has been no reduction in either mean trophic level or mean maximum length in the finfish catches recorded within the Pilbara or Kimberley, Western Australia (that is, no fishing-down of the food web)¹¹.
- Direct impacts on the benthic habitat of fishing activity for Goldband Snapper are limited to those of the trawl fisheries, which are restricted to around 7 per cent of the North West Shelf of Western Australia⁶ and parts of the Northern Territory. Trawl nets in the Northern Territory have been designed to fish off the seabed, reducing interaction with benthic habitats¹².
- There are few bycatch issues associated with trap- and line-based fishing. Bycatch of dolphins and turtles can occur in the fish trawls, but this has decreased significantly since turtle excluder devices were introduced in Western Australia in 2005 and the Northern Territory in 2006. Given the area of distribution and estimated population size of these protected species, the impact of the fish trawl fishery on the stocks of these protected species is likely to be minimal. Gear and fishing modification continue to reduce this level of interaction^{5,13}.
- The Northern Territory fisheries that target Goldband Snapper have received full Export Exemption accreditation under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). The Western Australian and Queensland east coast fisheries that target Crimson Snapper have received Approved Wildlife Trade Operation Exemption accreditation under the Act (except for the Pilbara Trap Managed Fishery [Western Australia], which does not export fish). These assessments, subject to adherence to any accompanying conditions and recommendations, demonstrate that these fisheries are managed in a manner that does not lead to overfishing, and that fishing operations have a minimal impact on the structure, productivity, function and biological diversity of the ecosystem.

Environmental effects on Goldband Snapper

- Climate change and climate variability have the potential to impact fish stocks in a range of ways, including influencing their geographic distribution (for example, latitudinal shifts in distribution). However, it is unclear how climate change may affect risks to the sustainability of this species. Slow-growing and long-lived species such as Goldband Snapper are less likely to be affected by short-duration environmental changes (of one or a few years), because adult stocks comprise fish that have been recruited over many years.
- Changes in ocean chemistry such as ocean acidification have the potential to affect the replenishment rates of fish populations by affecting larval survival¹⁴, as well as individual growth rates and spawning output¹⁵.

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57. Golden Snapper *Lutjanus johnii*

Thor Saunders^a, Stephen Newman^b, Malcolm Keag^c and Chris Errity^a



Table 1: Stock status determination for Golden Snapper

Jurisdiction	Northern Territory	Western Australia	Queensland	
Stock	Northern Territory (CLF, DF, FTO, TRF)	Western Australia (NDSMF, PTMF)	Gulf of Carpentaria (GOCDFFTF, GOCLF)	East coast (ECIFFF)
Stock status				
	Overfished	Undefined	Undefined	Undefined
Indicators	Catch, biomass, egg production	Catch	Catch, standardised CPUE, observer surveys	Catch, performance indicators

CLF = Coastal Line Fishery (Northern Territory); CPUE = catch per unit effort; DF = Demersal Fishery (Northern Territory); ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); FTO = Fishing Tour Operator (Northern Territory); GOCDFFTF = Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

Stock structure

Golden Snapper is a widespread Indo-Pacific species that is found from the Pilbara region in Western Australia across Northern Australia to the east coast of Queensland. The biological stock structure for this species is currently under investigation and undefined. As a result, status in this chapter is reported at the jurisdiction level for the Northern Territory and Western Australia, and the management unit level for Queensland. In Queensland, the Gulf of Carpentaria is considered a single management unit, comprising two separate fisheries.

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Stock status

Northern Territory

The most recent assessment (2011) estimated biomass of Golden Snapper in the Northern Territory to be approximately 25 per cent of unfished spawning stock biomass, which is below conventional target levels, and egg production to be at approximately 10 per cent of unfished levels, which is below conventional limit levels¹. The assessments are driven by the populations that receive the highest harvest rates, so the status for the Northern Territory can be assumed to be representative of the highest level of exploitation that occurs on any population. The immediate area of concern is in waters around Darwin, where most of the fishing pressure occurs and where abundance, catch and catch rate have substantially declined over the past 10 years². It is likely that populations of Golden Snapper exist in the Northern Territory that are not overfished because they have been subject to low fishing pressure. However, these still require identification in the current stock structure study for this species. Until this knowledge is gained, the modelling for Golden Snapper has been carried out assuming a single stock for the jurisdiction; hence the stock status is reported at this scale. Subsequent reports are likely to include a number of different stocks, with a variety of status classifications, within the Northern Territory. This precautionary approach has been taken because Golden Snapper has vulnerable life history traits (slow growth, late maturity, high longevity) and is highly susceptible to barotrauma when caught in waters deeper than 10 metres^{2,3}. All of this evidence indicates that the stock is likely to be recruitment overfished. Declining catch rates at low stock size indicate that the current level of fishing pressure is likely to prevent the stock recovering from a recruitment overfished state.

On the basis of the evidence provided above, Golden Snapper in the Northern Territory is classified as an **overfished stock**.

Western Australia

Golden Snapper is not a commercial target species in the demersal fisheries of Western Australia, but is landed in small quantities as byproduct. Golden Snapper are landed by recreational and charter fishers, primarily in the Kimberley region of Western Australia, but only in small quantities⁴. Because of the low level of take of Golden Snapper in Western Australia, which occurs across a limited area of the distribution of the species, it is unlikely that Golden Snapper in Western Australia is recruitment overfished, or that the level of fishing mortality is likely to cause the stock to become recruitment overfished. However, insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, Golden Snapper in Western Australia is classified as an **undefined stock**.

Gulf of Carpentaria (Queensland) management unit

In the Gulf of Carpentaria management unit, Golden Snapper is mainly harvested by the commercial sector. There is no reliable estimate of recreational harvest. Harvest from the adjacent Northern Territory jurisdiction has been low in recent years.

Queensland commercial catches remained stable at 20–35 tonnes (t) over the decade to 2011, with most fish taken by the Gulf of Carpentaria Developmental Fin Fish Trawl Fishery rather than the Gulf of Carpentaria Line Fishery, where participants primarily target Spanish Mackerel. Fish trawl effort in the Gulf of Carpentaria declined markedly in 2012 as a result of trawl effort being transferred to areas in the Northern Territory (outside the Gulf).

No stock assessment has been undertaken to estimate current biomass in relation to unfished biomass. However, standardised catch rates (calculated to 2009) in the trawl fishery showed significant declines after 2006, to approximately half the long-term average⁵. Observer surveys over the period 2004 to 2006 showed that most Golden Snapper caught in the Gulf of Carpentaria Developmental Fin Fish Trawl Fishery were also smaller than the size at maturity (unpublished data). Overall, there is insufficient information available to confidently classify the status of this stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

East coast (Queensland) management unit

No stock assessment has been undertaken to estimate current biomass in relation to unfished biomass in the Queensland east coast management unit. Golden Snapper is mainly harvested by the recreational sector.

Recreational harvest remained stable between estimates derived in 2000 (approximately 15 000 fish) and 2010 (approximately 14 000 fish)⁶. According to the 2010 survey, almost as many recreationally caught fish were released as were retained. Given the issues with barotrauma raised above, the actual harvest by this sector is likely to be higher.

The species is taken as byproduct in the East Coast Inshore Fin Fish Fishery, predominantly by net. Annual commercial catches increased from less than 1 t per year from 2000 to 2008, to a peak of 8 t in 2011. Catches in 2012 and 2013 declined from this peak, and in 2013 the catch was approximately 1 t.

No indices of abundance have been estimated, and insufficient information is available to confidently classify the status of the stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

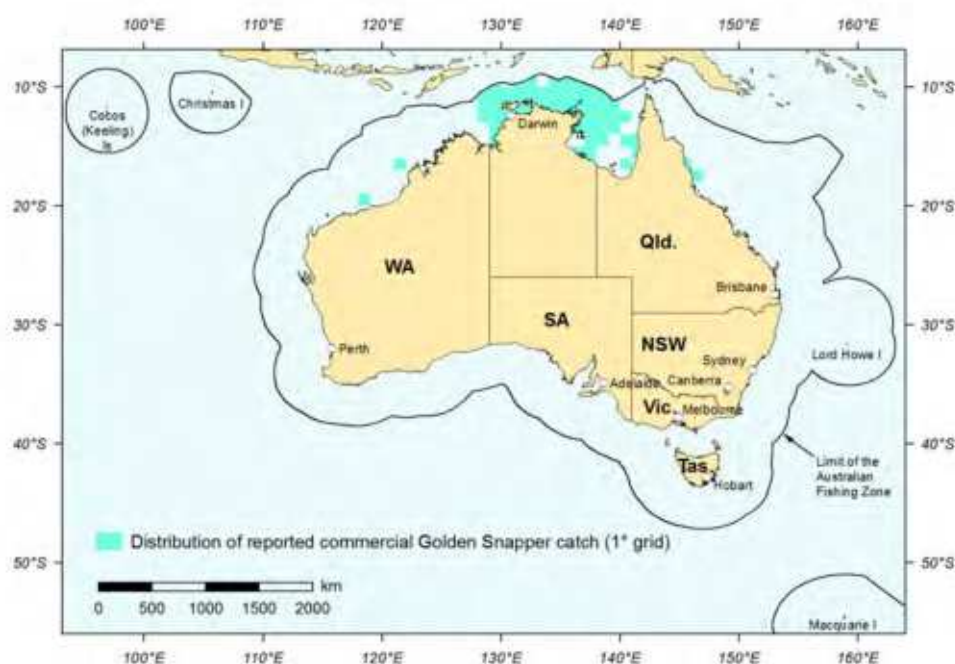
Table 2: Golden Snapper biology^{7,8}

<i>Longevity and maximum size</i>	30 years; 900 mm TL, 15 kg
<i>Maturity (50%)</i>	Northern Territory: males 520 mm TL (7 years), females 560 mm TL (8 years) Cape York: males 620 mm FL (9 years), females 640 mm (6 years) North Queensland^a: males 590 mm (6 years), females 690 mm (10 years)

FL = fork length; TL = total length

^a North Queensland refers to samples from Cairns to Townsville.

Figure 1: Distribution of reported commercial catch of Golden Snapper in Australian waters, 2013 (calendar year)



Note: Queensland east coast catch is reported by financial year.

Table 3: Main features and statistics for Golden Snapper fisheries in Australia, 2013 (calendar year)

Jurisdiction	Northern Territory	Queensland	Western Australia
Fishing methods			
Commercial			
Fish trawl	✓	✓	
Fish trap	✓		✓
Hand line	✓	✓	✓
Rod and line			✓
Recreational			
Rod and line	✓	✓	✓
Spearfishing	✓	✓	✓
Indigenous ^{a,b}			
Hand line	✓	✓	✓
Management methods			
Commercial			
Limited entry	✓	✓	✓
Spatial zoning			✓
Size limits		✓ (not in GOCDFFTF)	
Vessel restrictions	✓	✓	✓
Gear restrictions	✓	✓	✓
Total allowable catch	✓	✓ (GOCDFFTF)	
Total allowable effort			✓
Effort limits			✓
Spatial closures	✓	✓	✓

Jurisdiction	Northern Territory	Queensland	Western Australia
Recreational			
Licences			✓
Possession limits	✓	✓	✓
Bag limits			✓
Size limits		✓	✓
Spatial closures	✓	✓	✓
Charter			
Licences	✓	✓ (vessel)	✓
Limited entry	✓		✓
Spatial zoning			✓
Passenger restrictions			✓
Possession limits	✓	✓	✓
Size limits		✓	✓
Bag limits			✓
Spatial closures	✓	✓	✓
Indigenous ^{a,b}			
Laws of general application			✓
Active vessels			
	9 in CLF 9 in DF 8 in TRF	7 in ECIFFF 1 in GOCDFFTF 1 in GOCLF	1 in NDSMF 1 in PTMF
Catch			
Commercial	7 t in CLF 22 t in DF 2 t in TRF	3.5 t in ECIFFF 0.2 t in GOCDFFTF 0.2 t in GOCLF	<0.1 t in NDSMF <0.1 t in PTMF
Recreational	72 t (2010)	33 t (2010)	1490 fish (2011–12); ~2 t ⁹
Charter	10 t in FTO	0.2 t	2598 fish; ~4 t

Jurisdiction	Northern Territory	Queensland	Western Australia
Indigenous	Unknown	Unknown	Unknown
Markets			
Domestic	✓	✓	✓
Export			

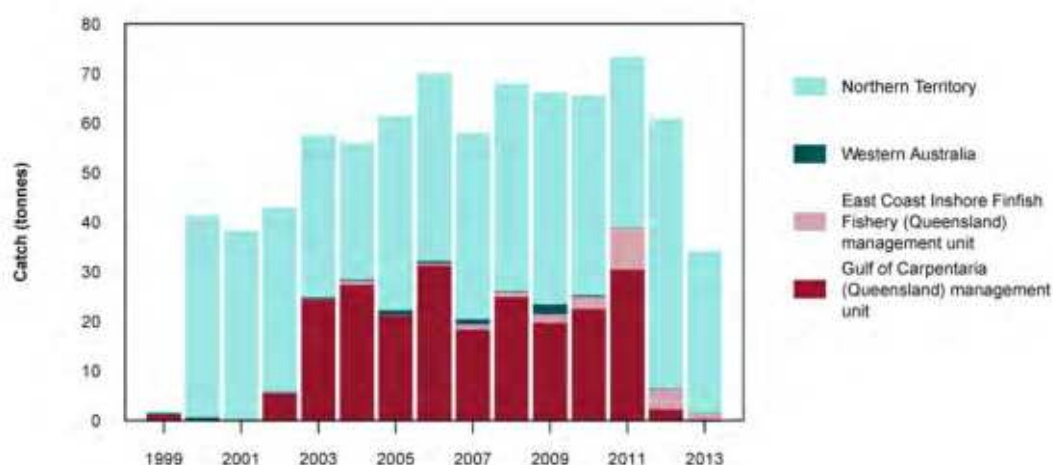
CLF = Coastal Line Fishery (Northern Territory); DF = Demersal Fishery (Northern Territory); ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); FTO = Fishing Tour Operator (Northern Territory); GOCDFTF = Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

Note: ECIFFF catch is reported by financial year.

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

b Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catch of Golden Snapper in Australian waters, 1999 to 2013 (calendar years)



Note: Queensland east coast catch is reported by financial year.

Effects of fishing on the marine environment

- Golden Snapper is mainly targeted in all sectors by fishers using hand lines, and rod and lines. Beyond the catch of target and a small quantity of bycatch species, there is little evidence to suggest that this gear significantly impacts on benthic or pelagic ecological communities.
- Commercial trawl gear used in the Northern Territory and Queensland has the potential to impact on the benthic habitat. However, trawl nets in these waters have been designed to fish off the seabed, reducing interaction with benthic habitats⁴. Additionally, the trawl fleet is very small and only fishes about 7 per cent of the available area¹⁰.

Environmental effects on Golden Snapper

- The impact of environmental factors on Golden Snapper stocks is largely unknown. However, the juvenile and larval phases of this species inhabit estuaries and coastal bays, making these phases of the life cycle vulnerable to changes in ocean current, strength and direction; rainfall; river flow; water temperature; salinity; and pH³.

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58. Red Emperor *Lutjanus sebae*

Stephen Newman^a, Julie Martin^b, Malcolm Keag^c and Corey Wakefield^a



Table 1: Stock status determination for Red Emperor

Jurisdiction	Western Australia			Northern Territory	Queensland	
Stock	Gascoyne (GDSMF)	Pilbara (PFTIMF, PTMF)	Kimberley (NDSMF)	Northern Territory (DF, TRF)	Gulf of Carpentaria (GOCDFFTF, GOCLF)	East coast Queensland (CRFFF)
Stock status						
	Sustainable	Sustainable	Sustainable	Undefined	Undefined	Undefined
Indicators	Age structure, fishing mortality rates of indicator species	Spawning stock level, age structure, catch, CPUE	Spawning stock level, age structure, catch, CPUE	Catch, trigger reference points	Catch, standardised CPUE, observer surveys	Catch, performance indicators

CPUE = catch per unit effort; CRFFF = Coral Reef Fin Fish Fishery (Queensland); DF = Demersal Fishery (Northern Territory); GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); GOCDFFTF = Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

Stock structure

Red Emperor is exploited primarily in the North Coast Bioregion of Western Australia¹. Smaller catches are taken in the Northern Territory and Queensland. Red Emperor is one of the indicator species used to assess the status of the demersal resources in the North Coast Bioregion. In Western Australia, analysis of otolith stable isotopes indicates that Red Emperor comprises a number of separate biological stocks, one in each of

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^c Department of Agriculture, Fisheries and Forestry, Queensland

the main management regions: the Kimberley, the Pilbara and the Gascoyne^{2,3}. Reporting of status is undertaken at the level of these individual biological stocks in Western Australia. Because multiple biological stocks are present within Western Australia, there is also a high likelihood of multiple biological stocks across the Northern Territory and Queensland. However, stock delineation is not currently known in these jurisdictions. In the Northern Territory, status is reported at the jurisdictional level; in Queensland, status is reported at the management unit level.

Stock status

Gascoyne biological stock

The Gascoyne biological stock is exploited as a component of the Gascoyne Demersal Scalefish Managed Fishery (Western Australia)¹. The catch of Red Emperor in the Gascoyne Bioregion is very low (Table 3). In the Gascoyne Bioregion Red Emperor is assessed on the basis of the status of several indicator species (Snapper—*Chrysophrys auratus*, Goldband Snapper—*Pristipomoides multidens*, and Spangled Emperor—*Lethrinus nebulosus*) that represent the entire inshore demersal suite of species occurring at depths of 30–250 m. These species were selected using a risk-based approach, based on the relative vulnerability of the species to exploitation.

The major performance measures for these indicator species are either estimates of current spawning stock levels or fishing mortality-based assessments. The target level of spawning biomass is 40 per cent of the unfished level, and the limit level is 30 per cent of the unfished level. Data analysis using an integrated age-structured model estimated that the spawning biomass levels of Snapper were close to 40 per cent of the unfished level in the Gascoyne Demersal Scalefish Managed Fishery (Western Australia) in 2011¹. The Gascoyne biological stock is not considered to be recruitment overfished.

The indicator species Goldband Snapper and Spangled Emperor in the Gascoyne Bioregion were assessed using fishing mortality (F)-based assessments¹ (derived from catch-curve analysis of representative samples of the age structure). These assessments use reference levels that are based on ratios of natural mortality (M) for each species, such that $F_{\text{target}} = 2/3M$, $F_{\text{threshold}} = M$ and $F_{\text{limit}} = 3/2 M$. These assessments indicated that the fishing levels of Goldband Snapper were at or below the target level. Whereas, Spangled Emperor were below the target level in one area, and above the limit level in another area, suggesting spatial confinement of growth overfishing. On balance, the assessments indicate that indicator species are not recruitment overfished. Therefore, given catches of Red Emperor are low, the current level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Pilbara biological stock

The major performance measures for the Pilbara biological stock, for Red Emperor landed in the Pilbara Trap Managed Fishery and the Pilbara Fish Trawl Interim Managed Fishery, are based on estimates of current spawning stock levels of Red Emperor. The target level of spawning biomass is 40 per cent of the unfished (1972) biomass. The limit level is 30 per cent of the unfished spawning biomass. The spawning biomass level of Red Emperor overall (across all management areas of the Pilbara biological stock) was greater than 40 per cent in the Pilbara Demersal Scalefish Fisheries in 2007 (the year the last integrated assessment was undertaken), using an integrated age-structured model⁴. The stock is therefore not considered to be recruitment overfished.

An assessment of fishing mortality derived from representative samples of the age structure of Red Emperor was also undertaken for separate management areas in the Pilbara biological stock in 2007. These fishing mortality (F)-based assessments use the reference levels defined above for the Gascoyne biological stock. The assessments indicated that the fishing level on Red Emperor in 2007 was between the target and threshold levels, but above the limit level in some areas⁴. This indicates that fishing was having an impact on the age structure of the population in some management areas. Effort reductions since 2008 have resulted in decreasing catch levels. In 2007, the Red Emperor catch from the Pilbara biological stock was 187 tonnes (t). The catch decreased to 154 t in 2008, and remained at a similar level in 2009 (159 t) and 2010 (167 t). From 2008 to 2010, the catch-rate trends for Red Emperor in all trawl managed areas increased each year. This was considered to be a response to the effort reductions imposed on the trawl fishery since 2008. From 2010 to 2013, the catch-rate trends of Red Emperor have been stable in all trawl managed areas, except Area 2, where

there has been a slight decline. The above evidence indicates that the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Kimberley biological stock

The major performance measures for the Kimberley biological stock of Red Emperor relate to spawning stock levels. The target level of spawning biomass is 40 per cent of the unfished (1980) level. The limit level is 30 per cent of the unfished level. The spawning biomass level of Red Emperor was greater than 40 per cent in the Northern Demersal Scalefish Managed Fishery in 2007 (the year the last integrated assessment was undertaken), as derived by synthesising the available data in an integrated age-structured model⁴. Catch levels of Red Emperor in the Northern Demersal Scalefish Managed Fishery over the past 5 years (2009 to 2013) have been stable, ranging between 128 and 156 t, and are below the catch levels for the preceding 5-year period (2004 to 2008) of sustainable fishing, when catches ranged between 164 and 192 t⁴. The stock is not considered to be recruitment overfished.

An assessment of fishing mortality derived from representative samples of the age structure of Red Emperor was also undertaken for the Northern Demersal Scalefish Managed Fishery in 2006 and 2008. These fishing mortality (F)-based assessments use the reference levels defined above for the Gascoyne biological stock. The assessments indicated that the fishing level on Red Emperor was lower than the target level in 2006 and 2008⁴. This indicates that fishing is not having an unacceptable impact on the age structure of the population. The above evidence indicates that the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Northern Territory

Red Emperor comprises around 2 per cent of the total catch in the Northern Territory offshore snapper fisheries. It is managed as part of the 'group species' quota category (species other than Goldband Snapper, Saddletail Snapper and Crimson Snapper) in the Timor Reef Fishery and the Demersal Fishery. The performance indicators and trigger points are based on significant changes in species composition of the catch, which are used to indicate whether significant catch increases warrant further management efforts. Since 1995, catches of Red Emperor have varied between 1.5 and 4.5 per cent of the total annual catch, and increased from 20 t in 1995 to 55 t in 2013. The trigger point of an increase of more than 15 per cent of the species' previous year's catch weight, or of a species becoming dominant relative to other species in the group, was not reached in 2013.

This evidence suggests that the current level of fishing mortality is unlikely to cause Red Emperor in the Northern Territory to become recruitment overfished. However, at present, insufficient information is available to determine the biomass of the species in the Northern Territory.

On the basis of the evidence provided above, Red Emperor in the Northern Territory is classified as an **undefined stock**.

Gulf of Carpentaria management unit

Red Emperor has historically been taken by demersal fish trawl (Gulf of Carpentaria Developmental Fin Fish Trawl Fishery [Queensland]) and by line (Gulf of Carpentaria Line Fishery [Queensland]). Participants in the Gulf of Carpentaria Line Fishery primarily target Spanish Mackerel (*Scomberomorus commerson*) by trolling. Since 2010, catch of Red Emperor in this fishery has fallen to very low levels, primarily as a result of decline in fishing effort in the area. Harvest from the adjacent Northern Territory component of the stock has been low in recent years.

Commercial catches in the Gulf of Carpentaria Developmental Fin Fish Trawl Fishery have been historically variable. Fish trawl effort in the Gulf of Carpentaria declined markedly in 2012 and further in 2013, as a result of transfer of effort to Northern Territory regions outside the Gulf. There are limited data on the distribution and abundance of Red Emperor in the Gulf of Carpentaria^{5,6}. Nominal commercial catch rates have been historically variable, although long-term standardised catch rates to 2009 showed significant declines⁷. Observer surveys from 2004 to 2006 showed that most Red Emperor caught in the Gulf of Carpentaria Developmental Fin Fish Trawl Fishery was discarded, the majority of which were immature (unpublished data).

Insufficient information is available to confidently classify the status of this stock.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

East coast Queensland management unit

There has been no stock assessment to determine biomass in the east coast Queensland management unit.

Red Emperor is mainly harvested by the recreational sector. Recreational catch estimates have fallen from approximately 200 t in 2000 to 150 t in 2010, despite the latest survey showing that recreational anglers are targeting Red Emperor more often. A harvest reduction of this magnitude was also reflected in charter catch over the same period (charter fishing is a subset of recreational fishing), mainly over the past 5 years.

Annual commercial catches have been 25–60 t since 2004–05, following several years of much higher catches (100–200 t per year) from 1997–98 to 2004–05. This decrease coincided with expansion of no-take marine reserves within the Great Barrier Reef Marine Park and the introduction of a quota management system for coral reef finfish species. Both factors are likely to have influenced commercial catch.

Commercial harvest is not effectively constrained by this species being part of the ‘other species’ quota category, which comprises many other coral reef finfish species, with no individual cap on any one species in this category.

Insufficient information is available to confidently classify the status of the stock.

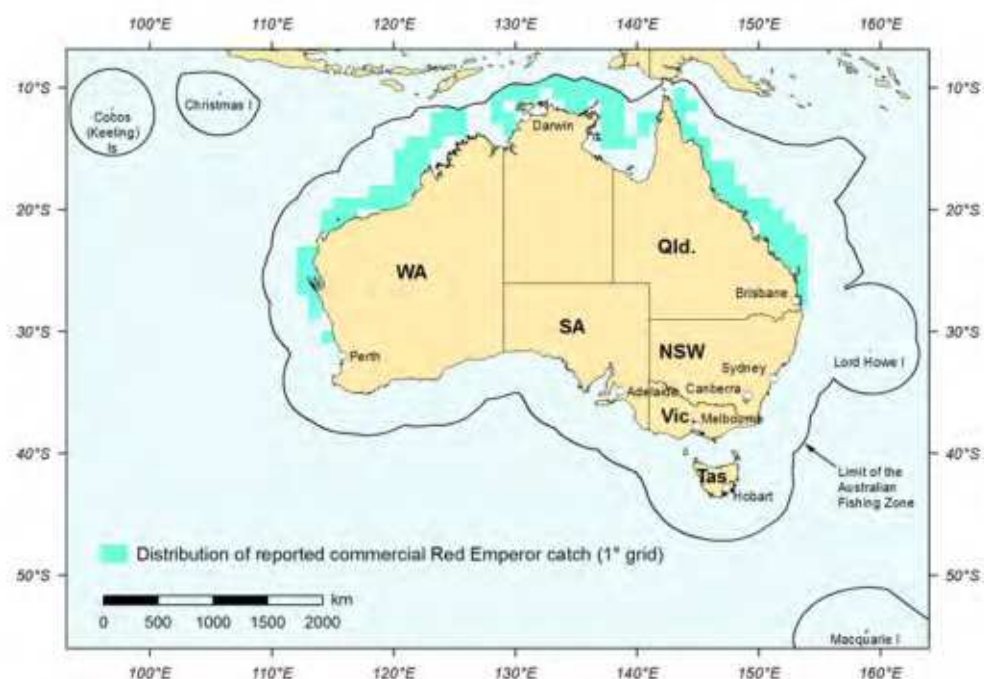
On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Table 2: Red Emperor biology ^(7–10)

<i>Longevity and maximum size</i>	40 years; 800 mm FL (860 mm TL)
<i>Maturity (50%)</i>	Females: 8–10 years; 430 mm FL (460 mm TL) Males: 8 years; 460 mm FL (490 mm TL)

FL = fork length; TL = total length

Figure 1: Distribution of reported commercial catch of Red Emperor in Australian waters, 2013 (calendar year)



Note: In Queensland, data for the Coral Reef Fin Fish Fishery relate to the 2012–13 financial year. Data for the Gulf of Carpentaria Developmental Fin Fish Trawl Fishery and Gulf of Carpentaria Line Fishery are for the 2013 calendar year.

Table 3: Main features and statistics for Red Emperor fisheries in Australia, 2013 (calendar year)^a

Jurisdiction	Western Australia	Northern Territory	Queensland
Fishing methods			
Commercial			
Fish trawl	✓	✓	✓
Fish trap	✓	✓	
Hand line	✓	✓	✓
Rod and line	✓	✓	✓
Longline	✓		
Recreational			
Hand line	✓		✓
Rod and line	✓	✓	✓
Spearfishing	✓		✓

Jurisdiction	Western Australia	Northern Territory	Queensland
Indigenous ^a			
Hand line			✓
Rod and line			✓
Management methods			
Commercial			
Limited entry	✓		✓
Spatial zoning	✓	✓	
Size limits	✓		✓ (not in GOCDFFTF)
Vessel restrictions	✓		✓
Gear restrictions	✓	✓	✓
Total allowable catch		✓	✓
Total allowable effort	✓		
Effort limits	✓		
Spatial closures	✓		✓
Recreational			
Licensing	✓		
Possession limits	✓	✓	✓
Bag limits	✓		
Size limits	✓		✓
Spatial closures	✓		✓
Charter			
Limited entry	✓		
Spatial zoning	✓		
Passenger restrictions	✓		
Bag limits	✓	✓	
Size limits	✓		✓

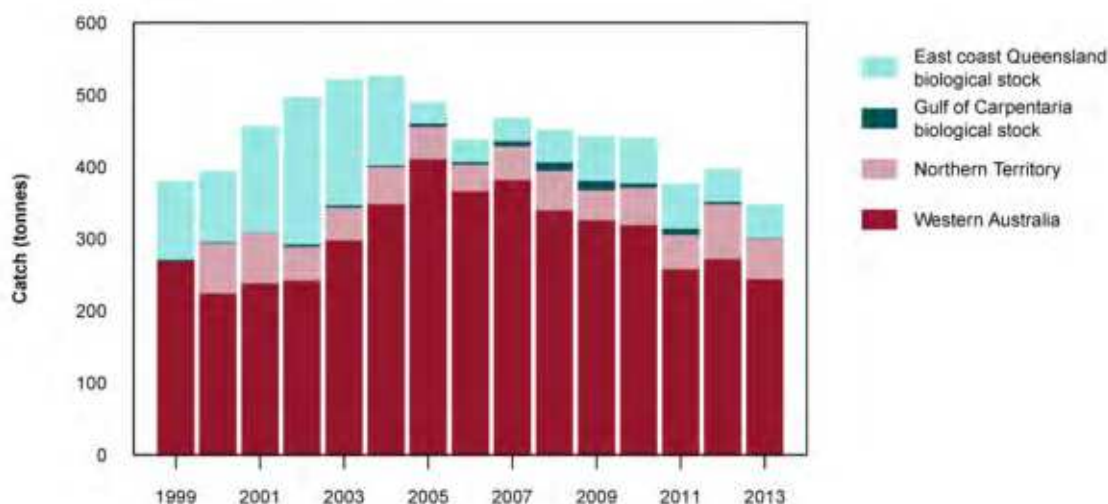
Jurisdiction	Western Australia	Northern Territory	Queensland
Spatial closures	✓		✓
Indigenous ^{a,b}			
Laws of general application	✓		
Active vessels			
	14 in GDSMF 8 in NDSMF 3 in PFTIMF 2 in PTMF	6 in DF 9 in TRF	179 in CRFFF 1 in GOCDFFTF 0 in GOCLF
Catch			
Commercial	7 t in GDSMF 131 t in NDSMF 53 t in PFTIMF 49 t in PTMF	27 t in DF 28 t in TRF	44 t in CRFFF 1 t in GOCDFFTF 0 t in GOCLF
Recreational	7350 fish (2011–12); ~25 t ¹¹	Unknown	150 t (2010)
Charter	2200 fish; ~8 t	Unknown	13 t
Indigenous	Unknown	Unknown	Included in recreational estimate
Markets			
Domestic	✓	✓	✓
Export			

CRFFF = Coral Reef Fin Fish Fishery (Queensland); DF = Demersal Fishery (Northern Territory); GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); GOCDFFTF = Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

b Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catch of Red Emperor in Australian waters, 1999 to 2013 (calendar years)



Note: Western Australian data are combined because of confidentiality issues for one or more stocks in one or more years.

Effects of fishing on the marine environment

- The maintenance of high levels of biomass of Red Emperor in each of the fisheries in Western Australia results in a negligible ecotrophic risk from these fisheries. Furthermore, there has been no reduction in either mean trophic level or mean maximum length in the finfish catches recorded within the Pilbara or Kimberley in Western Australia (that is, no indication of fishing-down of the food web)¹².
- Available information indicates that there are minimal impacts on habitat from trap- or line-based fishing methods for Red Emperor⁴.
- Impacts to the habitat from trawling are expected to be minimal because trawling is restricted to 7 per cent of the North West Shelf and parts of the Northern Territory. Trawling does not occur in the Kimberley region^{1,4,8}. Trawl nets in the Northern Territory have been designed to fish off the seabed, reducing interaction with benthic habitats¹³.
- The bycatch of dolphins and turtles has been reduced significantly since the introduction of turtle excluder devices in Pilbara fish trawl nets in 2005. Given the area of distribution and expected population size of these protected species, the impact of the fish trawl fishery on their stocks is likely to be minimal. Gear and fishing modification continue to reduce this level of interaction^{1,4}.
- The main Western Australian fisheries that target Red Emperor have received either full Export Exemption or Approved Wildlife Trade Operation Exemption accreditation under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). The Northern Territory fisheries that target Red Emperor have received full Export Exemption accreditation, and the Queensland fisheries that target Red Emperor have received an Approved Wildlife Trade Operation Exemption accreditation under the Act. These assessments, subject to adherence to accompanying conditions and recommendations, demonstrate that these fisheries are managed in a manner that does not lead to overfishing, and that fishing operations have a minimal impact on the structure, productivity, function and biological diversity of the ecosystem.

Environmental effects on Red Emperor

- Climate change and climate variability have the potential to impact fish stocks in a range of ways, including influencing their geographic distribution (for example, latitudinal shifts in distribution). However, it is unclear how climate change may affect risks to the sustainability of this species.
- Changes in oceanographic conditions have the potential to affect the replenishment rates of fish populations, as well as individual growth rates and spawning output¹⁴.

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59. Redthroat Emperor *Lethrinus miniatus*

Malcolm Keag^a, David Fairclough^b and Stephen Newman^b



Table 1: Stock status determination for Redthroat Emperor

Jurisdiction	Queensland	Western Australia
Stock	East coast Queensland (CRFFF)	Western Australian (GDSMF, WCDSIMF)
Stock status		
	Sustainable	Undefined
Indicators	Catch, CPUE, stock assessment	Catch

CPUE = catch per unit effort; CRFFF = Coral Reef Fin Fish Fishery (Queensland); GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia)

Stock structure

Genetic analysis indicates that there are two separate biological stocks of Redthroat Emperor in western and eastern Australian waters¹. Reporting of stock status is at the biological stock level.

Stock status

East coast Queensland biological stock

The most recent assessment (2006) of the east coast Queensland biological stock² of Redthroat Emperor analysed fishery data using an age-structured model that incorporated all available information on catch, catch per unit effort and age structure. The model estimated that biomass in 2004 was approximately 70 per cent of the unfished (1946) level. The maximum sustainable yield was estimated to be in the range of 760–964 tonnes (t) per year. Since 2004–05, annual commercial catches have averaged approximately 250 t. The latest recreational estimate (for 2010) was 90 t, with the combined catch being well below the estimated maximum sustainable yield³. The biomass of the stock is therefore not recruitment overfished.

^a Department of Agriculture, Fisheries and Forestry, Queensland

^b Department of Fisheries, Western Australia

Fishing mortality over the past decade has been low compared with the maximum sustainable yield estimate, and both catches and commercial standardised catch rates have been historically stable. Although recreational fishing effort is not capped, the current level of fishing pressure is highly unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Western Australian biological stock

A stock assessment of Western Australian Redthroat Emperor has not yet been conducted. Commercial catches have been stable over the past 5 years, but insufficient information is available to confidently classify the status of this biological stock.

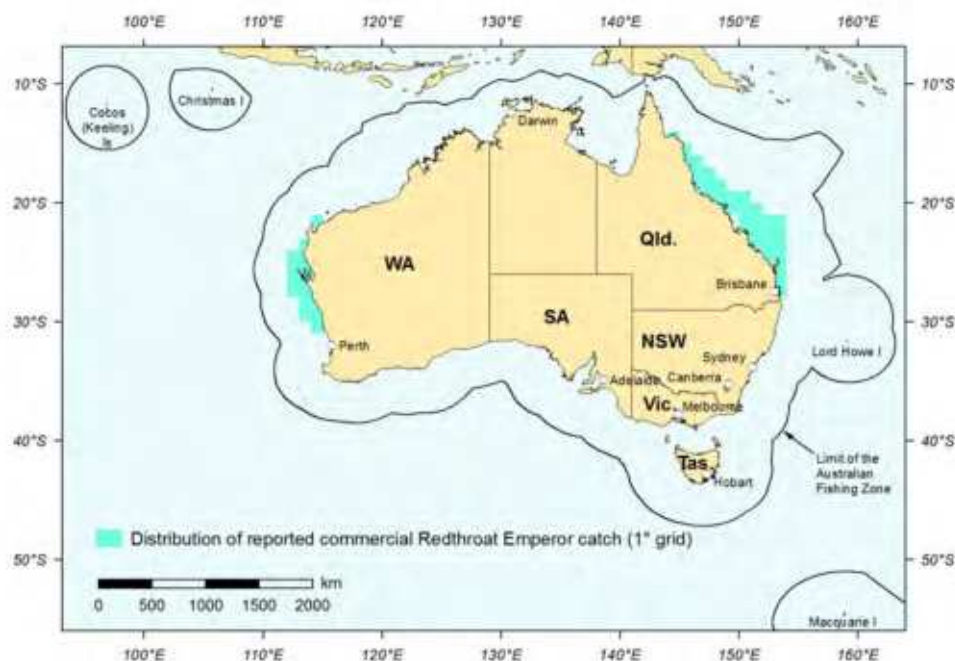
On the basis of the evidence provided above, the stock is classified as an **undefined stock**.

Table 2: Redthroat Emperor biology^{1,4,5}

Longevity and maximum size	20 years; 650 mm TL
Maturity (50%)	Females: 1.2 years; 280 mm FL, 310 mm TL

FL = fork length; TL = total length

Figure 1: Distribution of reported commercial catch of Redthroat Emperor in Australian waters, 2013 (calendar year)



Note: Data for the Western Australian catch align with the 2013 calendar year, whereas data for Queensland align with the 2012–13 financial year.

Table 3: Main features and statistics for Redthroat Emperor fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland ^a	Western Australia ^b
Fishing methods		
Commercial		
Hand line	✓	✓
Rod and line	✓	
Fish trawl		✓
Fish trap		✓
Recreational		
Hand line	✓	✓
Rod and line	✓	✓
Spearfishing	✓	✓
Indigenous ^{c,d}		
Hand line	✓	✓
Rod and line	✓	✓
Spearfishing	✓	✓
Management methods		
Commercial		
Limited entry	✓	✓
Gear restrictions	✓	✓
Size limits	✓	✓
Vessel restrictions	✓	✓
Catch restrictions	✓	✓
Spatial zoning		✓
Spatial closures	✓	✓
Temporal closures	✓	
Effort limits		✓
Total allowable effort		✓

Jurisdiction	Queensland ^a	Western Australia ^b
Recreational		
Licensing (fishing from a boat)		✓
Gear restrictions	✓	✓
Size limits	✓	✓
Catch limits	✓	✓
Spatial closures	✓	✓
Temporal closures	✓	✓
Charter		
Limited entry	✓	✓
Spatial zoning		✓
Gear restrictions	✓	✓
Passenger restrictions	✓	✓
Size limits	✓	✓
Catch limits	✓	✓
Spatial closures	✓	✓
Temporal closures	✓	✓
Indigenous ^{c,d}		
Laws of general application		✓
Active vessels		
	163 in CRFFF	12 in GDSMF 35 in WCDSIMF
Catch		
Commercial	218 t in CRFFF	4 t in GDSMF ⁶ 44 t in WCDSIMF
Recreational	65 000 fish (2010) ³ ; ~90 t	9100 fish (2011–12); ~11 t ⁷
Charter	72 t	2600 fish; ~3 t
Indigenous	Unknown	Unknown

Jurisdiction	Queensland ^a	Western Australia ^b
Markets		
Domestic	✓	✓
Export		

CRFFF = Coral Reef Fin Fish Fishery (Queensland); GDSMF = Gascoyne Demersal Scalefish Managed Fishery (Western Australia); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia)

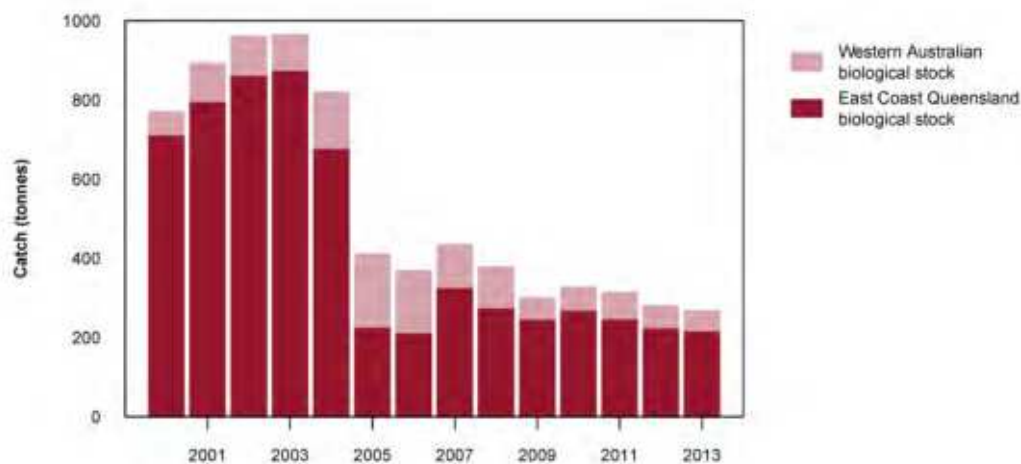
a Data for Queensland align with the 2012–13 financial year.

b Data for Western Australia align with the 2013 calendar year.

c Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

d Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catch of Redthroat Emperor in Australian waters, 2000 to 2013 (calendar year)



Note: Data for Western Australian catch align with calendar years, whereas data for Queensland align with financial years.

Effects of fishing on the marine environment

- Beyond the removal of target fish and smaller quantities of coral reef finfish species, there is little evidence to suggest that the fisheries targeting Redthroat Emperor impact significantly on the marine environment or ecosystems.

Environmental effects on Redthroat Emperor

- Coral bleaching events⁸, indicating changes in ocean chemistry due to ocean acidification, have the potential to impact on the replenishment rates of coral reef finfish populations by affecting larval survival⁹, as well as individual growth rates and spawning output¹⁰.

- There is evidence that tropical cyclones have resulted in both positive and negative changes in the catch rates of Redthroat Emperor, well beyond the duration of the cyclone itself¹¹. The reasons for this are not yet understood but possibly relate to water temperature and food availability¹¹. A related species (Red Snout Emperor—*Lethrinus reticulatus*) has been shown to have relatively low tolerance to increased water temperature¹².

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60. Saddletail Snapper *Lutjanus malabaricus*

Julie Martin^a, Malcolm Keag^b, Stephen Newman^c and Corey Wakefield^d



Table 1: Stock status determination for Saddletail Snapper

Jurisdiction	Northern Territory, Queensland	Queensland	Western Australia
Stock	Northern Australian (DF, GOCDFFTF, GOCLF, TRF)	East coast Queensland (CRFFF, DWFFF)	North West Shelf (NDSMF, PFTIMF, PTMF)
Stock status			
	Sustainable	Undefined	Sustainable
Indicators	Catch, CPUE	Catch	Catch, CPUE

CPUE = catch per unit effort; CRFFF = Coral Reef Fin Fish Fishery (Queensland); DF = Demersal Fishery (Northern Territory); DWFFF = Deep Water Fin Fish Fishery (Queensland); GOCDFFTF = Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

Stock structure

Saddletail Snapper is a widespread Indo–Pacific species that is found from Shark Bay in Western Australia across northern Australia to the east coast of Queensland¹. Genetic studies indicate that the species comprises three biological stocks: the North West Shelf biological stock, the northern Australian biological stock (including the Timor Sea, the Arafura Sea and the Gulf of Carpentaria) and the east coast Queensland biological stock^{2,3}.

a Department of Primary Industry and Fisheries, Northern Territory

b Department of Agriculture, Fisheries and Forestry, Queensland

c Department of Fisheries, Western Australia

Stock status

Northern Australian biological stock

The cross-jurisdictional northern Australian biological stock has components in the Northern Territory and Queensland. Each jurisdiction assesses that part of the biological stock that occurs in its waters. Status presented here for the entire biological stock has been established using evidence from both jurisdictions.

For the Northern Territory component of the biological stock (where most of the commercial catch is taken), Saddletail Snapper was assessed in 2013 using a stochastic stock reduction analysis model⁴. Egg production was estimated to be around 80 per cent of that before the start of the fishery, indicating that this part of the biological stock is not recruitment overfished.

The Northern Territory manages the commercial harvest of Saddletail Snapper and Crimson Snapper together as 'red snappers', with a combined total allowable commercial catch of 3800 tonnes (t). Saddletail Snapper has averaged 78 per cent of the annual red snapper catch over the past 10 years; the 2013 commercial catch of this species was 1806 t. The 2013 assessment indicated that the current harvest rate of Saddletail Snapper is well below that required to achieve maximum sustainable yield. This level of fishing mortality is unlikely to cause this part of the biological stock to become recruitment overfished.

For the Queensland part of the biological stock, commercial catch in 2013 was 9 t, constituting only 0.5 per cent of the total 2013 Saddletail Snapper catch from this stock. This contrasts with catches of 150–250 t per year during the period 2006 to 2011, and is the lowest catch since 2001. This low catch of the Queensland component of the stock would not have altered the stock assessment results for the predominant Northern Territory component.

Because the Northern Territory part of the biological stock constituted the majority of the total catch in 2013, the status of this part of the biological stock is indicative of the entire biological stock.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

East coast Queensland biological stock

Saddletail Snapper is taken in both the commercial and recreational sectors, probably in similar numbers.

Recreational harvest estimates group Saddletail Snapper and Crimson Snapper together because these two species are often not separately identified in recreational catches. The recreational harvest of these species was estimated at approximately 65 000 fish in 2010. The relative proportions of the two species in this figure are not known.

Since 2004, commercial harvest has decreased from an average of 150 t per year to around 50 t per year. This decrease coincided with expansion of no-take marine reserves within the Great Barrier Reef Marine Park and the introduction of a quota management system for coral reef finfish species. Both factors are likely to have influenced commercial catch. Saddletail Snapper is managed as part of the 'other species' quota category, which comprises many other coral reef finfish species. There is a cap on the total catch for the group, but no individual cap on any one species within the group. Although recreational fishing effort is not capped, the current level of combined fishing pressure is unlikely to cause the stock to become recruitment overfished.

Current information on population composition is unavailable, and no stock assessment has been completed, so insufficient information is available to confidently classify the status of this biological stock.

On the basis of the evidence provided above, the biological stock is classified as an **undefined stock**.

North West Shelf biological stock

Saddletail Snapper is exploited primarily on the north-west coast of Western Australia as a component of the Pilbara Trap Managed Fishery, Pilbara Fish Trawl Interim Managed Fishery and Northern Demersal Scalefish Managed Fishery (in the Kimberley region of Western Australia)⁵. Saddletail Snapper is assessed on the basis of the status of several indicator species (for example, Red Emperor—*Lutjanus sebae*, and Goldband Snapper—*Pristipomoides multidens* in the Kimberley region) that represent the inshore demersal suite of species occurring at depths of 30–250 m. The major performance measures for these indicator species are estimates of spawning stock levels. The target level of spawning biomass is 40 per cent of the unfished level. The limit level is 30 per cent of the estimate of initial spawning biomass. Data analysis using an integrated age-structured model determined that the spawning biomass levels of the indicator species were greater than

40 per cent of the unfished level in the Pilbara Trap Managed Fishery, Pilbara Fish Trawl Interim Managed Fishery and Northern Demersal Scalefish Managed Fishery in 2007⁶. In addition, the catch of Saddletail Snapper in the Northern Demersal Scalefish Managed Fishery has been stable for the past 5 years (2009 to 2013), ranging from 87 to 126 t⁶. Similarly, the catch of Saddletail Snapper in the Pilbara demersal fisheries has been low and stable, ranging from 64 to 73 t over the past 3 years⁶. The biological stock is therefore not considered to be recruitment overfished.

The fishing mortality (F)–based assessments⁶ indicated that the fishing levels on the indicator species were either lower than the target level or between the target and threshold levels. These assessments use reference levels based on ratios of natural mortality (M) for each species, such that $F_{\text{target}} = 2/3M$, $F_{\text{threshold}} = M$ and $F_{\text{limit}} = 3/2M$. This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

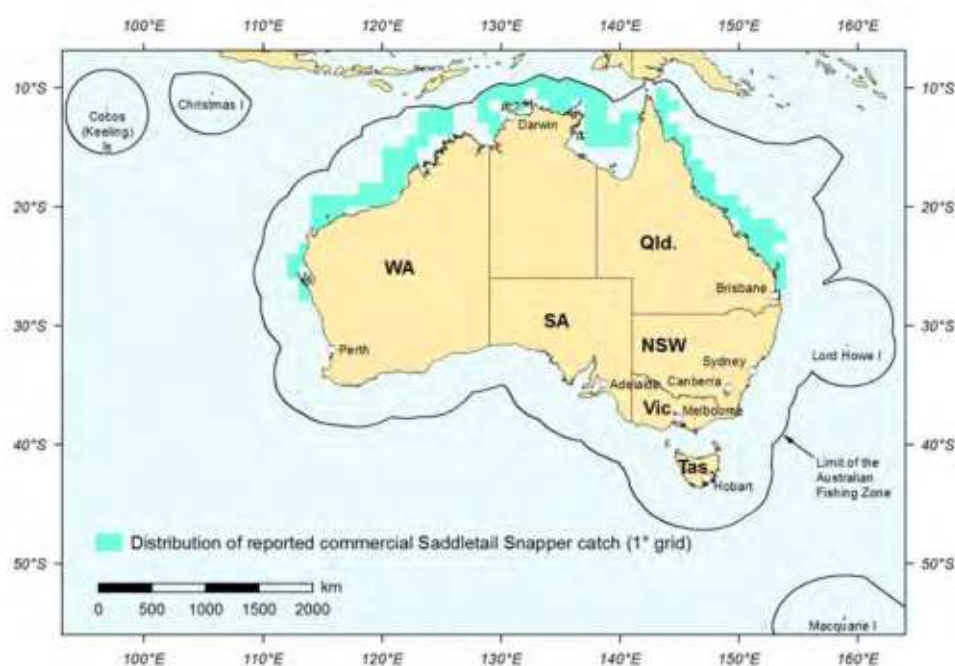
On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Saddletail Snapper biology^{7,8}

Longevity and maximum size	33 years; 680 mm SL
Maturity (50%)	9 years; males 270–280 mm SL, females 350–370 mm SL

SL = standard length

Figure 1: Distribution of reported commercial catch of Saddletail Snapper in Australian waters, 2013 (calendar year)



Note: Data for the Queensland Coral Reef Fin Fish Fishery and Deep Water Fin Fish Fishery are for the 2012–13 financial year.

Table 3: Main features and statistics for Saddletail Snapper fisheries in Australia, 2013 (calendar year)

Jurisdiction	Northern Territory	Queensland ^a	Western Australia
Fishing methods			
Commercial			
Hand line	✓ ^b	✓	✓
Rod and line	✓	✓	✓
Dropline	✓	✓	
Longline		✓	
Fish trap	✓		✓
Fish trawl	✓	✓	✓
Recreational (including charter)			
Hand line	✓	✓	✓
Rod and line	✓	✓	✓
Indigenous ^{c,d}			
Hand line		✓	
Rod and line		✓	
Management methods			
Commercial			
Limited entry		✓	✓
Spatial zoning	✓		✓
Total allowable catch	✓	✓	
Total allowable effort			✓
Size limits		✓ (not in GOCDFFTF)	
Vessel restrictions		✓	✓
Gear restrictions	✓	✓	✓
Effort limits			✓
Spatial closures		✓	✓
Temporal closures		✓	

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Jurisdiction	Northern Territory	Queensland ^a	Western Australia
Recreational			
Licensing			✓
Possession limits	✓	✓	✓
Size limits		✓	
Spatial closures		✓	✓
Temporal closures		✓	
Charter			
Limited entry			✓
Spatial zoning			✓
Passenger restrictions		✓	✓
Size limits		✓	
Bag limits			✓
Possession limits	✓	✓	
Spatial closures		✓	✓
Temporal closures		✓	
Indigenous ^{c,d}			
Laws of general application			✓
Active vessels			
	6 in DF 9 in TRF	107 in CRFFF 0 in DWFFF 1 in GOCDFFTF 0 in GOCLF	8 in NDSMF 3 in PFTIMF 2 in PTMF
Catch			
Commercial	1597 t in DF 209 t in TRF	47 t in CRFFF 0 t in DWFFF 9 t in GOCDFFTF 0 t in GOCLF	116 t in NDSMF 53 t in PFTIMF 15 t in PTMF
Recreational	55 t (2010) ^d	65 000 fish ^e	1422 fish (2011–12); ~3 t ^f
Charter	15 t (2012)	11 t	1737 fish; ~4 t

Jurisdiction	Northern Territory	Queensland ^a	Western Australia
Indigenous	Unknown	Unknown	Unknown
Markets			
Domestic	✓	✓	✓
Export	✓		

CRFFF = Coral Reef Fin Fish Fishery (Queensland); DF = Demersal Fishery (Northern Territory); DWFFF = Deep Water Fin Fish Fishery (Queensland); GOCDFTF = Gulf of Carpentaria Developmental Fin Fish Trawl Fishery (Queensland); GOCLF = Gulf of Carpentaria Line Fishery (Queensland); NDSMF = Northern Demersal Scalefish Managed Fishery (Western Australia); PFTIMF = Pilbara Fish Trawl Interim Managed Fishery (Western Australia); PTMF = Pilbara Trap Managed Fishery (Western Australia); TRF = Timor Reef Fishery (Northern Territory)

a Data for the CRFFF and DWFFF are for the 2012–13 financial year.

b In the Northern Territory, hand lines, droplines, and rod and line together constituted less than 4 per cent of the total commercial catch.

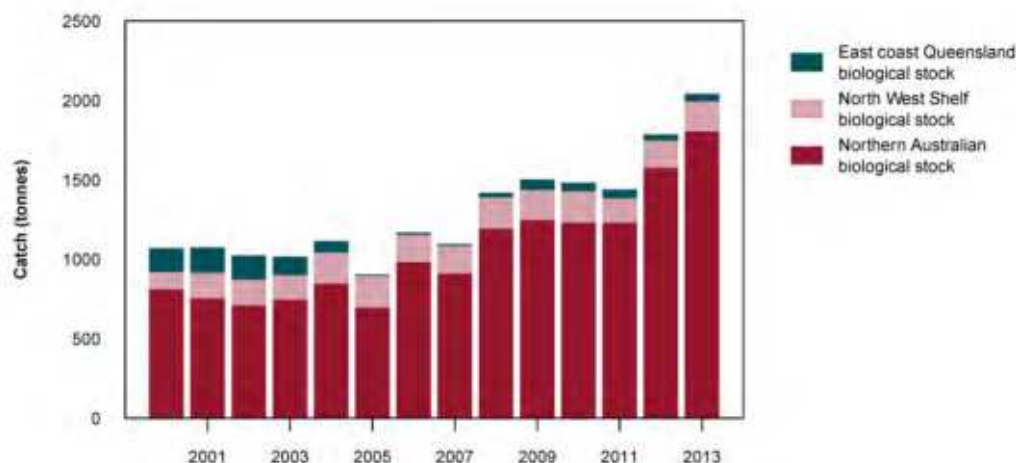
c Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

d Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

e Saddletail Snapper and Crimson Snapper catch were combined during the 2010 recreational fishing survey⁹.

f Recreational catch is from a boat-based survey, which is considered to be representative of the total recreational catch.

Figure 2: Commercial catch of Saddletail Snapper in Australian waters, 2000 to 2013 (calendar years)



Note: For Queensland, data for the Coral Reef Fin Fish Fishery and Deep Water Fin Fish Fishery are for financial years.

Effects of fishing on the marine environment

- The impacts on the benthic habitat of fishing activity for Saddletail Snapper are limited to those of the trawl fisheries, which are restricted to around 7 per cent of the North West Shelf of Western Australia⁵,

and parts of the Northern Territory and Queensland. Trawl nets in the Northern Territory have been designed to fish off the seabed, reducing interaction with benthic habitats¹⁰.

- There are few bycatch issues associated with trap- and line-based fishing. Bycatch of dolphins and turtles can occur in the fish trawls, but this has decreased significantly since turtle excluder devices were introduced in Western Australia in 2005 and the Northern Territory in 2006. Given the area of distribution and estimated population size of these protected species, the impact of the fish trawl fishery on their stocks is likely to be minimal. Gear and fishing modification continue to reduce this level of interaction^{5,11}.
- The Northern Territory fisheries that target Saddletail Snapper have received full Export Exemption accreditation under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). The Western Australian and Queensland east coast fisheries that target Saddletail Snapper have received Approved Wildlife Trade Operation Exemption accreditation under the Act (except for the Pilbara Trap Managed Fishery [Western Australia], which does not export fish). These assessments, subject to adherence to any accompanying conditions and recommendations, demonstrate that these fisheries are managed in a manner that does not lead to overfishing, and that fishing operations have a minimal impact on the structure, productivity, function and biological diversity of the ecosystem.

Environmental effects on Saddletail Snapper

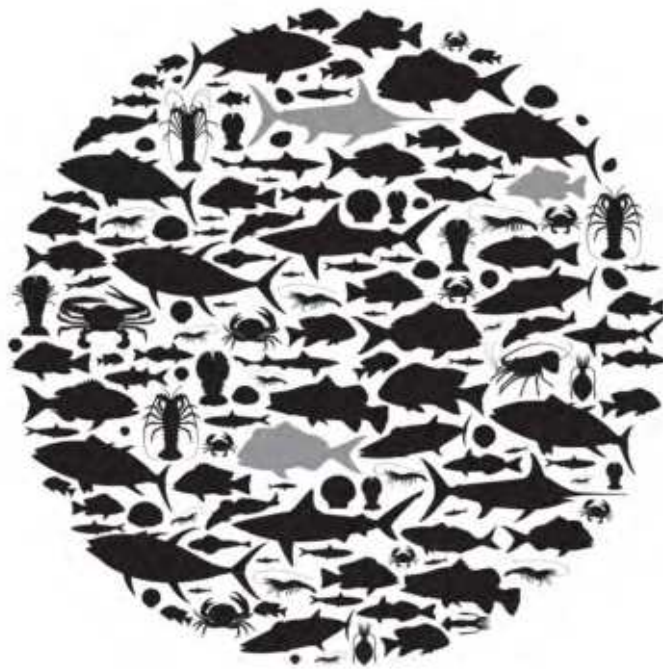
- Climate change and climate variability have the potential to impact fish stocks in a range of ways, including influencing their geographic distribution (for example, latitudinal shifts in distribution). However, it is unclear how climate change may affect risks to the sustainability of this species. Slow-growing and long-lived species such as Saddletail Snapper are less likely to be affected by short-duration environmental changes (of one or a few years), because adult stocks comprise fish that have been recruited over many years.
- Changes in ocean chemistry such as ocean acidification have the potential to affect the replenishment rates of fish populations by affecting larval survival¹², as well as individual growth rates and spawning output¹³.

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Finfish: *Tuna & Billfish*



61. Bigeye Tuna *Thunnus obesus*

Heather Patterson^a



Table 1: Stock status determination for Bigeye Tuna

Jurisdiction	Commonwealth	
Stock	Indian Ocean (WTBF, IOTC ^b)	Pacific Ocean (ETBF, WCPFC ^b)
Stock status		
	Sustainable	Overfished
Indicators	Spawning stock biomass, fishing mortality	Spawning stock biomass, fishing mortality

ETBF = Eastern Tuna and Billfish Fishery (Commonwealth); IOTC = Indian Ocean Tuna Commission; WCPFC = Western and Central Pacific Fisheries Commission; WTBF = Western Tuna and Billfish Fishery (Commonwealth)

^b The Indian Ocean Tuna Commission (www.iotc.org) and the Western and Central Pacific Fisheries Commission (www.wcpfc.int) are intergovernmental organisations established to manage a number of highly migratory fish species.

Stock structure

Bigeye Tuna in the Indian Ocean and Pacific Ocean are considered to be two distinct biological stocks and are managed by separate regional fisheries management organisations. In the Indian Ocean, tagging and genetic studies have indicated a single biological stock^{1,2}. Genetic studies have also indicated a single biological stock across the Pacific Ocean³. The Indian Ocean biological stock is under the jurisdiction of the Indian Ocean Tuna Commission. The Pacific Ocean stock is under the jurisdiction of the Western and Central Pacific Fisheries Commission.

Stock status

The data used to determine stock status differ, depending on the assessment, because of delays in reporting catch data to the Indian Ocean Tuna Commission, and the Western and Central Pacific Fisheries Commission. Data for the Indian Ocean assessment were from 1952 to 2011, or 1952 to 2012³ (several assessments were undertaken). Data for the Pacific Ocean assessment were from 1952 to 2012⁴.

Indian Ocean biological stock

The Indian Ocean biological stock is fished by Australian fishers endorsed to fish in the Western Tuna and Billfish Fishery (Commonwealth), and numerous international jurisdictions. The assessments undertaken by the Indian Ocean Tuna Commission take into account information from all jurisdictions.

In the Indian Ocean, the 2013 stock assessment¹ estimated (over the plausible models investigated) that the spawning biomass of the Bigeye Tuna biological stock in 2012 was 40 per cent of the initial unfished biomass and above the level that would produce maximum sustainable yield (MSY) in the long term. The biological stock is therefore not considered to be recruitment overfished⁵. This assessment also estimated that the current (2012) fishing mortality was below the level associated with MSY (42 per cent of mortality at MSY). This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished⁵.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Pacific Ocean biological stock

The Pacific Ocean biological stock is fished by Australian fishers endorsed to fish in the Eastern Tuna and Billfish Fishery (Commonwealth), and numerous international jurisdictions. The assessments undertaken for the Western and Central Pacific Fisheries Commission take into account information from all jurisdictions.

In the Pacific Ocean, the stock assessment⁴ estimated (over the plausible models investigated) that the 2012 spawning biomass of the Bigeye Tuna biological stock was 16 per cent of the levels predicted in the absence of fishing and below the level that would support MSY. The biological stock is therefore considered to be recruitment overfished⁶. This assessment also estimated that current fishing mortality was well above the level associated with MSY (127–196 per cent of mortality at MSY). This level of fishing mortality is expected to prevent the stock recovering from a recruitment overfished state⁶.

On the basis of the evidence provided above, the biological stock is classified as an **overfished stock**⁶.

Table 2: Bigeye Tuna biology^{7,8}

Longevity and maximum size	~16 years; 2000 mm FL
Maturity (50%)	3 years; ~1000 mm FL

FL = fork length

Figure 1: Distribution of reported commercial catch of Bigeye Tuna in Australian Fisheries, 2013 (calendar year)

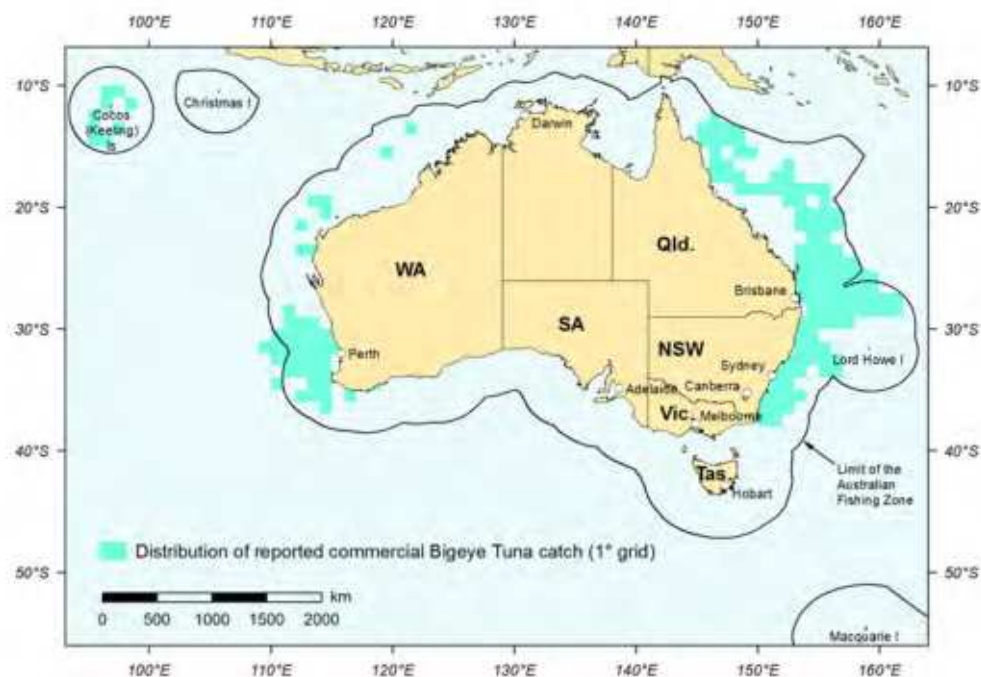


Table 3: Main features and statistics for Bigeye Tuna fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth (Indian Ocean)	Commonwealth (Pacific Ocean)
Fishing methods		
Commercial		
Pelagic longline	✓	✓
Minor lines (e.g. hand line, troll, rod and reel)	✓	✓
Purse seine	✓	
Recreational ^{a,b}		
Rod and line	✓	✓
Spearfishing		✓
Indigenous ^{b,c}		
	Unknown	Unknown
Management methods		
Commercial		
Limited entry	✓	✓
Gear restrictions	✓	✓
Area restrictions	✓	
Catch limits	✓	✓
Individual transferable quotas	✓	✓
Recreational ^{a,b}		
Bag limits	✓	✓
Indigenous ^{b,c}		
	None	None
Active vessels		
	5 in WTBF Unknown in IOTC	40 in ETBF Unknown in WCPFC

Jurisdiction	Commonwealth (Indian Ocean)	Commonwealth (Pacific Ocean)
Catch ^d		
Commercial	91 t in WTBF 115 794 t in IOTC (2012)	553 t in ETBF 161 561 t in WCPFC (2012)
Recreational ^{a,b}	Unknown	Unknown
Indigenous ^{b,c}	Unknown	Unknown
Markets		
Domestic	✓	✓
Export	✓	✓

ETBF = Eastern Tuna and Billfish Fishery (Commonwealth); IOTC = Indian Ocean Tuna Commission; WCPFC = Western and Central Pacific Fisheries Commission; WTBF = Western Tuna and Billfish Fishery (Commonwealth)

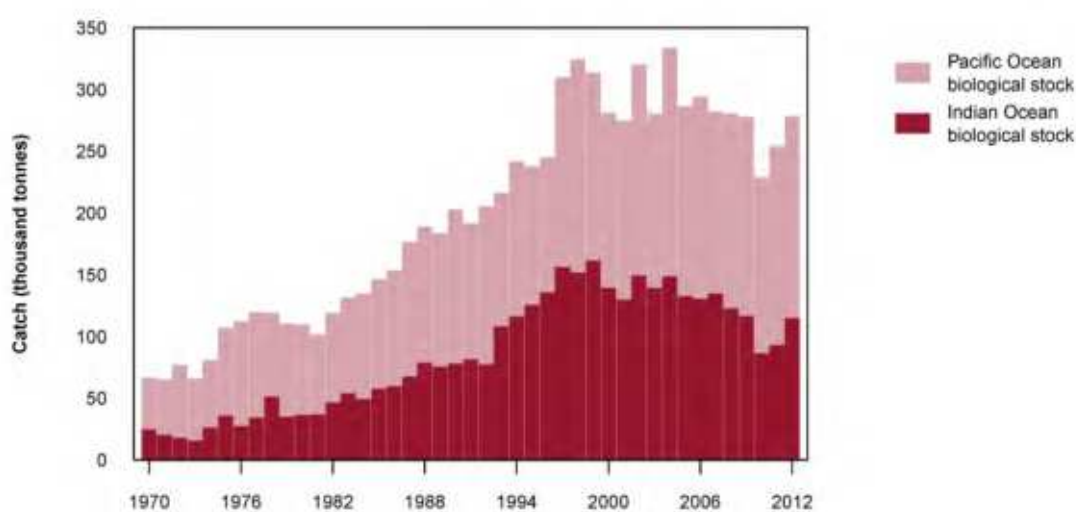
a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b Recreational and Indigenous fishing sectors in the Indian Ocean are Western Australia, South Australia and Victoria; recreational sectors in the Pacific Ocean are Queensland, New South Wales and Tasmania. A tick indicates that a measure exists in one of these jurisdictions.

c The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

d Catches reported for the IOTC and WCPFC are for 2012 (the most recent year available).

Figure 2: Commercial catch of Bigeye Tuna in the Western and Central Pacific Fisheries Commission, and Indian Ocean Tuna Commission areas, 1970 to 2012 (calendar years)



Effects of fishing on the marine environment

- Following completion of environmental risk assessments (levels 1–3) in the Western Tuna and Billfish Fishery (Commonwealth), no species were identified as high risk⁹. In the Eastern Tuna and Billfish Fishery (Commonwealth), nine species were identified as high risk or precautionary high risk. This is the priority list of species for attention under the Eastern Tuna and Billfish Fishery ecological risk management strategy; it includes two species of sunfish, four species of shark, two species of cetacean and one species of marine turtle^{10,11}.
- No target species, ecological communities or habitats were assessed to be at high risk from the effects of fishing in the Eastern Tuna and Billfish Fishery (Commonwealth) or the Western Tuna and Billfish Fishery (Commonwealth).
- Australia implements regulations to minimise the environmental impact of fisheries for tuna and tuna-like species on pelagic ecosystems, specifically on seabirds, sea turtles and sharks. Both the Indian Ocean Tuna Commission and the Western and Central Pacific Fisheries Commission have passed conservation and management measures that are broadly consistent with each other and with Australia's domestic requirements.
- Australia has prohibited shark finning in longline fisheries managed by the Commonwealth and has also prohibited the use of wire leaders¹² in these fisheries, to reduce fishery impacts on sharks.

Environmental effects on Bigeye Tuna

- The distribution and abundance of tuna can be affected by environmental factors^{13,14}. For example, seasonal changes in the abundance of Bigeye and Yellowfin Tuna on the east coast of Australia are linked to the expansion and contraction of the East Australian Current¹⁵.

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62. Southern Bluefin Tuna *Thunnus maccoyii*

Heather Patterson^a and Ilona Stobutzki^a



Table 1: Stock status determination for Southern Bluefin Tuna

Jurisdiction	Commonwealth
Stock	Global (CCSBT, SBTF)
Stock status	Overfished
Indicators	Spawning stock biomass, projections of rebuilding

CCSBT = Commission for the Conservation of Southern Bluefin Tuna; SBTF = Southern Bluefin Tuna Fishery (Commonwealth)

Stock structure

Southern Bluefin Tuna constitutes a single, highly migratory biological stock that spawns in the north-east Indian Ocean and migrates throughout the temperate southern oceans, supporting a number of international fisheries¹.

Stock status

Global biological stock

The biological stock of Southern Bluefin Tuna is fished by Australian fishers endorsed to fish in the Southern Bluefin Tuna Fishery (Commonwealth), and numerous other international jurisdictions. As well, the species is caught by recreational fishers in the waters off southern Australia, and there are other sources of unaccounted mortalities, including catches by fleets that are not members of the Commission for the Conservation of Southern Bluefin Tuna (CCSBT)^{2,3}. The reported global catch peaked in the late 1950s before declining substantially; it has been relatively stable since the mid-2000s.

In 2011, the CCSBT adopted a management procedure (analogous to a harvest strategy) to guide the recovery of the biological stock to 20 per cent of unfished biomass by 2035 with 70 per cent probability. Performance of the management procedure is measured using the biomass of fish that are 10 years and older. Since 2012, the agreed management procedure has been used to set the global total allowable catch, which was set at 10 949 tonnes (t) in 2013. In line with this, Australia's total allowable catch for the 2012-13 fishing season was 4 663 t,

^a Australian Bureau of Agricultural and Resource Economics and Sciences
^b www.ccsbt.org

of which 4 529 t was landed. The current level of fishing mortality from all sources is uncertain, but there are indications that it may be substantial³. The most recent assessment (2014) undertaken by the CCSBT takes into account reported catch from all international jurisdictions³. It also examines the sensitivity of the results to unaccounted mortalities, based on scenarios given the uncertainty.

The most recent assessment estimated that the biomass of fish 10 years and older in the Southern Bluefin Tuna biological stock is at 6–9 per cent of unfished levels³. The most recent estimate of spawning stock biomass is 8–12 per cent of unfished levels³. Projections of the performance of the management procedure under scenarios of different levels of unaccounted mortalities showed that these mortalities reduce the probability of rebuilding to below 70 per cent, the specified interim management target³. Although there has been a slight improvement in the estimated biomass of fish 10 years and older since the last assessment in 2011⁴, the biological stock is recruitment overfished at a global scale, and well below the interim target level agreed by the CCSBT^{2,3}. The level of fishing pressure may prevent the stock from recovering from its recruitment overfished state in line with the management procedure, and a significant trend of improvements in biomass is yet to be detected.

On the basis of the evidence provided above, the biological stock is classified as an **overfished stock**.

Table 2: Southern Bluefin Tuna biology^{5–7}

<i>Longevity and maximum size</i>	40+ years; ~1900 mm FL
<i>Maturity (50%)</i>	~11–12 years; 1580–1630 mm FL

FL = fork length

Figure 1: Distribution of reported commercial catch of Southern Bluefin Tuna in Australian Fisheries, 2013 (calendar year)

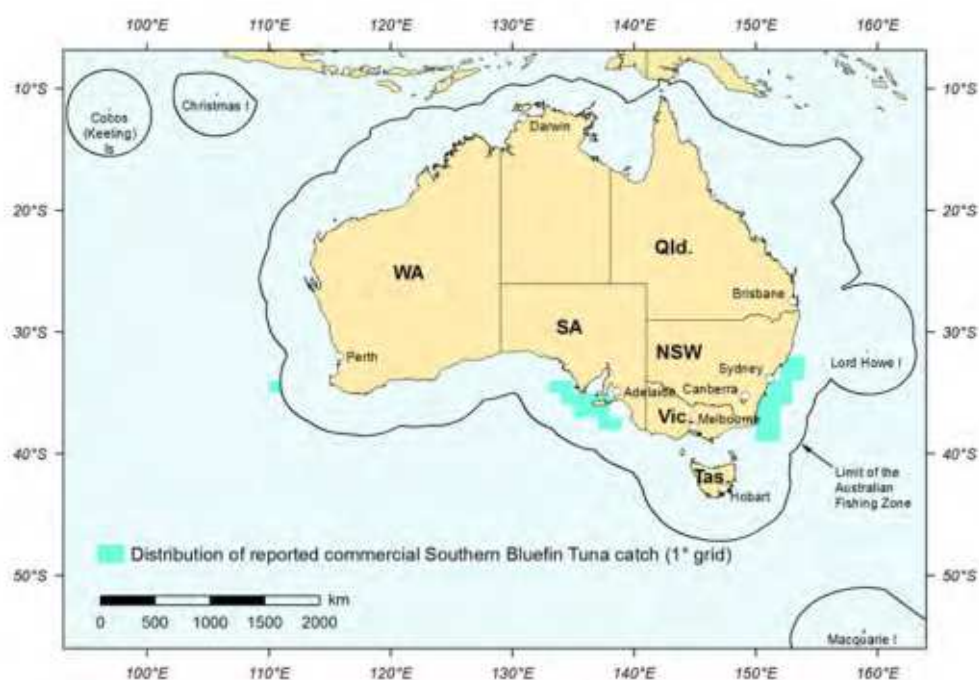


Table 3: Main features and statistics for Southern Bluefin Tuna fisheries in Australia, 2012–13 (fishing season: 1 December – 30 November)

Jurisdiction	Commonwealth
Fishing methods	
Commercial	
Purse seine	✓
Pelagic longline	✓
Minor line (troll and poling)	✓
Recreational ^{a,b}	
Rod and line	✓
Spearfishing	✓
Indigenous ^c	
	Unknown
Management methods	
Commercial	
Catch limits	✓
Individual transferable quotas	✓
Area restrictions	✓
Recreational ^{a,b}	
Bag limits	✓
Boat limits	✓
Indigenous ^c	
	None
Active vessels	
	25 in SBTF (5 purse seine; 20 longline) 391 in CCSBT

Jurisdiction	Commonwealth
Catch	
Commercial	4539 t in SBTF (4198 t in purse seine; 341 t in longline) 11 726 t in CCSBT (2013 calendar year)
Recreational ^{a,b}	Unknown
Indigenous ^c	Unknown
Markets	
Domestic	
Export	✓

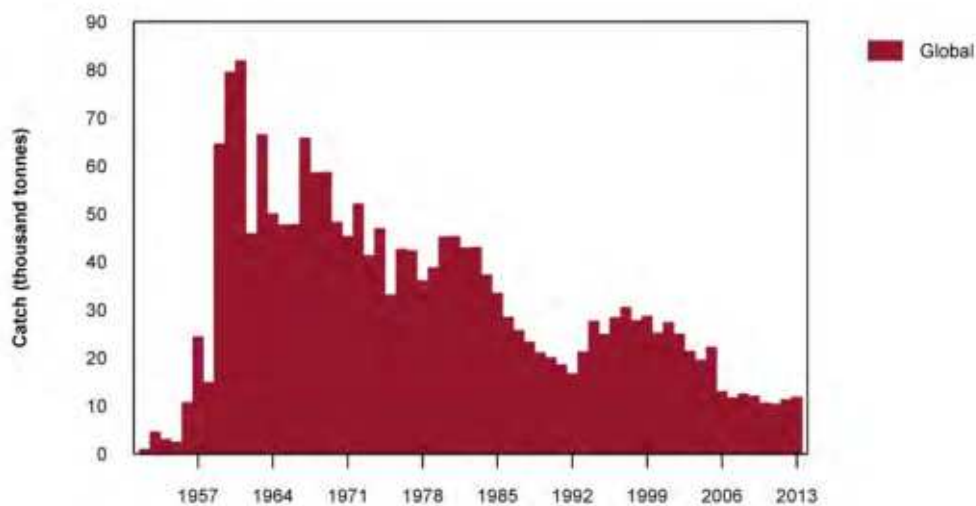
CCSBT = Commission for the Conservation of Southern Bluefin Tuna; SBTF = Southern Bluefin Tuna Fishery (Commonwealth)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b Recreational and Indigenous fishing sectors reported here are New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia. A tick indicates that a measure exists in at least one of these jurisdictions.

c The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

Figure 2: Global commercial catch of Southern Bluefin Tuna, 1952 to 2013 (calendar years)



Effects of fishing on the marine environment

- Southern Bluefin Tuna was listed as conservation dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) in 2010.
- An ecological risk assessment on nontarget species in the purse-seine fishery, which caught approximately 93 per cent of the Southern Bluefin Tuna in the 2012–13 fishing season, found that the risk to the sustainability of nontarget species was low⁸.
- Australia implements regulations to minimise the environmental impact of fisheries for tuna and tuna-like species on pelagic ecosystems, specifically on seabirds, sea turtles and sharks.
- Australia has prohibited the practice of shark finning and the use of wire leaders in longline fisheries managed by the Commonwealth, to reduce fishery impacts on sharks.

Environmental effects on Southern Bluefin Tuna

- Interannual variation in abundance of Southern Bluefin Tuna in the Great Australian Bight is well documented. This variation has not been directly linked to environmental variables⁹, although it is possible that environmental factors play a role.

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63. Yellowfin Tuna *Thunnus albacares*

Heather Patterson^a



Table 1: Stock status determination for Yellowfin Tuna

Jurisdiction	Commonwealth	
Stock	Indian Ocean (WTBF, IOTC ^b)	Western and central Pacific Ocean (ETBF, WCPFC ^b)
Stock status		
	Sustainable	Sustainable
Indicators	Spawning stock biomass, fishing mortality	Spawning stock biomass, fishing mortality

ETBF = Eastern Tuna and Billfish Fishery (Commonwealth); IOTC = Indian Ocean Tuna Commission; WCPFC = Western and Central Pacific Fisheries Commission; WTBF = Western Tuna and Billfish Fishery (Commonwealth)

^b The Indian Ocean Tuna Commission (www.iotc.org) and the Western and Central Pacific Fisheries Commission (www.wcpfc.int) are intergovernmental organisations established to manage a number of highly migratory fish species.

Stock structure

Yellowfin Tuna in the Indian Ocean, and western and central Pacific Ocean are considered to be two distinct biological stocks, which are managed under separate regional fisheries management organisations. In the Indian Ocean, although there is some evidence for stock structure that requires further investigation¹, tagging studies have indicated large movements of Yellowfin Tuna, supporting the assumption of a single biological stock². A single biological stock is considered to exist in the western and central Pacific Ocean³. The Indian Ocean biological stock is under the jurisdiction of the Indian Ocean Tuna Commission. The western and central Pacific Ocean stock is under the jurisdiction of the Western and Central Pacific Fisheries Commission.

Stock status

Data used to determine stock status differ depending on the assessment, because of delays in reporting catch data to the Indian Ocean Tuna Commission, and the Western and Central Pacific Fisheries Commission. Data for the Indian Ocean assessment were from 1950 to 2011, or 1972 to 2011⁴ (multiple assessments were undertaken). Data for the Pacific Ocean assessment were from 1952 to 2012.

Indian Ocean biological stock

The Indian Ocean biological stock is fished by Australian fishers endorsed to fish in the Western Tuna and Billfish Fishery (Commonwealth), and numerous other international jurisdictions. The assessments undertaken by the Indian Ocean Tuna Commission take into account information from all jurisdictions.

In the Indian Ocean, the 2012 stock assessments⁴ estimated (over the range of plausible models investigated) that the spawning biomass of the Yellowfin Tuna biological stock in 2010 was 38 per cent of the initial unfished biomass and above the biomass level that would produce maximum sustainable yield (MSY) in the long term. The biological stock is not considered to be recruitment overfished⁵. The assessments also estimated that current (2010 or 2011) fishing mortality was below the level associated with MSY (61–69 per cent of mortality at MSY). This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished⁵.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Western and central Pacific Ocean biological stock

The western and central Pacific Ocean biological stock is fished by Australian fishers endorsed to fish in the Eastern Tuna and Billfish Fishery (Commonwealth), and numerous other international jurisdictions. The assessments undertaken for the Western and Central Pacific Fisheries Commission take into account information from all jurisdictions.

In the western and central Pacific Ocean, the stock assessment³ estimated that the current (2008 to 2011) spawning biomass of the Yellowfin Tuna biological stock was 42 per cent of the initial unfished biomass and above the level that would produce MSY. The biological stock is not considered to be recruitment overfished⁶. This assessment also estimated that current fishing mortality was below the level associated with MSY (72 per cent of mortality at MSY). This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished⁶.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Yellowfin Tuna biology⁷

Longevity and maximum size	9 years; ~1800 mm FL
Maturity (50%)	~2 years; 1000 mm TL

FL = fork length

Figure 1: Distribution of reported commercial catch of Yellowfin Tuna in Australian Fisheries, 2013 (calendar year)

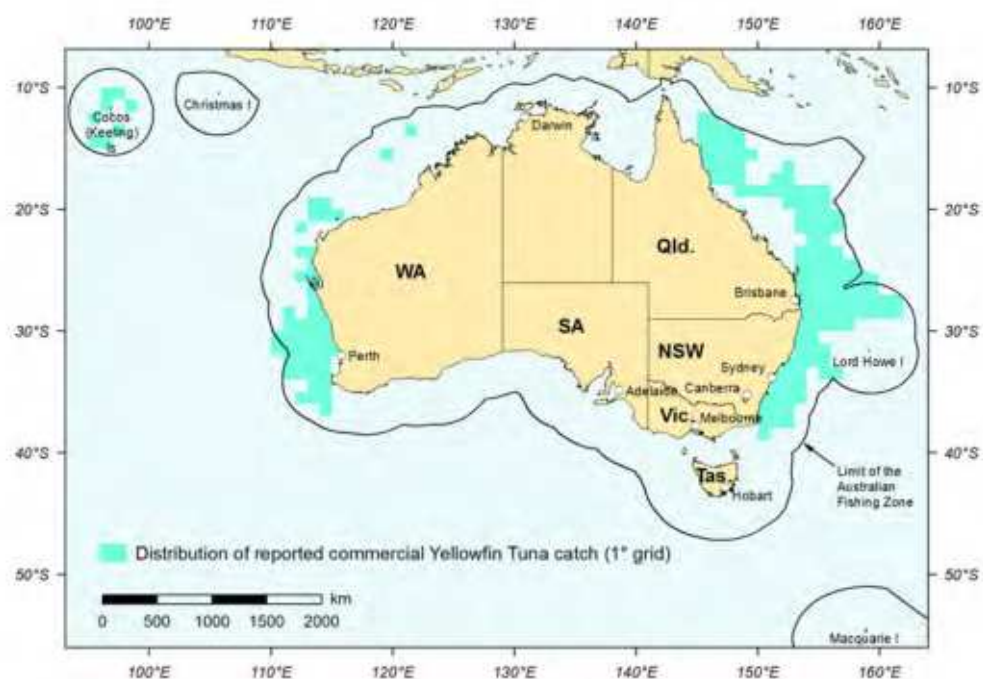


Table 3: Main features and statistics for Yellowfin Tuna fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth (Indian Ocean)	Commonwealth (western and central Pacific Ocean)
Fishing methods		
Commercial		
Pelagic longline	✓	✓
Minor lines (for example, hand line, troll, rod and reel)	✓	✓
Purse seine	✓	
Recreational ^{a,b}		
Rod and reel	✓	✓
Spearfishing		✓
Indigenous ^{b,c}		
	Unknown	Unknown

Jurisdiction	Commonwealth (Indian Ocean)	Commonwealth (western and central Pacific Ocean)
Management methods		
Commercial		
Limited entry	✓	✓
Gear restrictions	✓	✓
Area restrictions	✓	
Catch limits	✓	✓
Individual transferable quotas	✓	✓
Recreational ^{a,b}		
Bag limits	✓	✓
Boat limits	✓	
Indigenous ^{b,c}		
	None	None
Active vessels		
	4 in WTBF Unknown in IOTC	40 in ETBF Unknown in WCPFC
Catch ^d		
Commercial	40 t in WTBF 365 826 t in IOTC	1341 t in ETBF 646 165 t in WCPFC
Recreational	Unknown	Unknown
Indigenous	Unknown	Unknown
Markets		
Domestic	✓	✓
Export	✓	✓

ETBF = Eastern Tuna and Billfish Fishery (Commonwealth); IOTC = Indian Ocean Tuna Commission; WCPFC = Western and Central Pacific Fisheries Commission; WTBF = Western Tuna and Billfish Fishery (Commonwealth)

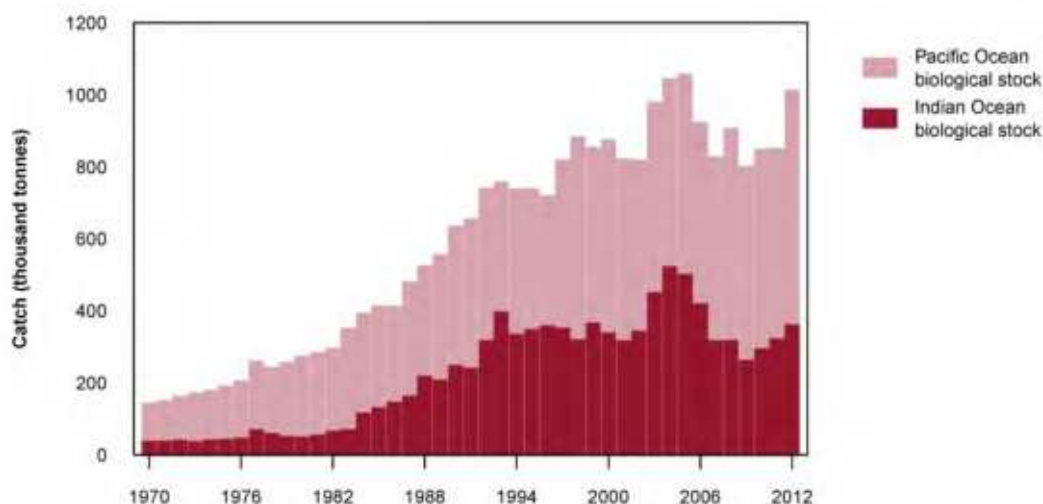
a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

b Recreational and Indigenous fishing sectors in the Indian Ocean are Western Australia, South Australia and Victoria; recreational sectors in the Pacific Ocean are Queensland, New South Wales and Tasmania. A tick indicates that a measure exists in one of these jurisdictions.

c The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

d Catches reported for the IOTC and WCPFC are for 2012, the most recent year available.

Figure 2: Commercial catch of Yellowfin Tuna in the Western and Central Pacific Fisheries Commission and Indian Ocean Tuna Commission areas, 1970 to 2012 (calendar years)



Effects of fishing on the marine environment

- Following completion of ecological risk assessments (levels 1–3) in the Western Tuna and Billfish Fishery (Commonwealth), no species were identified as high risk⁸. In the Eastern Tuna and Billfish Fishery (Commonwealth), a total of nine species were identified as being at high risk or precautionary high risk. This is the priority list of species for attention under the Eastern Tuna and Billfish Fishery ecological risk management strategy; it includes two species of sunfish, four species of shark, two species of cetacean and one species of marine turtle^{9,10}.
- No target species, ecological communities or habitats were assessed to be at high risk from the effects of fishing in the Eastern Tuna and Billfish Fishery (Commonwealth) or Western Tuna and Billfish Fishery (Commonwealth).
- Australia implements regulations to minimise the environmental impact of fisheries for tuna and tuna-like species on pelagic ecosystems, specifically on seabirds, sea turtles and sharks. Both the Indian Ocean Tuna Commission and the Western and Central Pacific Fisheries Commission have passed conservation and management measures that are broadly consistent with each other and with Australia's domestic requirements.
- To reduce fishery impacts on sharks, Australia has prohibited the practice of shark finning and the use of wire leaders¹¹ in longline fisheries managed by the Commonwealth.

Environmental effects on Yellowfin Tuna

- The distribution and abundance of tuna can be affected by environmental factors^{12,13}. For example, seasonal changes in the abundance of Bigeye Tuna and Yellowfin Tuna on the east coast of Australia are linked to the expansion and contraction of the East Australian Current¹⁴.

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64. Swordfish *Xiphias gladius*

Heather Patterson^a



Table 1: Stock status determination for Swordfish

Jurisdiction	Commonwealth	
Stock	Indian Ocean (WTBF, IOTC ^b)	South-west Pacific Ocean (ETBF, WCPFC ^b)
Stock status		
	Sustainable	Undefined
Indicators	Spawning stock biomass, fishing mortality	Spawning stock biomass, fishing mortality

ETBF = Eastern Tuna and Billfish Fishery (Commonwealth); IOTC = Indian Ocean Tuna Commission; WCPFC = Western and Central Pacific Fisheries Commission; WTBF = Western Tuna and Billfish Fishery (Commonwealth)

^b The Indian Ocean Tuna Commission (www.iotc.org) and the Western and Central Pacific Fisheries Commission (www.wcpfc.int) are intergovernmental organisations established to manage a number of highly migratory fish species.

Stock structure

Swordfish in the Indian and Pacific Oceans are considered to be two distinct biological stocks and are managed under separate regional fisheries management organisations. In the Indian Ocean, genetic research has indicated the presence of a single biological stock¹. In the Pacific Ocean, genetic studies have suggested the presence of several semi-independent biological stocks², although the degree of genetic variation among these stocks is generally low³. In addition, electronic tagging has indicated that Swordfish in the Coral/Tasman seas in Australia may be distinct from the larger south-west Pacific population⁴. Two stocks are assessed in the Pacific Ocean: the south-west Pacific stock and the north Pacific stock. Only the south-west Pacific stock is relevant to Australia, and status is reported at the management unit level (that is, for the south-west Pacific Ocean). The Indian Ocean biological stock is under the jurisdiction of the Indian Ocean Tuna Commission. The Pacific Ocean management unit is under the jurisdiction of the Western and Central Pacific Fisheries Commission.

Stock status

The data used to determine status differ, depending on the assessment, because of delays in reporting catch data to the Indian Ocean Tuna Commission, and the Western and Central Pacific Fisheries Commission. Data for the Indian Ocean assessments were from 1952 to 2009⁴; data for the Pacific Ocean assessment were from 1952 to 2011².

Indian Ocean biological stock

The Indian Ocean biological stock is fished by Australian fishers endorsed to fish in the Western Tuna and Billfish Fishery (Commonwealth), and numerous other international jurisdictions. The assessments undertaken by the Indian Ocean Tuna Commission take into account information from all jurisdictions.

In the Indian Ocean, the most recent stock assessments⁵ estimated (over the plausible models investigated) that spawning biomass of the Swordfish stock in 2009 was 30–53 per cent of initial unfished biomass, and above the level that would produce maximum sustainable yield (MSY) (107–159 per cent of MSY). The biological stock is therefore not considered to be recruitment overfished⁶. This assessment also estimated that fishing mortality in 2009 was below the level associated with MSY (50–63 per cent of mortality at MSY). This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished⁶.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

South-west Pacific Ocean management unit

The south-west Pacific Ocean management unit is fished by Australian fishers endorsed to fish in the Eastern Tuna and Billfish Fishery (Commonwealth), and numerous other international jurisdictions. The assessments undertaken for the Western and Central Pacific Fisheries Commission take into account information from all jurisdictions.

In the south-west Pacific Ocean, the most recent assessment² used two different growth and maturity schedules (Hawaiian and Australian). The key models selected across both schedules estimated that current (2007 to 2010) spawning stock biomass of the Swordfish management unit ranged from 27 to 55 per cent of initial unfished biomass and was above the biomass that would produce MSY (115–353 per cent of MSY)⁷. The management unit is therefore not considered to be recruitment overfished⁸.

However, the assessment found that the two growth schedules produced different estimates of fishing mortality. The Hawaiian schedule estimated that fishing mortality was below the level associated with MSY (40–70 per cent MSY), while the Australian schedule estimated that fishing mortality was above the level associated with MSY (106–177 per cent MSY). The Western and Central Pacific Fisheries Commission Scientific Committee was unable to determine which growth schedule was more reliable. The assessment of the current level of fishing pressure is therefore considered to be too uncertain to use for status determination⁸.

On the basis of the evidence provided above, the management unit is classified as an **undefined stock**.

Table 2: Swordfish biology^{9,10}

Longevity and maximum size	30+ years; 4550 mm FL
Maturity (50%)	Females 6–7 years; ~1700 mm FL Males: 1–3 years; ~1200 mm FL

FL = fork length (measured from the lower jaw for Swordfish)

Figure 1: Distribution of reported commercial catch of Swordfish in Australian fisheries, 2013 (calendar year)

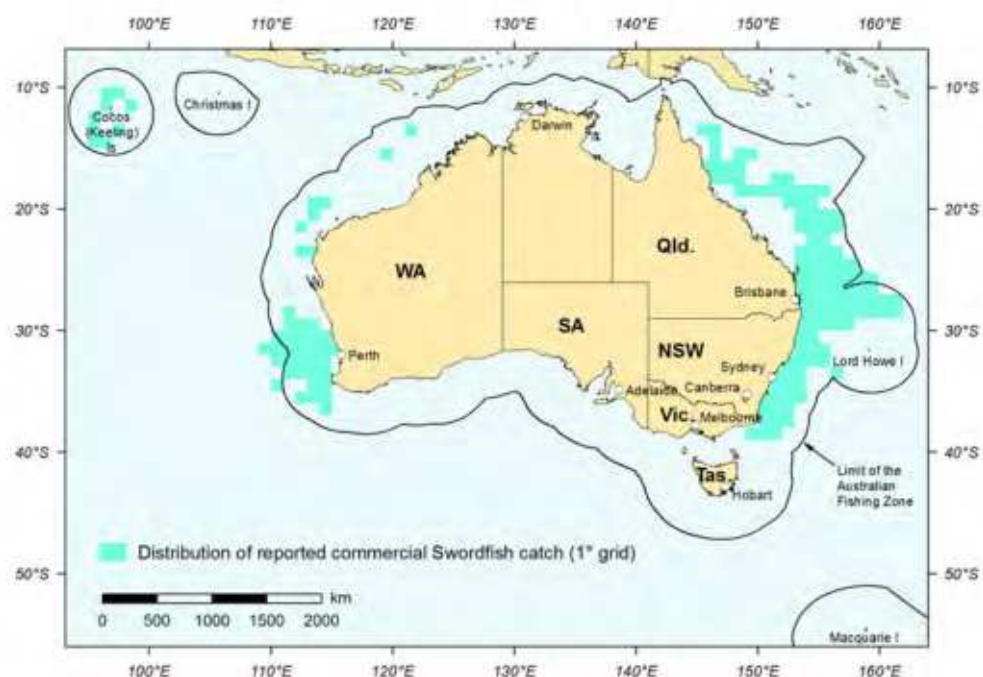


Table 3: Main features and statistics for Swordfish fisheries in Australia, 2013 (calendar year)

Jurisdiction	Commonwealth (Indian Ocean)	Commonwealth (south-west Pacific Ocean)
Fishing methods		
Commercial		
Pelagic longlines	✓	✓
Minor lines (e.g. hand line, troll, rod and reel)	✓	✓
Purse seine	✓	
Recreational ^{a,b}		
Rod and reel	✓	✓
Indigenous ^{b,c}		
	Unknown	Unknown

Jurisdiction	Commonwealth (Indian Ocean)	Commonwealth (south-west Pacific Ocean)
Management methods		
Commercial		
Limited entry	✓	✓
Gear restrictions	✓	✓
Area restrictions	✓	
Catch limits	✓	✓
Individual transferable quotas	✓	✓
Recreational ^{a,b}		
Bag limits	✓	✓
Indigenous ^{b,c}		
	None	None
Active vessels		
	4 in WTBF Unknown in IOTC	41 in ETBF Unknown in WCPFC
Catch ^{d,e}		
Commercial	204 t in WTBF 26 187 t in IOTC (2012)	1064 t in ETBF 22 202 t in WCPFC (2012)
Recreational ^{a,b}	Unknown	Unknown
Indigenous ^{b,c}	Unknown	Unknown
Markets		
Domestic	✓	✓
Export	✓	✓

ETBF = Eastern Tuna and Billfish Fishery (Commonwealth); IOTC = Indian Ocean Tuna Commission; WCPFC = Western and Central Pacific Fisheries Commission; WTBF = Western Tuna and Billfish Fishery (Commonwealth)

a The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

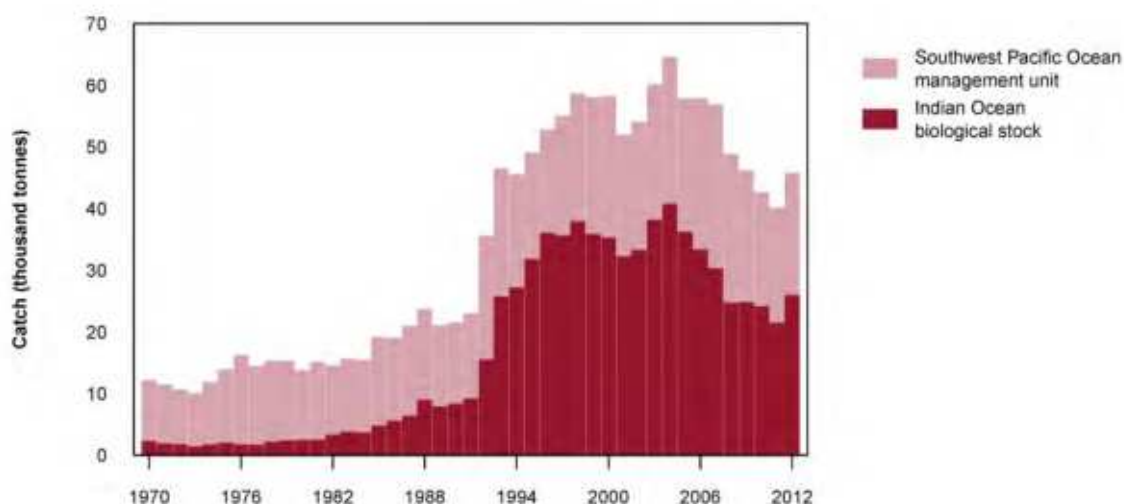
b Recreational and Indigenous fishing sectors in the Indian Ocean are South Australia, Victoria and Western Australia. Recreational sectors in the Pacific Ocean are New South Wales, Queensland and Tasmania. A tick indicates that a measure exists in at least one of these jurisdictions.

c The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

d Catches reported for the IOTC and WCPFC are for 2012, the most recent year available.

e WCPFC catches are for the entire south Pacific Ocean (south of the equator).

Figure 2: Commercial catch of Swordfish in the Western and Central Pacific Fisheries Commission and Indian Ocean Tuna Commission areas, 1970 to 2012 (calendar years)



Effects of fishing on the marine environment

- Following completion of ecological risk assessments (levels 1–3) in the Western Tuna and Billfish Fishery (Commonwealth), no species were identified as high risk¹¹. In the Eastern Tuna and Billfish Fishery (Commonwealth), a combined total of nine species were identified as being at high risk or precautionary high risk. This is the priority list of species for attention under the Eastern Tuna and Billfish Fishery ecological risk management strategy; it includes two species of sunfish, four species of shark, two species of cetacean and one species of marine turtle^{12,13}.
- No target species, ecological communities or habitats were assessed to be at high risk from the effects of fishing in the Eastern Tuna and Billfish Fishery (Commonwealth) or the Western Tuna and Billfish Fishery (Commonwealth).
- Australia implements regulations to minimise the environmental impact of fisheries for tuna and tuna-like species on pelagic ecosystems, specifically on seabirds, sea turtles and sharks. Both the Indian Ocean Tuna Commission and the Western and Central Pacific Fisheries Commission have passed conservation and management measures that are broadly consistent with each other and with Australia's domestic requirements.
- To reduce fishery impacts on sharks, Australia has prohibited the practice of shark finning and the use of wire leaders¹⁴ in longline fisheries managed by the Commonwealth.

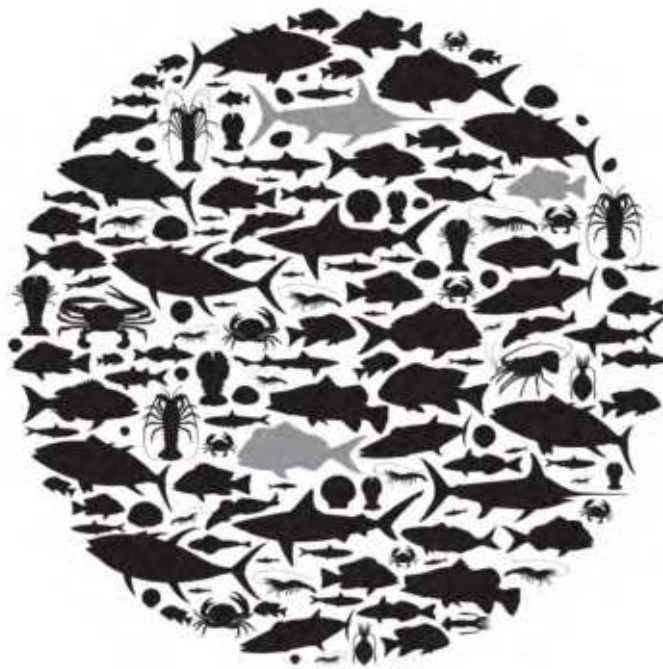
Environmental effects on Swordfish

- The distribution and abundance of tuna, and possibly billfish, can be affected by environmental factors^{15,16}. For example, seasonal changes in the abundance of Bigeye Tuna and Yellowfin Tuna on the east coast of Australia are linked to the expansion and contraction of the East Australian Current¹⁷.

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Finfish: *Whiting*



65. Eastern School Whiting *Sillago flindersi*

James Andrews^a, Jeremy Lyle^b, Amy Smoothey^c and Matthew Flood^d



Table 1: Stock status determination for Eastern School Whiting

Jurisdiction	Commonwealth, New South Wales, Tasmania, Victoria
Stock	South-eastern Australian (CTS, ITF, OTF, SF)
Stock status	
	Sustainable
Indicators	Spawning biomass, fishing mortality

CTS = Commonwealth Trawl Sector; ITF = Inshore Trawl Fishery (Victoria); OTF = Ocean Trawl Fishery (New South Wales); SF = Scalefish Fishery (Tasmania)

Stock structure

Endemic to south-eastern Australia, Eastern School Whiting occurs from southern Queensland to western Victoria, and is considered to be a single biological stock for assessment purposes¹. Status is reported at the biological stock level.

Stock status

South-eastern Australian biological stock

The most recent assessment of Eastern School Whiting, which includes commercial catch estimates for New South Wales, Victoria, Tasmania and the Commonwealth, estimated that the spawning biomass would be 50 per cent of the unfished level at the beginning of 2010². The assessment was updated in 2010 and 2011, with recent catch, discard, age and length data^{3,4}. The estimated levels of depletion in the updated assessments were similar to those in the previous full assessment. In 2010, spawning biomass would have been well above the level at which the biological stock would be considered recruitment overfished (20 per cent of the unfished biomass). Although this assessment is quite dated, which is of concern for a short-lived species such as school whiting, recent catches have remained below the long-term recommended biological catch (RBC), and the stock is unlikely to have become recruitment overfished. In addition, standardised catch-rate data from 2012 do not raise concerns about stock status⁵. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished⁶.

a Department of Environment and Primary Industries, Victoria

b Institute for Marine and Antarctic Studies, University of Tasmania

c Department of Primary Industries, New South Wales

d Australian Bureau of Agricultural and Resource Economics and Sciences

The RBC for Eastern School Whiting was 1660 tonnes (t) for the 2012–13 fishing season⁵. Total Australian commercial catch of Eastern School Whiting in 2012–13 was 1235.5 t (Commonwealth—359 t [fishing season]; New South Wales—859.6 t [financial year]; Tasmania—12.8 t [financial year]; Victoria—4.1 t [financial year]), significantly below the 2012–13 RBC. The above evidence indicates that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished⁶.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Eastern School Whiting biology^{2,7–9}

Longevity and maximum size	7 years; ~320 mm SL
Maturity (50%)	2 years; 140–180 mm FL

FL = fork length; SL = standard length

Figure 1: Distribution of reported commercial catch of Eastern School Whiting in Australian waters, 2013 (calendar year)

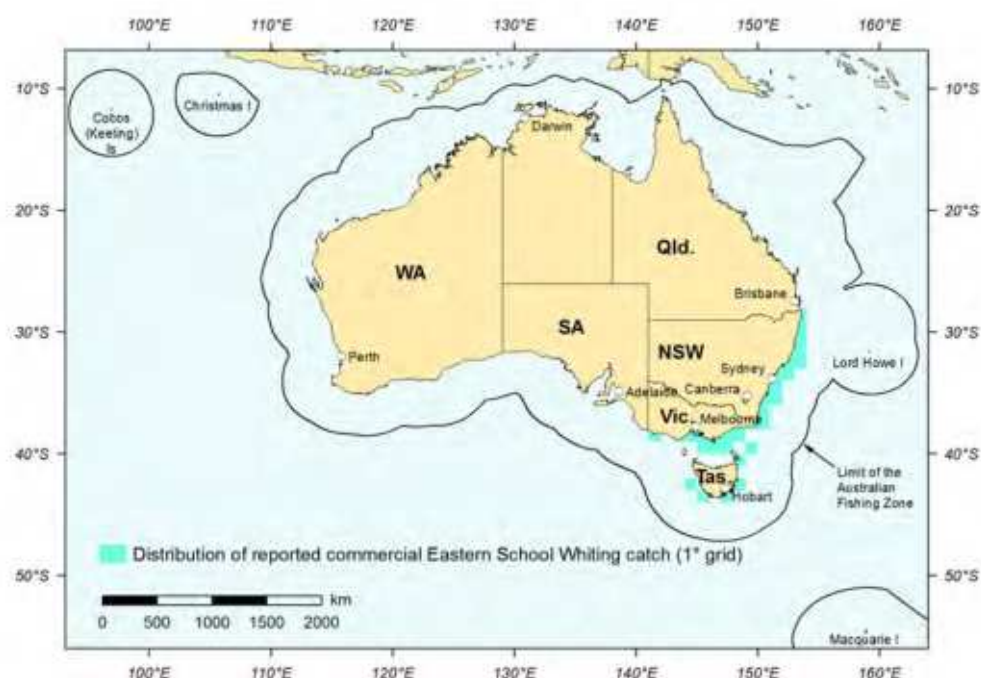


Table 3: Main features and statistics for Eastern School Whiting fisheries in Australia, 2012–13 (fishing season/financial year)

Jurisdiction	Commonwealth ^a	New South Wales ^b	Tasmania ^b	Victoria ^b
Fishing methods				
Commercial				
Danish-seine	✓	✓	✓	
Otter trawl	✓	✓		✓
Gillnet			✓	

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Jurisdiction	Commonwealth ^a	New South Wales ^b	Tasmania ^b	Victoria ^b
Recreational ^c				
Rod and line		✓	✓	✓
Gillnet			✓	
Indigenous ^{d,e}				
Rod and line		✓	Unknown	
Management methods				
Commercial				
Limited entry	✓	✓	✓	✓
Total allowable catch	✓			
Spatial closures	✓	✓	✓	✓
Gear restrictions	✓	✓	✓	✓
Recreational ^c				
Bag limits		✓	✓	✓
Spatial closures		✓	✓	✓
Indigenous ^{d,e,f,g}				
Bag limits		✓	✓	
Spatial closures		✓		
Section 37(1)(c1) Aboriginal cultural fishing authority		✓		
Active vessels				
	28 in CTS	100 in OTF	2 in SF	5 in ITF
Catch				
Commercial	359 t in CTS	859.6 t in OTF	12.8 t in SF	4.1 t in ITF
Recreational ^c		Unknown	3.4 t (2007–08)	Unknown
Indigenous ^d		Unknown	Unknown	None

Jurisdiction	Commonwealth ^a	New South Wales ^b	Tasmania ^b	Victoria ^b
Markets				
Domestic	✓	✓	✓	✓
Export	✓	✓	Unknown	Unknown

CTS = Commonwealth Trawl Sector; ITF = Inshore Trawl Fishery (Victoria); OTF = Ocean Trawl Fishery (New South Wales); SF = Scalefish Fishery (Tasmania)

a Commonwealth data are for the 2012–13 fishing season (1 May 2012 – 21 April 2013).

b State data are for the 2012–13 financial year (1 July 2012 – 30 June 2013).

c The Australian Government does not manage recreational fishing in Commonwealth waters. Recreational fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters, under its management regulations.

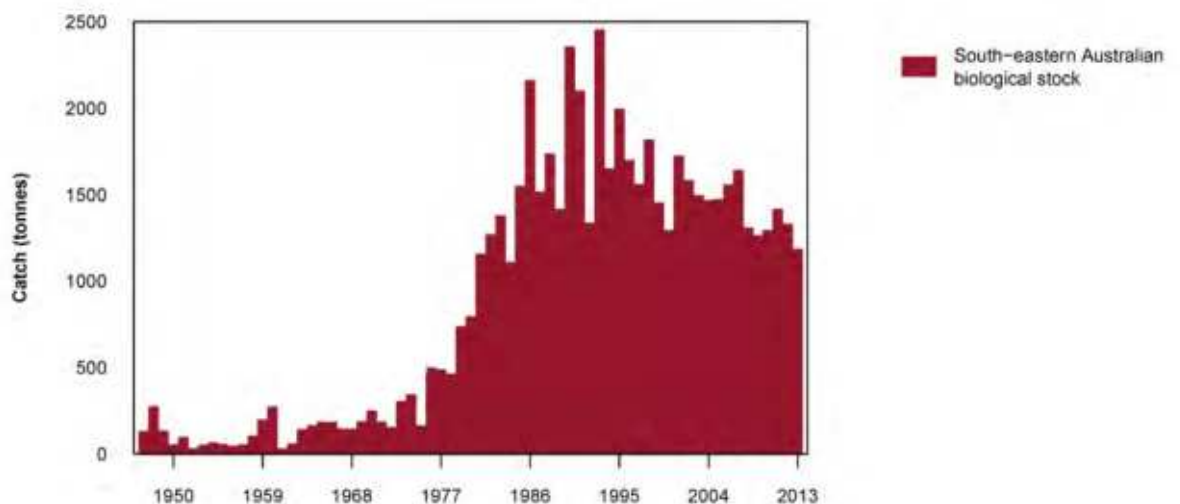
d The Australian Government does not manage noncommercial Indigenous fishing in Commonwealth waters, with the exception of the Torres Strait. In general, noncommercial Indigenous fishing in Commonwealth waters is managed by the state or territory immediately adjacent to those waters.

e In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (for example, different catch and size limits or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access Eastern School Whiting.

f. The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

g. The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Eastern School Whiting in Australian waters, 1947 to 2013 (calendar years)



Effects of fishing on the marine environment

- There can be a substantial level of bycatch in the fish trawl sector. In 2006, mandatory requirements for otter trawls to use 90 mm square-mesh codend panels were introduced to reduce the catch of small species and juvenile fish¹⁰.
- Interactions also occur with animals protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), including marine mammals (dolphins, seals and sea lions), seabirds, some shark species and seahorses and pipefish (syngnathids). These interactions are reported quarterly by the Australian Fisheries Management Authority¹¹ and on-board observer programs are used to validate the reporting in commercial logbooks.
- In 2007, the South East Trawl Fishing Industry Association 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 generally¹². Operators have developed other mitigation protocols that have further reduced seal mortalities, including using breakaway ties that keep the net closed until it is below depths that seals regularly inhabit, adopting techniques to close the trawl opening during recovery to minimise opportunities for seals to enter the net, switching off gantry lights that are not required during night trawling to avoid attracting bait species and seals, and dumping offal only when the boat is not engaged in deploying or hauling gear¹².
- In 2011, AFMA mandated individual vessel seabird management plans¹³. The seabird action plans are used in the Commonwealth Trawl Sector to mitigate the impacts of trawling on seabirds. Seabird mitigation measures include warp deflectors ('pinkys'), bird bafflers (a system of ropes and PVC piping that protects the warp cable) and seal excluder devices.
- The effects of trawl fishing on the marine environment are assessed through an environmental risk assessment and risk management framework and mitigated through spatial closures, and the implementation of bycatch and discard workplans in the Commonwealth Trawl Sector and Great Australian Bight Trawl Sector fisheries.
- Danish-seine and otter trawl interact with a broad range of habitat types. However, an ecological risk assessment identified no high-risk habitats on the inner shelf (less than 100 m depth), where Eastern School Whiting is targeted¹⁴.
- Danish-seining has the potential to affect seahorses and pipefish (syngnathids) because Danish-seiners operate in relatively shallow waters and use nets with a small mesh size. An ecological risk assessment (ERA) indicated that the Spiny Pipehorse was at low risk because the fishery overlaps with only a small portion of the range of this species¹⁴.

Environmental effects on Eastern School Whiting

- Because Eastern School Whiting is a relatively short-lived species that reaches maturity after only 2 years, it is likely that year-to-year variations in environmental conditions will have a greater effect on this fishery than on a fishery for long-lived species. This is because stocks with a greater number of year-classes are generally more resilient to variable recruitment than stocks with few year-classes.

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66. King George Whiting *Sillaginodes punctatus*

Paul Hamer^a, Anthony Fowler^b and Joshua Brown^c



Table 1: Stock status determination for King George Whiting

Jurisdiction	South Australia			Western Australia	Victoria
Stock	Gulf St Vincent (MSF)	Spencer Gulf (MSF, NZRLF)	West coast—Eyre Peninsula (MSF, NZRLF)	Western Australia (OA, SCEMF, WCDSIMF, WCEIMF)	Victoria (CIF, GLF, OF, PPBF)
Stock status	↓	↓			
	Transitional–depleting	Transitional–depleting	Sustainable	Sustainable	Sustainable
Indicators	Catch, CPUE, age structures, biomass	Catch, CPUE, age structures, biomass	Catch, CPUE, age structures, biomass	Catch, CPUE, recruitment trend, fishing mortality, per-recruit analysis	Catch, CPUE, age and length structures, pre-recruit surveys

CIF = Corner Inlet Fishery (Victoria); CPUE = catch per unit effort; GLF = Gippsland Lakes Fishery (Victoria); MSF = Marine Scalefish Fishery (South Australia); NZRLF = Northern Zone Rock Lobster Fishery (South Australia); OA = Open Access (Western Australia); OF = Offshore Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia); WCEIMF = West Coast Estuarine (Interim) Managed Fishery (Western Australia)

Stock structure

The South Australian population of King George Whiting comprises three biological stocks^{1–3}: Gulf St Vincent, Spencer Gulf and the west coast of the Eyre Peninsula. This delineation has been determined based on a detailed understanding of the species' life history, including movement patterns of adult fish, location of spawning grounds and nursery areas^{1,2}, and larval advection pathways and distances (based on early life history and hydrodynamic modelling)³. The biological stock structure in Victoria and Western Australia is unclear, but they are assumed to be separate single stocks for management purposes, and separate from the South Australian stocks. The biological stock structure of King George Whiting in southern Australia is currently under investigation using otolith chemistry and genetic techniques. The status of Victorian and Western Australian stocks is therefore reported at the jurisdictional level, whereas the status of the South Australian stocks is reported at the biological stock level.

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Stock status

In South Australia King George Whiting is the premium species in the multispecies Marine Scalefish Fishery, attracting the highest price per unit weight for commercial fishers. Assessment of the status of the South Australian stocks uses a weight-of-evidence approach that considers commercial catch-and-effort data, recreational fishery data, biological information on population size and age structures, and output from a computer fishery model that integrates these main input datasets. The primary indicators are hand-line effort and catch per unit effort (CPUE), and exploitation rate and biomass from the assessment model. The most recent assessment was completed in July 2014².

Gulf St Vincent (South Australia) biological stock

The Gulf St Vincent biological stock is found throughout Gulf St Vincent and Investigator Strait, and around Kangaroo Island. Hand-line effort for this stock has declined since 2009, and hand-line CPUE has declined since 2007². Both of these declining trends for this species are consistent with a declining level of biomass, since, given the value of the species, it is expected that effort would remain high or consistent if biomass were available. The model-estimated biomass for this stock has been relatively flat for recent years. However, because the estimates of effort and CPUE used in the model did not take into account a likely increase in the 'effective' effort, and because of uncertainty in the time series of recreational catch and effort, the decline in fishable biomass is likely to have been greater than suggested by the model output. Although it is likely that the biomass of King George Whiting has declined between 2009 and 2013, the stock is not yet considered to be in a recruitment overfished state. However, the above evidence indicates that the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **transitional—depleting stock**.

Spencer Gulf (South Australia) biological stock

The Spencer Gulf (South Australia) biological stock extends throughout the entire northern and southern regions of Spencer Gulf. Both catch and effort for this region have shown recent declining trends, culminating in the lowest recorded values for both in 2013². Furthermore, CPUE has declined for this region since 2007. As discussed above for the Gulf St Vincent stock, such trends in fishery statistics for this high-value species are consistent with a declining biomass. This is reflected in the model outputs, which indicate that there was a marginal decline in biomass between 2008 and 2013. Because the estimates of effort and CPUE used in the model did not take into account likely increases in 'effective' effort, and because of uncertainty in the time series of recreational catch and effort, the decline in fishable biomass may have been greater than suggested by the model output. Although declining slowly, the stock is not yet considered to be in a recruitment overfished state. However, the above evidence indicates that the current level of fishing pressure is likely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **transitional—depleting stock**.

West coast—Eyre Peninsula (South Australia) biological stock

This biological stock extends throughout all the bays and offshore areas of the west coast of the Eyre Peninsula. Hand-line fishing effort for this stock was relatively stable in recent years. Catch increased for a number of years, and hand-line CPUE increased until 2013, reaching the highest level ever recorded². Output from the stock assessment model showed trends of increasing recruitment rates and levels of biomass between 2004 and 2013. Furthermore, between 1984 and 2013, the exploitation rate fell considerably, relating to long-term declines in commercial and recreational fishing effort. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished and that the current level of fishing mortality is unlikely to cause the biomass to become recruitment overfished.

On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Western Australia

The life cycle of King George Whiting in Western Australia involves both inshore and offshore habitats; juvenile fish occupy near-shore waters in estuaries and protected coastal embayments before migrating to deeper waters as they mature (at around 40 cm), where they remain. Because of this offshore, size-related movement, it is difficult to obtain a representative sample of the age structure for the overall population to reliably estimate fishing mortality using traditional methods. A novel modelling approach was thus developed

to produce estimates of fishing mortality that account for the offshore movement of this species⁴. These estimates were subsequently applied in a per-recruit analysis.

The status of the King George Whiting stock in Western Australia was recently assessed in 2013 using a weight-of-evidence approach that included estimates of fishing mortality and per-recruit analyses determined in the modelling approach, as well as commercial and recreational catch and catch rates, and fishery-independent juvenile recruitment indices⁵. Using age data collected during 2010 to 2012, fishing mortality for the King George Whiting breeding stock (offshore component) was estimated to be low (below the target fishing mortality [F_{target}]). At current estimated levels of fishing mortality for King George Whiting, the spawning potential ratio (based on the spawning biomass per recruit) was estimated to be at a sustainable level (42 per cent). Catch and catch-rate trends for the main commercial fisheries in Western Australia (South Coast Estuarine Managed Fishery and West Coast Estuarine [Interim] Managed Fishery) are confounded by environmental influences in these estuarine systems (for example, sandbar closing and opening). They are, however, within the historical range and are considered acceptable, as the data indicate no evidence of a declining stock biomass. Trends in recreational catch and catch rate are difficult to interpret because of the infrequent nature of the surveys, different designs of the surveys, and changes to size and bag limits. Annual trends in recruitment appear to correlate with trends in the recreational catch, with a time lag of 2–3 years. Annual recruitment by juvenile (age zero years) King George Whiting has been highly variable since recruitment surveys began in 1999. Recruitment levels were relatively high in 1999, 2000 and 2008 but were at more typical low levels in most other years. The high recruitment levels were observed during strong Leeuwin Current (La Niña) years. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

The King George Whiting stock is exposed to relatively high fishing pressure on the inshore component of the stock, which is entirely comprised of immature fish. However, the breeding stock is offered some protection by its unidirectional offshore migration to deeper waters, where individuals tend to become more dispersed and less easily targeted. The current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence provided above, King George Whiting in Western Australia is classified as a **sustainable stock**.

Victoria

Stock status assessment of King George Whiting in Victoria uses a weight-of-evidence approach that considers CPUE from both the commercial and recreational sectors, fishery-independent annual surveys of pre-recruit (post-larval) catch rates in Port Phillip Bay, and age–length composition of the catch. Importantly, the indicator data are derived from bay and estuary fisheries that only target juvenile King George Whiting.

When describing the status of the Victorian King George Whiting stock, it is important to consider how life history characteristics influence the above indicators. The dynamics of King George Whiting populations and fisheries in Victorian bays and estuaries are strongly influenced by climatic factors that influence the numbers of larvae transported into the bay and estuary nursery grounds during spring each year^{6–8}. Because King George Whiting leave these nursery areas permanently by 4–5 years of age (before adulthood), the fisheries in bays and estuaries are based on only a few age classes at any point in time (typically 2–4-year-olds)^{7,9}. This means that the fisheries are highly variable in response to the variable supply of these larval stages. Over the past 60 years, King George Whiting fisheries production in Victoria's bays and estuaries has shown peaks and troughs at approximately 10-year intervals^{7,9}.

The most recent formal stock assessment of Victorian King George Whiting was in 2010¹⁰. Review of more recent commercial fisheries data (Port Phillip Bay Fishery and Corner Inlet Fishery) indicates that the King George Whiting fishery productivity and biomass (that is, catches and CPUE) have declined since the previous peak in 2011. This decline is within historical variability and is consistent with the low numbers of post-larvae observed by fishery-independent pre-recruit surveys from 2009 to 2012 in Port Phillip Bay. However, the pre-recruit survey in spring 2013 showed a major increase in the abundance of post-larvae recruiting in Port Phillip Bay. Therefore, while fishery production and biomass in Port Phillip Bay will continue to be lower than average, and will likely decline further in 2014–15, they are expected to increase significantly in 2015–16. The situation for the Corner Inlet Fishery is less certain, as pre-recruit surveys are not conducted for this location. Effort for all gear types in Victoria has decreased since 1999, as a result of the reduction in the number of licensed fishers in Victorian waters, and is at historically low levels. Further, consistent with the lower catches

of King George Whiting in the Port Phillip Bay Fishery and Corner Inlet Fishery in recent years, effort with the main gear type, haul seines, has decreased.

The decline of catches and CPUE in recent years is consistent with environmental influences reducing larval supply to bays and estuaries in the previous 3–5 years. The recent poor post-larval recruitment of King George Whiting into the bay and inlet nursery areas, combined with fishing mortality and the natural movement of older King George Whiting to coastal waters, has led to the notable recent decline in catches and catch rates in the key fishery areas. However, the King George Whiting stock is exposed to relatively low fishing pressure in the offshore waters where the adults reside. The available information, along with consideration of the species' life history, indicates that, although biomass has declined in the major bay and inlet fisheries, the biomass of the stock is unlikely to be recruitment overfished. The current level of fishing pressure is also unlikely to cause the stock to become recruitment overfished.

On the basis of the evidence above, King George Whiting in Victoria is classified as a **sustainable stock**.

Table 2: King George Whiting biology^(1,9–12)

<i>Longevity and maximum size</i>	South Australia: 22 years; 590 mm TL Western Australia: 14 years; 620 mm TL Victoria: ≥6–11 years; 600 mm TL
<i>Maturity (50%)</i>	South Australia: 3–4 years; 300–350 mm TL Western Australia: 3–4 years, 410 mm TL Victoria: unknown

TL = total length

Figure 1: Distribution of reported commercial catch of King George Whiting in Australian waters, 2013 (calendar year)

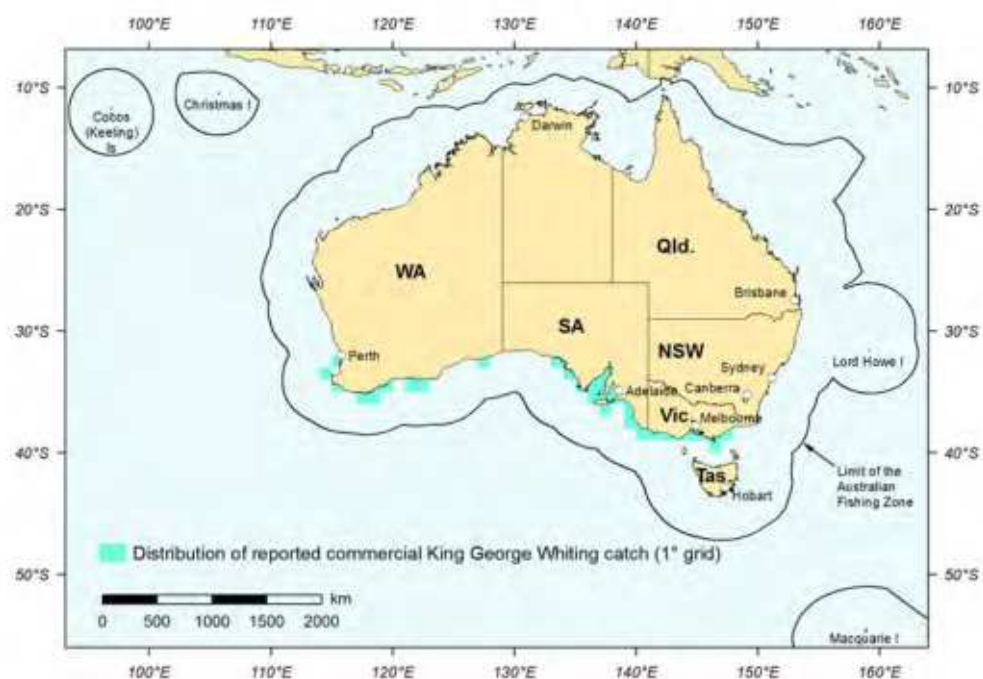


Table 3: Main features and statistics for King George Whiting fisheries in Australia, 2013 (calendar year)

Jurisdiction	South Australia	Western Australia	Victoria
Fishing methods			
Commercial			
Hand line	✓	✓	✓
Ring net	✓		✓
Gillnet	✓	✓	✓
Anchored longline	✓		
Haul seine		✓	✓
Beach seine		✓	✓
Recreational			
Rod and line	✓	✓	✓
Hand line	✓	✓	✓
Spearfishing	✓	✓	✓

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
KING GEORGE WHITING

Jurisdiction	South Australia	Western Australia	Victoria
Indigenous ^{a,b}			
Rod and line	✓	✓	✓
Hand line	✓	✓	✓
Spearfishing	✓	✓	✓
Management methods			
Commercial			
Limited entry	✓	✓	✓
Size limits	✓	✓	✓
Spatial restrictions and closures (nets)	✓	✓	✓
Temporal closures		✓	
Vessel restrictions		✓	
Gear restrictions	✓	✓	✓
Recreational			
Bag and boat limits	✓	✓	✓
Size limits	✓	✓	✓
Licensing (fishing from boat in Western Australia; recreational fishing in all waters in Victoria)		✓	✓
Indigenous ^{a,b}			
Bag and boat limits	✓	✓	✓
Size limits	✓	✓	✓
Active vessels			
	244 in MSF 17 in NZRLF	20 in OA 21 in SCEMF 1 in WCDSIMF 4 in WCEIMF	18 in CIF 7 in GLF 11 in OF 32 in PPBF

STATUS OF KEY AUSTRALIAN FISH STOCKS REPORTS 2014
KING GEORGE WHITING

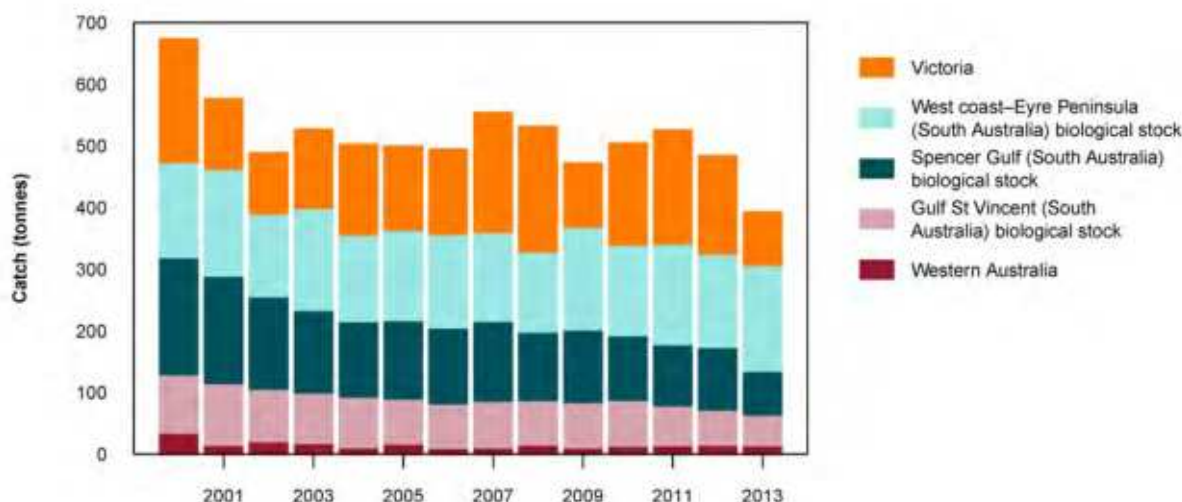
Jurisdiction	South Australia	Western Australia	Victoria
Catch			
Commercial	284 t in MSF 8.3 t in NZRLF	3 t in OA 9 t in SCEMF <0.1 t in WCDSIMF 2 t in WCEIMF	37 t in CIF 0.1 t in GLF 2.2 t in OF 47 t in PPBF
Recreational	324 t (2007–08) ¹²	26 t (2011–12) ¹³ (boat based only)	155 t (2006–07) ^{8,14}
Indigenous	Unknown	Unknown	Unknown
Markets			
Domestic	✓	✓	✓
Export			

CIF = Corner Inlet Fishery (Victoria); GLF = Gippsland Lakes Fishery (Victoria); MSF = Marine Scalefish Fishery (South Australia); NZRLF = Northern Zone Rock Lobster Fishery (South Australia); OA = Open Access (Western Australia); OF = Offshore Fishery (Victoria); PPBF = Port Phillip Bay Fishery (Victoria); SCEMF = South Coast Estuarine Managed Fishery (Western Australia); WCDSIMF = West Coast Demersal Scalefish (Interim) Managed Fishery (Western Australia); WCEIMF = West Coast Estuarine (Interim) Managed Fishery (Western Australia)

a In Victoria, regulations for managing recreational fishing are also applied to fishing activities by Indigenous people. Recognised Traditional Owners (groups that hold native title or have agreements under the *Traditional Owner Settlement Act 2010* (Vic)) are exempt (subject to conditions) from the requirement to hold a recreational fishing licence, and can apply for permits under the *Fisheries Act 1995* (Vic) that authorise customary fishing (e.g. different catch and size limits, or equipment). The Indigenous category in Table 3 refers to customary fishing undertaken by recognised Traditional Owners. In 2012–13, there were no applications for customary fishing permits to access King George Whiting in Victoria.

b Subject to the defence that applies under section 211 of the *Native Title Act 1993* (Cth), and the exemption from a requirement to hold a recreational fishing licence, the non-commercial take by indigenous fishers is covered by the same arrangements as that for recreational fishing.

Figure 2: Commercial catch of King George Whiting in Australian waters, 2000 to 2013 (calendar years)



Effects of fishing on the marine environment

- Some bycatch is expected from net or line fishing methods used to target King George Whiting. There has been one major study on the effects of haul-seine fishing on seagrass (fine leaf, eel grass, *Zostera*) habitat¹⁵. In that study, there was limited evidence of significant damage to seagrass beds by haul-net fishing, although the study had some limitations and recommended longer-term replicated studies involving industry, and studies on other seagrass species (that is, broad leaf, *Posidonia*)¹⁵. However, as a result of the targeted nature of the fishing and the methods used, the effects of fishing for King George Whiting on the marine environment are considered to be minor.

Environmental effects on King George whiting

- Historically, catch and catch rates in Victoria have followed an approximate 10-year cyclic pattern. Fluctuations in these biomass indicators are likely to result from environmental conditions affecting spawning success or, more likely, recruitment of the post-larval stages to the bay and estuary fishing areas from oceanic spawning areas to the west⁶. A significant relationship has been found between the strength of zonal westerly winds in south-eastern Australia and abundance of post-larvae recruiting into Port Phillip Bay, Victoria, during spring each year^{6,9}. The zonal westerly wind index has shown a long-term downward trend since about 1970, suggesting that the strength of the westerly wind flow over Victoria has decreased over the past 40 years. The decline in zonal westerly winds is consistent with the prediction that westerly winds will weaken in southern Australia under climate change because of a southward migration of the high-latitude westerly wind belt south of Australia¹⁶. This may ultimately have a significant impact on the average abundance of larvae that enter Victoria's bays and inlets.
- Although westerly winds⁶ and oceanic water temperatures¹⁷ during the winter larval dispersal phase play an important role in determining recruitment patterns to the bay and estuary fisheries, the availability of suitable nursery habitat—primarily seagrass¹⁸—is another critical factor that could influence survival and growth of the young fish, and therefore fisheries productivity. Significant long-term loss of seagrass habitat in bays and estuaries would affect production of this species.
- In other states, as in Victoria, annual recruitment by juvenile King George Whiting is highly variable, most likely as a result of various complex interactions with the environment, on both broad and local scales. In Western Australia, relatively strong recruitment occurred in 1999, 2000 and 2008, which coincided with a strong Leeuwin Current in these years. The warm water temperatures associated with this southward-

flowing current may have led to increased larval growth and survival rates.

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67. Sand Whiting *Sillago ciliata*

Jason McGilvray^a and Faith Doyle^b

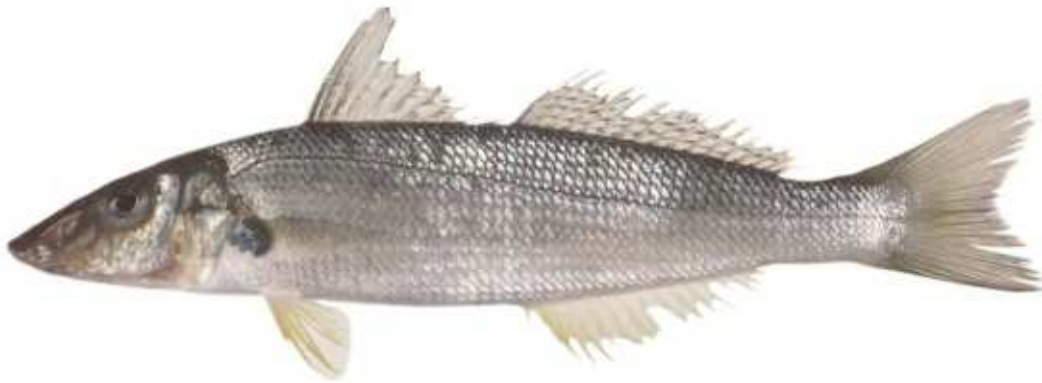


Table 1: Stock status determination for Sand Whiting

Jurisdiction	Queensland	New South Wales
Stock	Queensland (ECIFFF)	New South Wales (EGF, OHF, OTF-PS)
Stock status		
	Sustainable	Sustainable
Indicators	Commercial catch and CPUE, length and age frequencies, mortality rate	Commercial catch and CPUE, length and age frequencies, mortality rate

CPUE = catch per unit effort; ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); EGF = Estuary General Fishery (New South Wales); OHF = Ocean Haul Fishery (New South Wales); OTF-PS = Ocean Trawl Fishery–Prawn Sector (New South Wales)

Stock structure

Sand Whiting occur along the east coast of Australia, and are most abundant in southern Queensland and northern New South Wales. Tagging studies have shown movement of adult fish between estuaries, but information on biological stock boundaries remains incomplete. Because the biological stock composition is unknown, no formal assessment of the entire biological stock has been completed. Separate assessments of Sand Whiting have been conducted in Queensland and New South Wales^{1–4} and stock status of Sand Whiting is reported at the jurisdictional level.

Stock status

Queensland

In 2013, the commercial catch of Sand Whiting in Queensland was below the mean catch during the period 2000 to 2012 (309 tonnes [t]); the catch in 2013 was 240 t. Nominal catch rate (62 kg/day) in 2013 was higher than in the previous 2 years and was similar to the 2009 nominal catch rate (65 kg/day)⁵. Fishery-dependent monitoring of Sand Whiting, beginning in 2007, indicates consistent length and age structures⁵. These are good indicators of a stable population with continued recruitment. The data indicate that the biomass of this stock is unlikely to be recruitment overfished.

^a Department of Agriculture, Fisheries and Forestry, Queensland
^b Department of Primary Industries, New South Wales

Nominal effort in the Queensland commercial fishery in 2013 was much lower than in previous years (3922 days in 2013, compared with 4771 days in 2012 and 5400 days in 2009), which has improved the commercial catch rate⁵. Effort in the recreational sector of the fishery has decreased since 2001⁶, and the introduction in 2009 of a possession limit (30 fish) caps harvest to acceptable levels. The current minimum legal size for Sand Whiting in Queensland (23 cm total length [TL]) allows a proportion of mature fish to spawn at least once. Sand Whiting has a high rate of survival when released by recreational anglers, thus reducing discard mortality impacts on the stock⁷. Estimates of mortality for Sand Whiting in Queensland (from catch curves) are high. The rate of fishing mortality is equal to the rate of natural mortality, indicating a fully fished stock; however, these mortality estimates have remained steady since 2007⁵. The current level of fishing pressure is unlikely to cause this stock to become recruitment overfished.

Based on the evidence provided above, Sand Whiting in Queensland is classified as a **sustainable stock**.

New South Wales

Median commercial catch rates (nominal) of Sand Whiting in New South Wales have been relatively steady for the past 5 years and, for commercial hauling in particular, have been slightly greater than those observed in the previous 5 years⁸. The length composition of landings for this species has also been relatively stable since the late 1960s. Local populations that have been studied predominantly comprised fish aged 2–5 years^{3,8}. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

Nominal effort levels in 2013 (number of fisher days) in the Estuary General Fishery (approximately 9793 days, summed across methods), the Ocean Haul Fishery (approximately 292 days) and the Ocean Trawl Fishery–Prawn Sector (approximately 217 days) were among the lowest reported⁸. Partly as a result of the historical low nominal effort, the 61 t catch of Sand Whiting in 2013 was below the long-term average of 145 t. The minimum legal length for both commercial and recreational fishers in New South Wales (27 cm TL) reduces fishing pressure on the spawning stock. Recent estimates of mortality from catch curves indicate that the rate of fishing mortality is less than the rate of natural mortality³. The above evidence indicates that the current level of fishing pressure is unlikely to cause this stock to become recruitment overfished.

Based on the evidence provided above, Sand Whiting in New South Wales is classified as a **sustainable stock**.

Table 2: Sand Whiting biology^{3,9–11}

Longevity and maximum size	12 years; 510 mm TL
Maturity (50%)	Males: 170–240 mm FL Females: 190–240 mm FL

FL = fork length; TL = total length

Figure 1: Distribution of reported commercial catch of Sand Whiting in Australian waters, 2013 (calendar year)

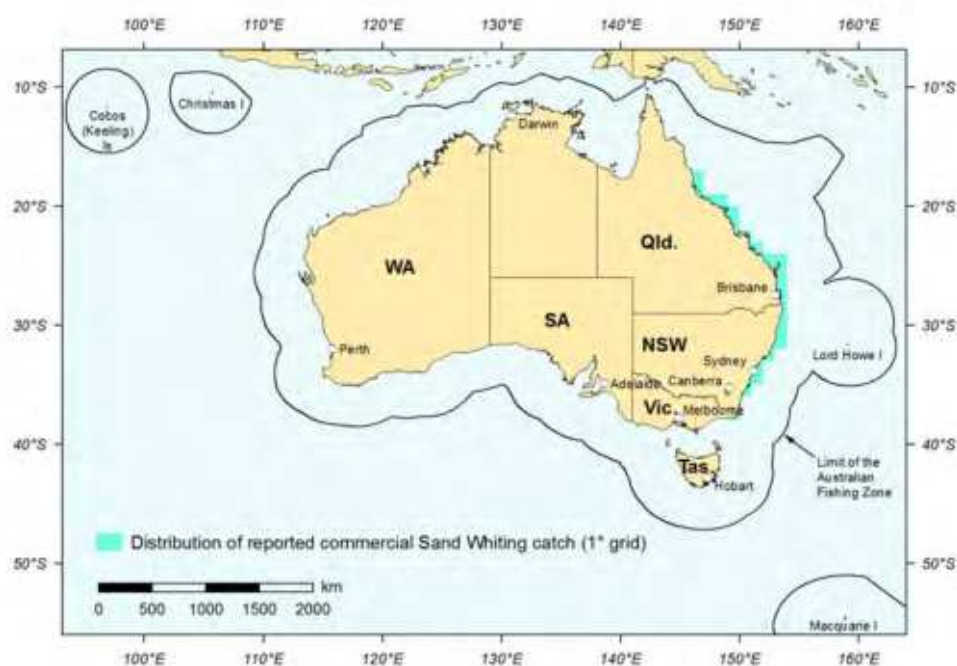


Table 3: Main features and statistics for Sand Whiting fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland	New South Wales
Fishing methods		
Commercial		
Gillnet	✓	✓
Seine net	✓	✓
Tunnel net	✓	
Prawn trawl		✓
Recreational		
Rod and line	✓	✓
Cast net	✓	
Crab trap and pot	✓	
Indigenous ^{a,b}		
Rod and line		✓

Jurisdiction	Queensland	New South Wales
Management methods		
Commercial		
Limited entry	✓	✓
Size limits	✓	✓
Fishing gear and method restrictions	✓	✓
Spatial closures	✓	✓
Temporal closures	✓	✓
Recreational		
Size limits	✓	✓
Bag limits		✓
Possession limits	✓	✓
Fishing gear and method restrictions	✓	✓
Licences		✓
Spatial closures	✓	✓
Indigenous ^{a-d}		
Section 37(1)(c1), Aboriginal cultural fishing authority		✓
Bag limits		✓
Active vessels		
	185 in ECIFFF	235 in EGF 22 in OHF 12 in OTF-PS
Catch		
Commercial	237 t in ECIFFF	53.8 t in EGF 5.1 t in OHF 2.7 t in OTF-PS
Recreational	125 t (2010–11) ⁶	394 t (2000–01) ¹²
Indigenous	Unknown	Unknown

Jurisdiction	Queensland	New South Wales
Markets		
Domestic	✓	✓
Export		

ECIFFF = East Coast Inshore Fin Fish Fishery (Queensland); EGF = Estuary General Fishery (New South Wales); OHF = Ocean Haul Fishery (New South Wales); OTF-PS = Ocean Trawl Fishery–Prawn Sector (New South Wales)

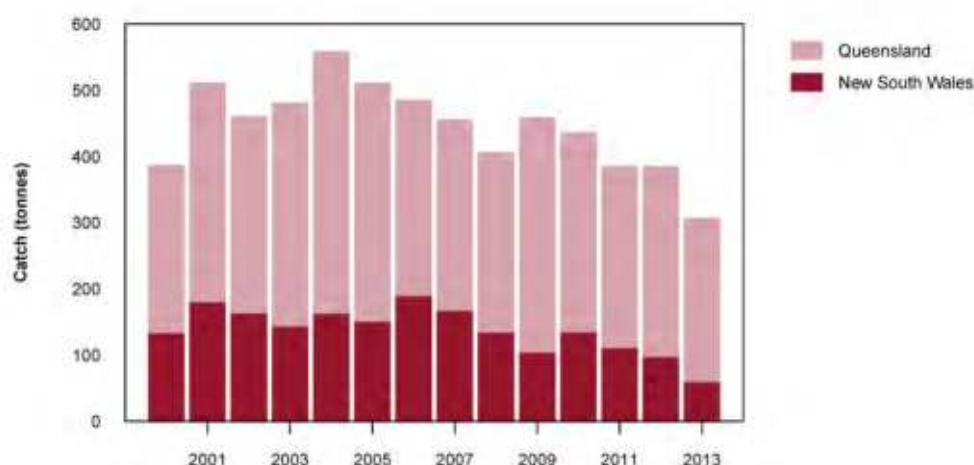
a Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are able to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and bag limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations can be obtained through permits.

b In New South Wales, Indigenous fishers are able to use traditional and noncommercial apparatus to take double the recreational bag limit. Further exemptions to fishery regulations can be obtained through permits.

c The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

d The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

Figure 2: Commercial catch of Sand Whiting in Australian waters, 2000 to 2013 (calendar year)



Effects of fishing on the marine environment

- In Queensland, coastal river and estuary set gillnets have been shown to have minimal impact on the environment and are quite selective in their harvest¹³. Bycatch is generally low compared with the harvest of the target species¹³. Fishers using tunnel nets operate under industry-developed codes of best practice¹⁴. Marine turtles are released with minimal difficulty, and undersized or unwanted catch is returned to the water alive.
- In New South Wales, seining in estuaries can incur large amounts of bycatch of undersized organisms and unwanted species, but the use of appropriately sized mesh can reduce mortalities of these species^{15–18}. Studies conducted in New South Wales indicate that gillnets used in estuaries can incur substantial bycatches, including the capture of undersized individuals of key species^{19–21}.
- Seabirds and other marine life often become entangled in discarded recreational fishing tackle²². In south-

east Queensland, a Fishing Line Recovery Bin program was instigated in 2012 to minimise the occurrence of discarded tackle at popular shore-based fishing locations.

Environmental effects on Sand Whiting

- Shallow vegetated marine habitats are important for juvenile Sand Whiting, particularly during recruitment periods^{23,24}. Physical impacts on coastal marine vegetation, subsurface topography and water quality are likely to be detrimental to the Sand Whiting stock.

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68. Stout Whiting *Sillago robusta*

Darren Roy^a and Amy Smoothey^b



Table 1: Stock status determination for Stout Whiting

Jurisdiction	Queensland, New South Wales
Stock	Eastern Australian (FTF, OTF)
Stock status	 Sustainable
Indicators	Standardised catch rate, catch-at-age frequencies

FTF = Finfish Trawl Fishery (Queensland); OTF= Ocean Trawl Fishery (New South Wales)

Stock structure

The geographic distribution of the east-coast Stout Whiting biological stock is restricted to southern Queensland and northern New South Wales. Genetic analysis of Stout Whiting catches from southern Queensland locations indicates that substocks are unlikely to exist¹. Hence, status for this species is reported at the level of the biological stock.

Stock status

Eastern Australian biological stock

On average, 80 per cent of the annual commercial catch of Stout Whiting is taken in Queensland, and 20 per cent is taken in New South Wales. The status of the Stout Whiting biological stock in Queensland waters is therefore adopted as representative of the whole biological stock in any given year².

In Queensland, the current annual total allowable catch (TAC) for Stout Whiting is 1360 tonnes (t). The annual TAC is reassessed before the start of each fishing year using a decision-support model developed in 2002³. Every 5 years, a full stock assessment of the fishery is completed. In 2014, the Queensland Department of Agriculture, Fisheries and Forestry completed a quantitative stock assessment for the Finfish Trawl Fishery (unpublished data from the Department of Agriculture, Fisheries and Forestry, Queensland), incorporating new data on changes to the fishery area, fishing gear and otolith weight. The assessment included New South Wales catch data on Stout Whiting, and Queensland otter trawl fishery bycatch estimates. The 2014 assessment recommended reducing the TAC (which represents the maximum sustainable yield [MSY] of the fishery) from 1500 t to 1360 t, despite the current harvest being much lower than these limits.

^a Department of Agriculture, Fisheries and Forestry, Queensland

^b Department of Primary Industries, New South Wales

The 2014 assessment estimated that the 2013 standardised catch rate (1.016) was about equal to the long-term average standardised catch rate (1) and 18 per cent higher than in 2012. Estimated total mortality (1.043) was above the reference point (0.855) for the recommended target catch. There have been no declining trends in catch per unit effort over time. Fish length frequencies were similar across years, and age structures were dominated by 1–3-year-old fish (longevity is 8 years). The assessment model estimated sustainable (greater than 1) stock status ratios in 2013 for exploitable biomass ($B_{2013}/B_{MSY} = 1.07$, where B = biomass) and for spawning egg production ($E_{2013}/E_{MSY} = 1.19$, where E = effort). The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished.

The 2013 total commercial catch of 704 t was approximately 52 per cent of the Queensland annually adjusted TAC (equal to MSY). Long-term size-at-catch and age-at-catch frequency data from commercial landings indicate that the biological stock size structure is relatively stable². This evidence indicates that the current level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

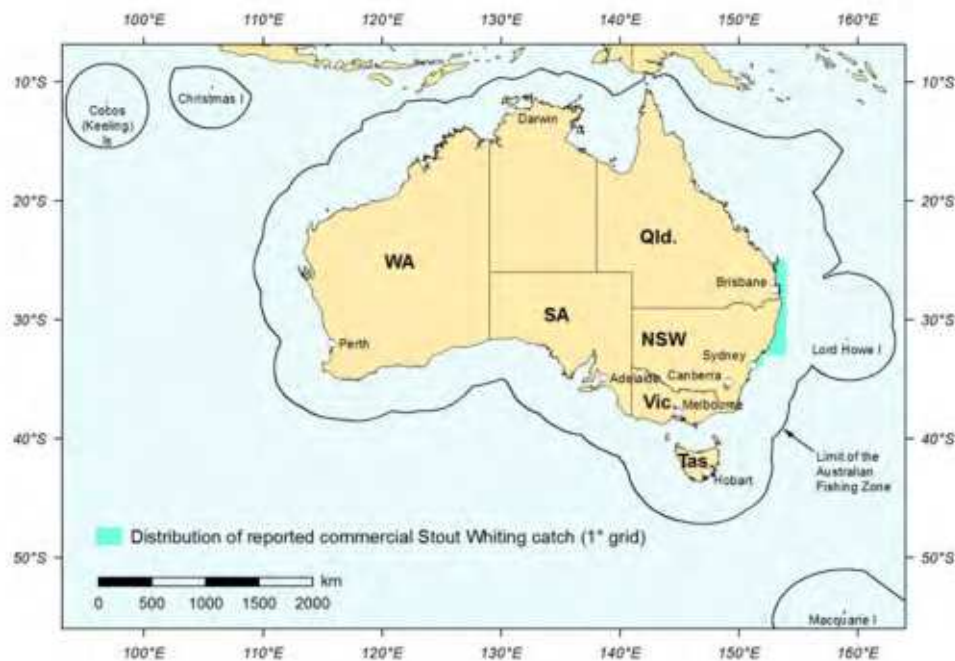
On the basis of the evidence provided above, the biological stock is classified as a **sustainable stock**.

Table 2: Stout Whiting biology³

Longevity and maximum size	8 years; 230 mm FL
Maturity (50%)	2–3 years; 140–180 mm FL

FL = fork length

Figure 1: Distribution of reported commercial catch of Stout Whiting in Australian waters, 2013 (calendar year)



Note: The reporting period is fishing season (1 April – 31 December) for Queensland data, and calendar year for New South Wales data.

Table 3: Main features and statistics for Stout Whiting fisheries in Australia, 2013 (calendar year)

Jurisdiction	Queensland ^a	New South Wales ^b
Fishing methods		
Commercial		
Otter trawl	✓	✓
Danish-seine	✓	✓
Recreational		
Rod and line		✓
Indigenous ^c		
Rod and line		✓
Management methods		
Commercial		
Limited entry	✓	✓
Vessel restrictions	✓	✓
Catch limits	✓	
Gear restrictions	✓	✓
Spatial closures	✓	✓
Temporal closures	✓	✓
Recreational		
Bag limits		✓
Spatial closures		✓
Indigenous ^{c,d,e}		
Bag limits		✓
Spatial closures		✓
Section 37(1)(c1), Aboriginal cultural fishing authority		✓
Active vessels		
	2 in FTF	48 in OTF

Jurisdiction	Queensland ^a	New South Wales ^b
Catch		
Commercial ^f	704 t in FTF	148 t in OTF
Recreational	Negligible	Unknown
Indigenous	Negligible	Unknown
Markets		
Domestic	✓	✓
Export	✓	✓

FTF = Finfish Trawl Fishery; OTF = Ocean Trawl Fishery

a Queensland reporting period is fishing season (1 April – 31 December).

b New South Wales reporting period is calendar year.

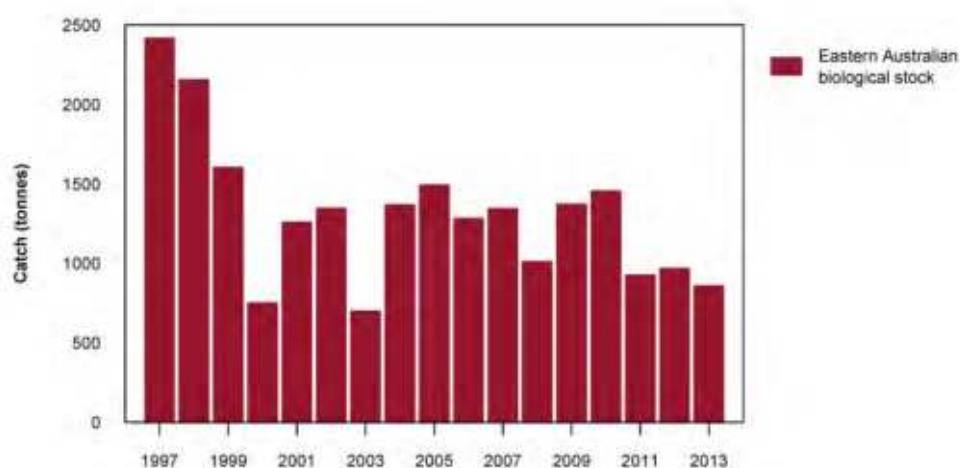
c Under the *Fisheries Act 1994* (Qld), Indigenous fishers in Queensland are entitled to use prescribed traditional and noncommercial fishing apparatus in waters open to fishing. Size and possession limits, and seasonal closures do not apply to Indigenous fishers. Further exemptions to fishery regulations may be applied for through permits.

d The Aboriginal Fishing Interim Compliance Policy allows an Indigenous fisher in New South Wales to take in excess of a recreational bag limit in certain circumstances—for example, if they are doing so to provide fish to other community members who cannot harvest themselves.

e The Aboriginal cultural fishing authority is the authority that Indigenous persons can apply to to take catches outside the recreational limits under the *Fisheries Management Act 1994* (NSW), section 37(1)(c1) (Aboriginal cultural fishing authority).

f Unknown quantity taken as bycatch in the East Coast Otter Trawl Fishery (Queensland).

Figure 2: Commercial catch of Stout Whiting in Australian waters, 1997 to 2013 (calendar years)



Note: The reporting period is fishing season (1 April – 31 December) for Queensland data, and calendar year for New South Wales data.

Effects of fishing on the marine environment

- The seabed where the fishery occurs lacks major reef structures⁴. Anecdotal information from research trawls and commercial fishers indicates that the seabed in the fishery area is predominantly bare sand⁵. Consequently, the impact of trawling on benthic habitats in the fishery area is likely to be relatively low⁵.
- The fishery has potential for interactions with sea turtles, but these occur infrequently⁶. Compulsory use of turtle excluder devices (TEDs) in otter trawls minimises the impact of interactions with turtles. TEDs are not required in Danish-seine nets; however, the nature of this type of fishing means that nets are hauled at a much slower speed and pose minimal risks to turtles, which are able to outswim the nets.
- Although Danish-seine is legislated as an acceptable method for targeting Stout Whiting in Queensland and New South Wales, it is only used by one vessel, which fishes in both Queensland and New South Wales. Compared with trawling, Danish-seining harvests Stout Whiting more efficiently, has less physical contact with the seabed, and more effectively reduces some forms of bycatch, including prawns, bugs, squid, sea snakes and pipefish⁶. However, since Danish-seine nets are not required to have TEDs installed, the bycatch of small sharks and rays can be high when using this type of gear⁶.
- Sustainability of Stout Whiting taken as bycatch in the East Coast Otter Trawl Fishery (Queensland) has been assessed. At predicted future levels of effort, there is no more than an intermediate risk that discarding will result in an unacceptable decline in Stout Whiting biological stock abundance (unpublished data from the Department of Agriculture, Fisheries and Forestry, Queensland).

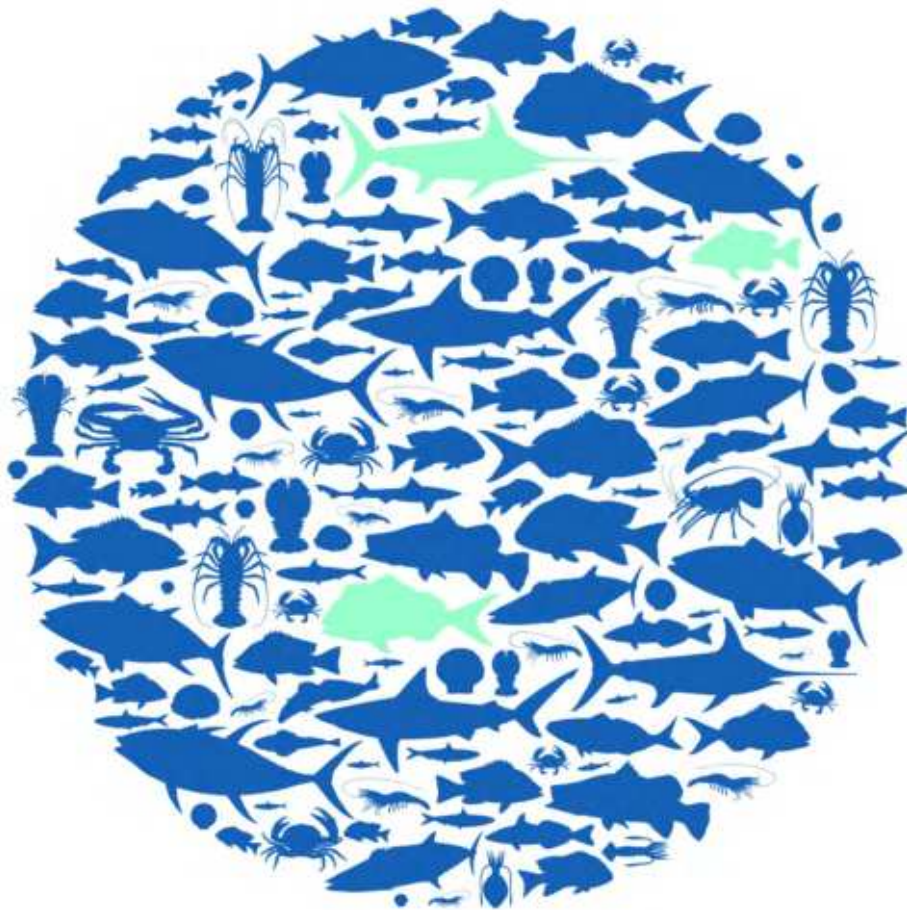
Environmental effects on Stout Whiting

- Because Stout Whiting is a shallow-water oceanic species, it is unlikely that land-based events would significantly affect the biological stock. Marine environmental pressures that may affect the biological stock have not been identified.

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Glossary



A

Abalone viral ganglioneuritis (AVG). A highly virulent herpes-like virus, which affects the nervous tissue of abalone and rapidly causes death. Can be spread through direct contact, through the water column without contact, and in mucus that infected abalone produce before dying.

Acceptable biological catch. See Recommended biological catch.

Age–length (age–length key or curve). Relationship between age and length—that is, growth.

Age–length frequency. Numbers of fish in each age class from a sample of fish captured during a fishing season. Sometimes sampled separately for retained and discarded catch. An important data input for age-structured fisheries stock assessments.

Age-structured assessment. Assessment of the status of a fish stock, incorporating a range of data sources, including length- and age-frequency data, to estimate the number of fish of each age each year.

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/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 (that is, from 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* (Cth), which also specifies a number of 'excepted waters', notably in Antarctica and the Torres Strait, that are excluded from the AFZ.

B

B. See Biomass.

B₀ (mean equilibrium unfished biomass). Average biomass level if fishing had not occurred.

Bag limit. The number of fish that one person can legally take and keep in a day's fishing. Most often applied to recreational fisheries.

Benthic. Associated with the bottom of a water body.

Berried female. Female crustacean carrying eggs.

Biodiversity. Biological diversity; variety among living organisms, including genetic diversity, diversity within and between species, and diversity within ecosystems.

Bioeconomic model. Method of fisheries stock assessment that models the interaction between the biology of harvested species and the human behaviour of fishers as shaped by economic factors.

Biological reference point. Biomass or fishing mortality level used to guide management decisions. Can be either a 'target reference point' or a minimum biologically acceptable limit ('limit reference point').

Biological 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.

Biomass. Total weight of a stock or a component of a stock.

Biomass limit reference point (BLIM). Stock biomass below which the risk to the stock is regarded as unacceptably high. Usually expressed as a fraction of the average adult biomass before the commencement of fishing.

Biomass at maximum economic yield (BMEY). Average biomass corresponding to maximum economic yield.

Biomass at maximum sustainable yield (BMSY). Average biomass corresponding to maximum sustainable yield.

Biomass proxy. A relative biomass level used in place of a quantitatively estimated biological reference point when the latter is not available. For example, the biomass that sustains maximum economic yield (BMEY).

Bioregion. 'A region defined by common oceanographic characteristics in its marine environment, and by climate/rainfall characteristics in its inland river systems'⁴.

Boat-days. A measure of fishing effort. Refers to the number of 'days' that a fishing licence holder is permitted to fish/has fished.

Boat-nights. A measure of fishing effort. Refers to the number of 'nights' that a fishing licence holder is permitted to fish/has fished. Generally used in prawn trawl fisheries.

Boom-and-bust cycle. Repeated and regular increases and decreases in the size of a population.

Bycatch. A species that is (a) returned to the sea either because it has no commercial value or because regulations preclude it being retained, or (b) is affected by interaction with the fishing gear, but does not reach the deck of the fishing vessel.

Bycatch reduction device (BRD). A device that allows fish and other animals to escape immediately after being taken in or with fishing gear.

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 (CL). In prawns, the distance from the posterior margin of the orbit to the mid-caudodorsal margin of the carapace; in lobster, the distance from the tip of the rostrum to the mid-caudodorsal margin of the carapace.

Catch 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 prediction. Forecasts undertaken in Western Australian prawn fisheries, based on surveys of recruitment and spawning stocks^a.

Catch rate. See Catch per unit effort.

Clade. An ancestor (organism, population or species) and all of its descendants.

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* (Cth) dictates that a native species is eligible to be included in the conservation dependent category at a particular time if, at that time, (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for

⁴ Fletcher, WJ & Santoro, K (eds) 2011, *State of the fisheries and aquatic resources report 2010/11*, Western Australian Department of Fisheries, Perth.

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.

Coral bleaching. The loss of colour from corals under stressful environmental conditions. Bleached corals have the ability to recover as conditions return to normal; however, if the conditions remain unfavourable for an extended time, they will die.

Cryptic mortality. Substantial mortality of a fish stock, occurring in part of the fishery, that cannot be detected in fishery data.

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.

Decision rules. Agreed responses that management must make under predefined circumstances regarding stock status. Also called 'control rules' or 'harvest control rules'.

Demersal. Found on or near the benthic habitat (c.f. Pelagic).

Depletion (stock depletion). Reduction in the biomass of a fish stock.

Depletion estimation methods. Stock assessment methods that estimate biomass at the beginning of a period of exploitation, based on the rate of the decline of catch rates with the cumulative removal of individuals or with cumulative effort.

Developmental fishery. A fishery managed under developmental fishery permits. Developmental fishing involves fishing in an area of Australian jurisdiction as specified in the permit; activities include (a) assessing the commercial viability of a fishery, and (b) assessing the commercial viability of kinds of fishing activities, vessels or equipment specified in the permit.

Discarding. Any part of the catch that is returned to the sea, whether dead or alive.

Domestic fishery. Fishery within the Australian Fishing Zone operated by Australian-flagged vessels.

E

East Australian Current. A large-scale ocean current that runs south along the east coast of Australia, taking warm tropical waters from the Coral Sea southwards into the temperate waters of the Tasman Sea.

Ecologically sustainable. 'Use of natural resources within their capacity to sustain natural processes while maintaining the life-support systems of nature and ensuring that the benefit of the use to the present generation does not diminish the potential to meet the needs and aspirations of future generations'⁵.

Ecologically viable stock. 'Ecologically viable stock has a general rather than a specific meaning. It refers to the maintenance of the exploited population at high levels of abundance, designed to maintain productivity, provide margins of safety for error and uncertainty, and maintain yields over the long term, in a way that conserves the stocks' role and function in the ecosystem'^a.

Ecological risk assessment. A process of estimating the effects of human actions on a natural resource.

⁵ Australian Government Department of the Environment and Water Resources 2007, *Guidelines for the ecologically sustainable management of fisheries*, 2nd edn, DEWR, Canberra.

Ecologically sustainable development (ESD). ESD principles require that:

- decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations
- if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- the principle of inter-generational equity: that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making and
- improved valuation, pricing and incentive mechanisms should be promoted.

Ecosystem. A complex of plant, animal and microorganism communities that, together with the nonliving 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, the 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.

El Niño. The extensive warming of the central and eastern Pacific Ocean that leads to a major shift in weather patterns across the Pacific region. In Australia (particularly eastern Australia), El Niño events are associated with an increased probability of drier conditions.

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* (Cth) 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.

Environmentally limited. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'overfished stock' as follows: Spawning stock biomass has been reduced to the point where average recruitment levels are significantly reduced, primarily as a result of substantial environmental changes/impacts or disease outbreaks (i.e. the stock is not recruitment overfished). Fisheries management has responded appropriately to the environmental change in productivity.

Environment Protection and Biodiversity Conservation Act 1999 (Cth) (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 a particular event (for example, predation, natural mortality, fishing mortality), often to spawn.

Eutrophication. The natural or human-induced process by which a body of water becomes enriched in dissolved mineral nutrients (particularly phosphorus and nitrogen) that stimulate the growth of aquatic plants and increase organic production of the water body. Excessive enrichment may result in the depletion of dissolved oxygen and eventually lead to death of many organisms that live in the water.

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. Australia has sovereign rights and responsibilities over the water column and the seabed in its EEZ, 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_{LIM} (fishing mortality limit reference point). The point above which the removal rate from the stock is too high.

F_{MSY} (fishing mortality maximum sustainable yield). The fishing mortality rate that achieves the maximum sustainable yield.

Fecundity. Number of eggs an animal produces each reproductive cycle; the potential reproductive capacity of an organism or population.

Fish-aggregating device (FAD). Buoys or platforms used to attract and 'hold' pelagic fishes to enhance fishing. Can be as simple as a floating log or bamboo raft, but tuna fishers setting purse-seine nets around tuna schools now deploy sophisticated FADs that allow satellite tracking and interrogation of information, such as sea surface temperature.

Fishery-dependent data (survey). Data collected directly on a fish or fishery from commercial fishers, processors and retailers. Common methods include logbooks, fishery observers and port sampling (c.f. Fishery-independent data [survey]). More difficult to interpret than fishery-independent data because the fishery-dependent data are influenced by fishers' attempts to maximise economic returns.

Fishery-independent data (survey). Data collected by systematic survey, carried out by research vessels or contracted commercial fishing vessels, to gather information independently of normal commercial fishing operations.

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 mortality (F). 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 the 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, respectively, of deaths of a stock due to fishing. *See also* Mortality, Natural mortality (M).

Fishing power. Effectiveness of a vessel's fishing effort relative to that of other vessels or in other periods of time. Also used to describe the average fishing mortality per unit of effort of a fishing fleet—this often tends to increase with time as a result of improvements in technology and fisher knowledge.

Fishing season. The period during which a fishery can be accessed by fishers. Sometimes referred to as fishing year.

Fishing year. *See* Fishing season.

Fork length (FL). Length of a fish measured as the distance between the tip of the snout and the point of the fork or 'V' of the tail. Commonly used to record the length of commercial fish because it is little affected by damage to the tail fin (c.f. Total length). Fork length is measured flat, from point to point, not by stretching a tape along the body surface, which would result in a longer measurement for full-bodied fish like tuna. *See also* Lower-jaw fork length.

Fully fished. Generally describes a fish stock for which current catches and fishing pressure are close to optimal. In the *Status of fisheries resources in NSW 2008/09*⁶, this term has the following specific meaning: 'Fishing mortality is approximately the same as natural mortality; estimates of biomass are greater than 30% of the estimated unfished biomass; catch rates have been steady for 5–10 years and/or catch rates are greater than 30% of initial catch rates; length and age distributions are stable; species are fished throughout their entire geographic range'.

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.

⁶ Rowling, K, Hegarty, A & Ives, M (eds) 2010, *Status of fisheries resources in NSW 2008/09*, Industry & Investment NSW, Cronulla.

Generalist feeders. Species that feed on a variety of food types and are not restricted to a particular food source.

Generation time. Average time taken for an individual animal to replace itself in a population.

Ghost fishing. Capture of fish in gear—usually nets or traps—that has been lost.

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 GVP of each species.

Growth overfished. In the *Status of fisheries resources in NSW 2008/09*^a, this term has the following specific meaning: 'Yield per recruit would increase if length at first capture was increased or fishing mortality decreased'.

Growth overfishing. Occurs when fish are harvested at an average size that is smaller than the size that would produce the maximum yield per recruit. When a fish stock is growth overfished, increases in fishing effort and fishing mortality produce decreasing yields, even though more individuals are harvested, because of the reduced average size of harvested individuals.

H

Harvest control rules. See Decision rules.

Harvest strategy. A set of management actions necessary to achieve defined biological and economic objectives in a given fishery.

High seas. Waters outside national jurisdictions (that is, outside Exclusive Economic Zones).

Hyperstability. A relationship between catch per unit effort (CPUE) and abundance in which, initially, CPUE declines more slowly than true abundance.

Hypoxia. A phenomenon that occurs in aquatic environments as dissolved oxygen becomes reduced in concentration to a point at which its level becomes detrimental to aquatic organisms living in the system. Also called oxygen depletion.

I

Incidental catch. See Bycatch

Index of abundance. Relative measure of the abundance of a stock (for example, catch per unit of effort).

Index of annual recruitment. Estimate of the relative number of individuals entering the fishery each year, usually based on a data source dedicated to the purpose.

Individual transferable effort (ITE). 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.

Intrinsic productivity. The natural rate of growth of a population, measured as births minus deaths per capita in the absence of environmental constraints on population increase.

J

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.

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* (Cth) 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

La Niña. The extensive cooling of the central and eastern Pacific Ocean. In Australia (particularly eastern Australia), La Niña events are associated with an increased probability of wetter conditions.

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 [TACs] 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. It is likely that fisheries in which latency exists are close to the open-access equilibrium. Apart from being an indicator of efficiency, a high level of latency in a fishery may be detrimental to the fish stock and to any chances the fishery has of being profitable in the future. For example, a significant increase in the market price of a fishery's product is likely to entice inactive effort into the fishery. In input-controlled fisheries, if enough inactive effort is triggered, the fish stock could be jeopardised and/or profits dissipated as soon as they arise if the fishery is driven to a point of open-access equilibrium. In an output-controlled fishery, this is less of a problem, provided that TACs are set in accordance with appropriate targets.

Leeuwin Current. A warm ocean current that transports warm tropical water southwards along the Western Australian coast and east around southern Australia.

Length and age frequency. See Age-length frequency.

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).

Logbook. Official record of catch-and-effort data completed by fishers. In many fisheries, a licence condition makes the return of logbooks mandatory.

Lower-jaw fork length. Length of a fish measured as the distance between the tip of the lower jaw and the point of the fork or 'V' of the tail. Commonly used to record the length of commercial fish with bills (for example, Swordfish) because it is little affected by damage to the tail fin (*c.f.* Total length) and bill. Fork length is measured flat, from point to point, not by stretching a tape along the body surface, which would result in a longer measurement for full-bodied fish like tuna.

M

Management strategy evaluation (MSE). Procedure whereby management strategies are tested and compared using simulations of stock and fishery dynamics.

Mantle length. The standard measure of length in coleoid cephalopods (for example, squid, cuttlefish and octopus). Usually measured along the dorsal midline from the mantle margin to the posterior tip of the body, excluding long tails, or from a line joining the midpoint of the eyes rather than the mantle margin.

Mark–recapture. A method for estimating population size and other parameters by tagging and releasing fish, and comparing the ratios of marked (tagged) to unmarked (untagged) individuals in future catches.

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 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.

Maximum sustainable yield rate (MSYR). The ratio of the MSY to the biomass at which MSY is obtained (i.e. $MSY : B_{MSY}$).

Meristics. The counting of structures occurring in series, such as the number of fin rays or vertebrae. Meristics can be used to describe or identify a species of fish.

Migration. Nonrandom movement of individuals of a stock from one place to another, often in groups.

Minimum size (minimum legal size). Size below which a captured animal may not legally be retained. Usually specified by species. May be varied as a management tool.

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).

Multispecies fishery. A fishery in which fishers' profits depend on the catch of more than one species. Fishery data from multispecies fisheries are more difficult to interpret because of uncertainty around the relative targeting of individual species.

N

Natural mortality (M). 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* Fishing mortality (F), Mortality.

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 1852 metres.

Nominal catch. The sum of the catches that are landed (expressed as liveweight equivalent). Nominal catches do not include unreported discards.

Nontarget species. Species that is unintentionally taken by a fishery or not routinely assessed for fisheries management. See *also* Bycatch, Byproduct.

O

Observer. A certified person on board fishing vessels who collects scientific and technical information for the management authority on the fishing operations and the catch. Observer programs can be used for monitoring fishing operations (for example, areas fished, fishing effort, gear characteristics, catches and species caught, discards, collecting tag returns). Observers may or may not have legal coercion powers, and their data may or may not be used for nonscientific purposes (for example, enforcement), depending on the situation.

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 (national, state and territory) 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.

Oligotrophic. Refers to water bodies that are poor in nutrients and have low primary productivity. Low nutrient content reduces plankton blooms, but also results in high dissolved oxygen levels.

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-equaling costs, with no economic profits being generated. The fishing effort employed at this point exceeds the level that would achieve maximum economic yield.

Otoliths. Bone-like structures formed in the inner ear of fish. The rings or layers can be counted to determine age.

Otolith microchemistry. A technique used in fisheries management and fisheries biology to delineate stocks, and characterise movements and natal origin of fish.

Output controls. Management measures that place restraints on what is caught, including total allowable catch, quota, size limits and species.

Overfished stock. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'overfished stock' as follows: Spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced (*i.e.* recruitment overfished). Current management is not adequate to recover the stock, or adequate management measures have been put in place but have not yet resulted in measurable improvements.

Ovigerous. Carrying or bearing eggs.

P

Panmictic. A panmictic population is one where all individuals have equal opportunity of mating. This assumes that there are no mating restrictions, either genetic or behavioural, on the population.

Pelagic. Inhabiting surface waters rather than the sea floor. Usually applied to free-swimming species such as tunas and sharks (*c.f.* Demersal).

Performance indicator (performance measure). Parameter used to assess the performance of a fishery against predetermined sustainability objectives.

Perkinsus. Protistan parasites that infect many species of marine molluscs throughout the world and can cause mass mortality.

Planktonic larval stage. An early life stage of many marine organisms, when larvae are dispersed in the water column before settling on suitable habitat and developing into their adult form.

Population modelling. Mathematical description of a population that is designed to fully simulate the life cycle of animals in that population. Can project the effects on the population of environmental factors or biological characteristics of these animals.

Possession limit. The maximum number of fish that a person is allowed to have in their possession at any time. It discourages the accumulation of large quantities of fish by recreational fishers.

Precautionary approach. Approach to fisheries management where the absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment.

Pre-recruits. The proportion of a population that has not yet entered a fishery (that is, not able to be caught or retained).

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 (labour, capital, fuel, etc.) 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) to changes in total inputs such as fuel, labour and capital.

Protected species. As per the meaning used in the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

Protogynous hermaphrodites. Organisms that change sex from female to male during their life cycle.

Puerulus. The last pelagic stage of rock lobster larvae. Surveys to estimate the density of rock lobster puerulus that settle on the seabed are sometimes used to predict future recruitment strength in rock lobster fisheries.

Q

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-time management. Method of fisheries management that allows fishing activities (for example, vessel movements, catch) to be monitored in real time.

Recommended biological catch (RBC). The total mortality from fishing by all sources – derived from application of the harvest control rule.

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 failure. A situation in which a population is not able to naturally produce viable offspring as a consequence of physical factors (for example, damaged spawning areas) or biological factors (for example, inadequate numbers of fish).

Recruitment overfished. The point at which a stock is considered to be recruitment overfished is the point at which the spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced.

Recruitment overfishing. A level of exploitation that, if maintained, would result in the stock falling to levels at which there is a significant risk of recruitment and stock collapse. The corresponding term for the state of the stock is 'recruitment overfished', in which the average annual recruitment to the stock is significantly reduced. Both terms define a limit reference point (for exploitation rate or stock size) beyond which urgent management action should be taken to reduce exploitation and recover the stock.

The following uses of the term provide some guidance to how it should be interpreted and applied.

The FAO fisheries glossary (www.fao.org/fi/glossary/default.asp) defines recruitment overfished as 'a situation in which ... annual recruitment ... has become significantly reduced. The situation is characterized by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch, and generally very low recruitment year after year'.

Cook⁷ defines recruitment overfished as a situation in which 'a reduction in the proportion of fish caught would be more than compensated for by the increased number of recruits to the fishery as a result of increased escapement of mature fish'.

The EPBC *Guidelines for the ecologically sustainable management of fisheries*⁸ define recruitment overfishing as occurring 'where fishing activities are causing a reduction in recruitment in succeeding years and cause the mortality of too many fish in total, too many pre-productive fish, or too many fish that have only spawned a few times. The end result is that the stock can no longer replenish itself adequately'.

⁷ Cook, JG 1984, Glossary of technical terms, in RM May (ed.), *Exploitation of marine communities*, Springer-Verlag, Berlin, 341–348.

⁸ Australian Government Department of the Environment and Water Resources 2007, *Guidelines for the ecologically sustainable management of fisheries*, 2nd edn, DEWR, Canberra.

Various jurisdictions have defined a biomass limit reference point (B_{LIM}) that also corresponds to this concept of recruitment overfishing. These limit reference points (LRPs) are often related to the biomass at which maximum sustainable yield (MSY) occurs. Examples of LRPs include the following:

- $B_{\text{LIM}} = 0.5B_{\text{MSY}}$ (Commonwealth of Australia).
- $B_{\text{LIM}} = 0.5B_{\text{MSY}}$ (or greater) (United States).
- B_{LIM} is usually defined relative to fishing mortality rates rather than biomass (European Union).
- $B_{\text{LIM}} = 0.5B_{\text{MSY}}$ (or greater—for example, for forage fish) (Marine Stewardship Council).

New Zealand explicitly uses the concept of recruitment overfishing, which is defined as occurring 'when excessive fishing effort or catch reduces the spawning stock biomass to a level below which future recruitment levels may be jeopardised; this spawning biomass level should correspond closely to the biomass limit reference point'.

No jurisdictions appear to have explicitly defined how much recruitment would be reduced to constitute recruitment overfishing, perhaps because recruitment tends to fluctuate much more than overall stock biomass.

Reference point. Indicator of the level of fishing (or stock size); used as a benchmark for assessment (see also Biological reference point).

Relative abundance. The number of living individuals at a point in time, expressed as a fraction of the average number of living individuals estimated before the beginning of fishing.

Risk analysis. Analysis that evaluates the possible outcomes of various harvesting strategies or management options.

Rotational closure. Closure of an area to allow stocks to rebuild, while another area that has been previously closed and allowed to rebuild is fished.

S

Sacrificial panel. Part of a trap designed to rust out after a short period to allow fish to escape if the trap is lost; reduces the impacts of ghost fishing.

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.

Semelparous. Species that reproduce only once and then die.

Settlement. Transition from a pelagic larval stage to a substrate-associated juvenile or adult existence.

Shared biological stock. A biological stock that spans the waters of more than one jurisdiction.

Shark finning. The removal and retention of shark fins. The remainder of the body is generally discarded, often still alive. The process has been banned in Australian waters, and management measures are in place to reduce or restrict targeting of sharks for fin markets by illegal, unreported and unregulated fishing.

Shell height. A straight-line measurement of molluscs from the hinge to the part of the shell that is furthest away from the hinge.

Shell length. A straight-line measurement of molluscs, often along a straight line at the widest point of the shell.

Size frequency. See Length-frequency distribution.

Spatial closure. A method of fisheries management that prevents fishing in a defined area.

Spawning biomass (SB). The total weight of all adult (reproductively mature) fish in a population.

Spawning stock biomass. See Spawning biomass (SB).

Species complex. Group of similar species that are often difficult to differentiate without detailed examination.

Species group. See Species complex.

Standardised data. Data that have been adjusted to be directly comparable to a unit that is defined as the 'standard' one. Standardised catch-per-unit-effort data are often used as an indicator of fish abundance.

Standard length (SL). 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 midlateral portion of the hypural plate.

Statoliths. Bone-like structures found in cephalopods that can be used to record life history events. Similar to *otoliths* found in fish.

Statolith microchemistry. A technique used in fisheries management and fisheries biology to characterise life history, natal origin and movements of cephalopods.

Statutory fishing right (SFR). Right 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.

Stochastic demographic modelling. Stock assessment method used to estimate the intrinsic productivity and response to fishing of fish stocks, based on age structure, allowing for variation in annual recruitment. Mostly used for stock assessment of shark species.

Stock. Within the *Status of key Australian fish stocks reports*, the term 'stock' is used generically in reference to all three levels of stock status assessment—that is, biological stocks, management units and populations assessed at the jurisdictional level. *See also* Biological stock.

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.

Stock reduction analysis. A method of inferring the extent to which a fisheries stock is likely to have been reduced by fishing, assuming constant recruitment. Requires only a time series of total catch data, but can also incorporate other information.

Stock synthesis model. A statistical framework for calibration of a population dynamics model, using a range of fishery and survey data. It is designed to accommodate both age and size structure in the population, and multiple stock subareas. Selectivity can be cast as age specific only, size specific in the observations only, or size specific with the ability to capture the major effect of size-specific survivorship. The overall model contains subcomponents that simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data.

Sustainable stock. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'sustainable stock' as follows: Stock for which biomass (or biomass proxy) is at a level sufficient to ensure that, on average, future levels of recruitment are adequate (that is, not recruitment overfished) and for which fishing pressure is adequately controlled to avoid the stock becoming recruitment overfished.

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, stock structure and size.

Target biomass (B_{TARG}). The desired biomass of the stock.

Target catch range. The range of annual catches, taking into account natural variations in recruitment to the fished stock, that can be expected under a fishing effort–based management plan.

Target fishing (targeting). Fishing selectively for particular species or sizes of fish.

Target species. *See* Key commercial species.

Temporal closure. Closure that is implemented to protect fish stocks during specific stages of their life cycle (for example, while spawning).

Territorial sea (12 nautical mile limit). 'The Territorial Sea is a belt of water not exceeding 12 nautical miles in width measured from the territorial sea baseline. Australia's sovereignty extends to the territorial sea, its seabed and subsoil, and to the air space above it. This sovereignty is exercised in accordance with international law as reflected in the Convention on the Law of the Sea.'

The major limitation on Australia's exercise of sovereignty in the territorial sea is the right of innocent passage for foreign ships. The territorial sea around certain islands in the Torres Strait is 3 nautical miles⁹.

Territorial sea baseline. The baseline from which all the zones (for example, the Exclusive Economic Zone) of Australia's maritime jurisdiction are measured. The baseline is defined as the level of lowest astronomical tide, but straight baselines and bay or river closing lines may be drawn further out from the low-water mark to encompass areas such as the mouths of rivers, bays, ports, roadsteads and fringing reefs.

Threatened species. As per the meaning used in the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

Torres Strait Protected Zone. An area under an agreement between Australia and Papua New Guinea that describes the boundaries between the two countries and how the sea area may be used. The main reason for the protected zone is so that Torres Strait Islanders and the coastal people of Papua New Guinea can carry on their traditional way of life. For example, traditional people from both countries may move freely (without passports or visas) for traditional activities in the protected zone.

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) applies. 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 the species with amendments applied, such as carryover or debits from the previous year.

Total allowable commercial catch (TACC). See Total allowable catch (TAC).

Total allowable effort (TAE). An upper limit on the amount of effort that can be applied in the fishery.

Total length (TL). The length 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 (c.f. Fork length).

Transitional–depleting stock. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'transitional–depleting stock' as follows: A deteriorating stock—biomass is not yet recruitment overfished, but fishing pressure is too high and moving the stock in the direction of becoming recruitment overfished.

Transitional–recovering stock. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'transitional–recovering stock' as follows: A recovering stock—biomass is recruitment overfished, but management measures are in place to promote stock recovery, and recovery is occurring.

Trigger points. Pre-specified quantities (total catch, spawning biomass, etc.) that indicate the need for a review of fishery management.

U

Undefined stock. The agreed national reporting framework for the *Status of key Australian fish stocks reports* defines the term 'undefined stock' as follows: Not enough information exists to determine stock status.

Unfished biomass. Biomass of a stock that has not been fished (also called the 'unfished' or 'unexploited' biomass or unfished level).

Upwelling. An oceanic process whereby cold, nutrient-rich water is brought to the surface. Typically results in increased productivity of fisheries where it occurs, as a result of the increased nutrients.

V

Vessel monitoring system (VMS). Electronic device that transmits the identity and location of a vessel.

Virgin biomass. See Unfished biomass.

⁹ Geoscience Australia 2012, *Maritime boundary definitions*, Geoscience Australia, Canberra, www.ga.gov.au/marine/jurisdiction/maritime-boundary-definitions.html.

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* (Cth) 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.

W

Warp strike. Incident of seabirds striking trawl gear while interacting with fishing activity. Often results in mortality.

Weight-of-evidence approach. The systematic consideration of a range of biological and fisheries information for assembly and review of indicators of biomass status and levels of fishing mortality, to support a status determination. Lines of evidence used in the weight-of-evidence approach include empirical indicators (catch, effort, catch rate, size- or age-based indicators, spatial and temporal distribution of the fishery), risk assessments, fishery-independent surveys, quantitative stock assessment models and harvest strategies.

Y

Yield. Total weight of fish harvested from a fishery.

Yield-per-recruit analysis. Analysis of how growth and natural mortality interact to determine the best size of animals to harvest; for example, it may be more economically beneficial to catch fish when they are young and plentiful, or when they are older and larger but fewer. Biological reference points based on yield-per-recruit analysis will be expected to lack precaution because the potential for reduced future recruitment resulting from decreased parental biomass is not considered.



N

NORTH : TROPICAL

SOUTH : TEMPERATE

S