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Sustainability of harvest levels by Australian flagged vessels in the high seas areas of the South Pacific Ocean and South Indian Ocean

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Australian fishing vessels target demersal (associated with the sea floor) fish species in the southern Pacific and southern Indian Oceans. Fishing occurs under high seas permits authorised by the Australian Fisheries Management Authority. These areas are covered by two new regional fisheries agreements: the Southern Indian Ocean Fisheries Agreement and the Convention on the Conservation and Management of the High Seas Fishery Resources of the South Pacific Ocean.

In 2006 the United Nations General Assembly, in considering the implementation of the United Nations Convention on the Law of the Sea 1982, adopted resolution A/RES/61/105 on sustainable fisheries. This resolution calls on states and regional fisheries management organisations to take action to protect vulnerable marine ecosystems from the adverse impacts of bottom fisheries on the high seas and to ensure the long-term sustainability of deep-sea fish stocks. In 2009, A/RES/64/72 reinforced the previous resolution and called for action to regulate bottom fishing.

The Australian Fisheries Management Authority commissioned ABARES to assess the sustainability of harvest levels of deep-sea stocks. The aim of this work was to assess the sustainability of the harvest of key commercial species by Australian vessels in the South Pacific Regional Fisheries Management Organisation and Southern Indian Ocean Fisheries Agreement areas.

This report focuses on non-highly migratory species taken using bottom fishing methods, such as demersal trawl, demersal longline, dropline and traps. This report does not consider highly migratory species taken using pelagic longline or purse seine on the high seas.

High seas fishing operations in the South Pacific and southern Indian Ocean take a wide variety of species, using a diverse range of gears. The project description called for consideration of blue-eye trevalla (*Hyperoglyphe antarctica*), ocean blue-eye (*Schedophilus labyrinthica*), morwong (*Nemadactylus macropterus* and *Nemadactylus* spp.), ocean perch (*Helicolenus barathri* and *H. percoides*), orange roughy (*Hoplostethus atlanticus*), smooth oreodory (*Pseudocyttus maculatus*) and spikey oreodory (*Neocyttus rhomboidalis*). Other species are also considered in this report, based on their importance to the catch (by weight) of the respective high seas fishery area. However, Australian catch in the SIOFA area is not disclosed in this report in order to protect the commercial confidentiality of the single Australian operator that fishes in the SIOFA area.

Limited stock assessment information exists for the species accessed by these fisheries. For this reason, ABARES has used a weight-of-evidence process to determine status. This process considers the spatial and temporal extent of Australian fishing activity in the context of potential habitat area and what is known about other similar fisheries for the same, or similar, species.

Little data was available with which to determine the sustainability of harvest levels in high seas fisheries. However, ABARES has been able to draw some conclusions about the potential impact of Australian fishing operations on high seas stocks. Where possible, this report presents stock status for both the Australian fishery and the broader fishery areas. In many cases, insufficient information was available with which to assess status at the broader fishery scale, resulting in stocks being given an uncertain classification.

None of the species or stocks accessed by Australian operations was classified as overfished or subject to overfishing. Most species or stocks currently accessed by Australian operations are only accessed in a small proportion of the total assumed available habitat area. The exception to this generalisation may be orange roughy in the South Pacific Regional Fisheries Management Organisation area. For this species, there is more information on Australian and New Zealand catch, and estimates have been made of sustainable harvest rates for a number of key fishery grounds in the South Pacific. It is uncertain whether harvest levels above what was estimated to be sustainable will drive orange roughy stocks into an overfished state.

To improve our understanding of the sustainability of harvest levels in high seas fisheries, greater resolution is required in catch and effort data. This would allow assessments to be conducted for high seas and straddling stocks between or among jurisdictions. A better understanding of stock structure and the level of connectivity between stocks or fishing grounds would improve interpretation of catch and effort data.

Table S1 Status summary for trawl and non-trawl stocks, South Pacific Regional Fisheries Management Organisation Area and Southern Indian Ocean Fisheries Agreement Area

Fishery	Species	Status Australian fishery	Status Whole fishery area
SPRFMO trawl	Alfonsino (*Beryx splendens*)	Not subject to overfishing	Uncertain
	Orange roughy (*Hoplostethus atlanticus*)	Uncertain	Uncertain
	Smooth oreodory (*Pseudocyttus maculates*)	Not subject to overfishing	Uncertain
	Spikey oreodory (*Neocyttus rhomboidalis*)	Not subject to overfishing	Uncertain
SPRFMO non-trawl	Blue-eye trevalla (*Hyperoglyphe antarctica*)	Not subject to overfishing	Uncertain
	Morwong species (*Nemadactylus macropterus* and *Nemadactylus* spp.)	Not subject to overfishing	Uncertain
	Ocean blue-eye (*Schedophilus labyrinthica*)	Not subject to overfishing	Uncertain
	Ocean perch (*Helicolenus barathri* and *H. percoides*)	Not subject to overfishing	Uncertain
	Red throat emperor (*Lethrinus miniatus*)*	Not assessed	Not assessed
	Yellowtail kingfish (*Seriola lalandi*)*	Not assessed	Not assessed
SIOFA trawl	Alfonsino	Uncertain	Uncertain
	Blue-eye trevalla	Not subject to overfishing	Uncertain
	Boarfish, unspecified (*Pentacerotidae* spp.)*	Not assessed	Not assessed
	Cardinalfish, unspecified (Apogonidae, Dinolestidae)*	Not assessed	Not assessed
	Ocean blue-eye	Not subject to overfishing	Uncertain
	Ocean perch	Not assessed	Not assessed
	Orange roughy	Uncertain	Uncertain
	Smooth oreodory	Not subject to overfishing	Uncertain
	Spikey oreodory	Not subject to overfishing	Uncertain

Note: * additional species that may be of interest to the management of high seas fisheries.

1 Introduction

Background

There has been increasing focus on the management of high seas fisheries, and in particular deep-sea or bottom fisheries involving non-highly migratory species. In such fisheries, the fishing gear operates close to, or in contact with, the sea floor. Methods used include demersal trawling, demersal longlining, droplining and traps.

Australian fishing vessels target demersal (associated with the sea floor) fish species in the southern Pacific and southern Indian Oceans. Fishing occurs under high seas permits authorised by the Australian Fisheries Management Authority (AFMA). These fishing areas are covered by two new regional agreements:

- Southern Indian Ocean Fisheries Agreement (SIOFA)—adopted in 2006 and entered into force on 21 June 2012. Australia ratified the agreement in March 2012.
- Convention on the Conservation and Management of the High Seas Fishery Resources of the South Pacific Ocean—adopted in 2009 and entered into force on 24 August 2012. The convention is implemented by the South Pacific Regional Fisheries Management Organisation (SPRFMO). Australia ratified the convention in March 2012.

This report does not consider pelagic longlining or purse seine fishing for highly migratory species on the high seas. Australia is a member of the Indian Ocean Tuna Commission and the Western and Central Pacific Fisheries Commission. These bodies are responsible for managing highly migratory species. Species considered in this report are detailed in Table 3.

In 2006 the United Nations General Assembly (UNGA), in considering implementation of the United Nations Convention on the Law of the Sea 1982, adopted resolution A/RES/61/105 on sustainable fisheries. The resolution calls on states and regional fisheries management organisations (RFMOs) to take action to protect vulnerable marine ecosystems from the adverse impacts of bottom fisheries on the high seas and to ensure the long-term sustainability of deep-sea fish stocks. In 2009, resolution A/RES/64/72 repeated the call for action to regulate bottom fishing. These resolutions are applicable to Australia's high seas fishing activities in the SPRFMO and SIOFA areas.

In line with the UNGA resolutions and SPRFMO interim measures (SPRFMO 2007a), AFMA commissioned bottom fishery impact assessments (BFIAs) for Australian high seas fishing in SPRFMO and SIOFA areas (Williams et al 2011a, 2011b). These assessments focused on the impact of fishing on vulnerable marine ecosystems; AFMA developed management responses on the basis of the outcomes (AFMA 2011).

AFMA commissioned ABARES to undertake an assessment of the sustainability of harvest levels of deep-sea stocks, the results of which are presented in this report. This work complements the BFIAs and addresses a condition of the high seas permits to export native species under the *Environment Protection and Biodiversity Conservation Act 1999*.

Deep-sea fisheries are generally located at depths between 200 and 2000 metres, on continental slopes or isolated oceanic structures such as ridges, seamounts and banks (FAO 2012). These structures tend to support commercially viable fish populations because their modified physical and biological dynamics enhance the localised production and retention of food. Some deepwater species form dense aggregations over these structures, providing the potential for large catches (Norse et al. 2012).

Often these fisheries are based on species that tend to be slow growing, late maturing (~30 years) and low in reproductive capacity. These life history characteristics and the aggregating behaviour of some species make them particularly vulnerable to commercial fishing activities and have resulted in a number of deep-sea trawl fisheries experiencing a boom in catch, followed by a bust (Norse et al. 2012). While management measures may have been adopted, such as the limitation of fishing effort or total allowable catches, recovery rates have been relatively slow and many deepwater species are still fished beyond sustainable biological limits (Koslow et al. 2000).

The depths and distances from the coast at which these fisheries occur pose scientific and technical challenges, particularly in providing scientific support for management (FAO 2012). Commercial deepwater fisheries began to develop in the 1960s and 1970s, coinciding with declines in shallow-water stocks (Koslow et al. 2000). Consequently, there has been an increased worldwide effort to exploit these resources. It is estimated that 40 per cent of the world's trawling grounds are now in waters deeper than the continental shelves (Roberts 2002).

Overview of fishing in regional fisheries management organisations

South Pacific Regional Fisheries Management Organisation

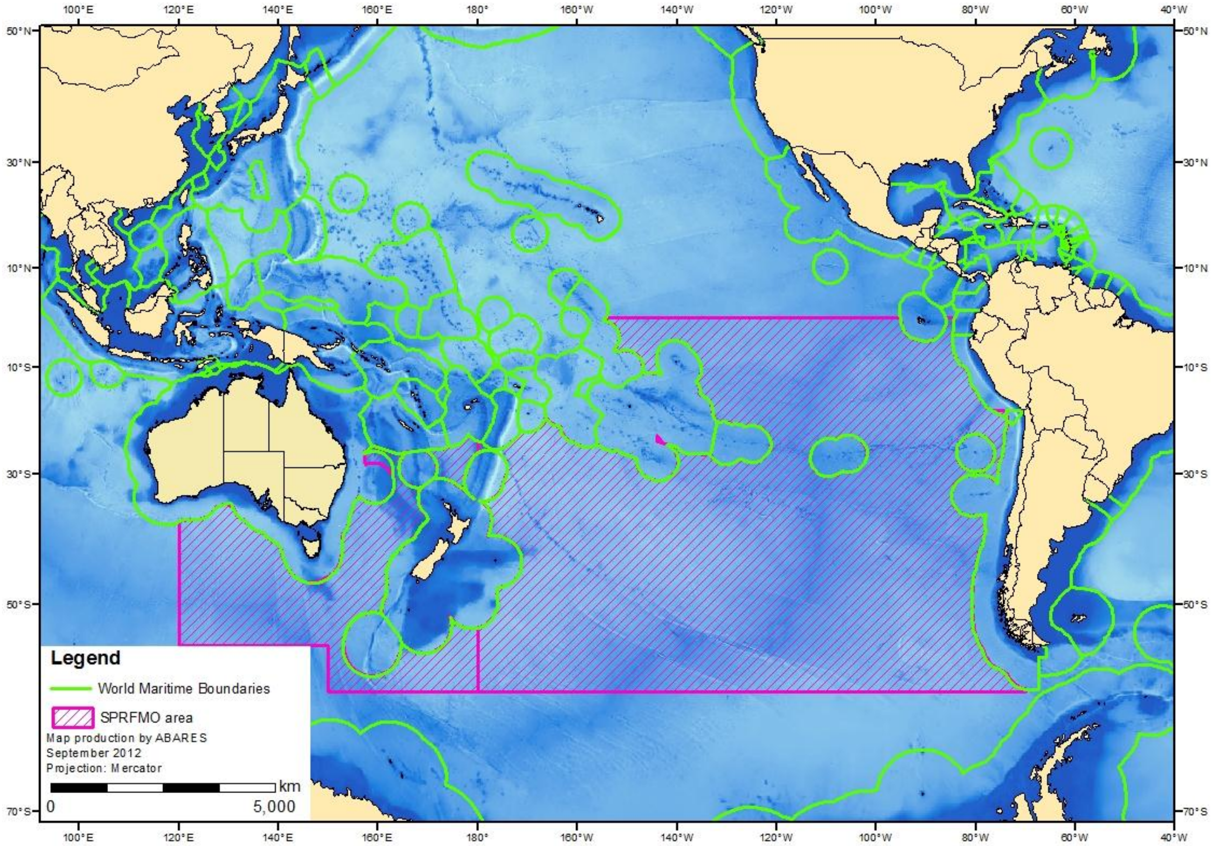
The Convention on the Conservation and Management of the High Seas Fishery Resources of the South Pacific Ocean covers non-highly migratory fisheries resources in the South Pacific Ocean (Map 1). The area has been fished by vessels from a number of countries, using both pelagic and demersal gear. The bottom fisheries target demersal species found on seamounts and ridges in the central and western areas of the southern Pacific Ocean.

In the early 1970s, trawl fleets from the then Union of Soviet Socialist Republics (USSR) began fishing the high seas in the South Pacific for deep-sea species. These vessels fished on the Geracyl Ridge, south east of the Louisville Ridge (Map 1), taking pencil (or bigeye) cardinalfish (*Epigonus denticulatus*), orange roughy (*Hoplostethus atlanticus*), blue grenadier (*Macruronus novaezelandiae*) and oreodories (Clark et al. 2007). New Zealand began developing deep-sea trawl fisheries for orange roughy inside its exclusive economic zone (EEZ) in the late 1970s. Deep-sea fishing for orange roughy in Australian waters began in the latter half of the 1980s (FAO 2008).

Expansion of Australian and New Zealand high-seas bottom fisheries saw the establishment of a fishery on the Louisville Ridge in 1993 and on the South Tasman Rise in 1997. New Zealand and Australian vessels dominated these fisheries. However, other nations, such as Norway, Japan, the Republic of Korea, Belize, Ukraine and Panama, also accessed these deep-sea resources at various times (Gianni 2004).

Australian fishing in the South Pacific Regional Fisheries Management Organisation (SPRFMO) Area occurs under AFMA high seas permits. Historically, the Australian fishing effort targeted orange roughy, using demersal trawl gear. There was no trawl activity between 2008 and 2010 (the last year included in these analyses). Non-trawl activity (predominately line methods) has been at a low level in recent years, targeted at different species; and there was limited gillnet effort between 1998 and 2003.

Map 1 South Pacific Regional Fisheries Management Organisation Area



Note: SPRFMO = South Pacific Regional Fisheries Management Organisation.

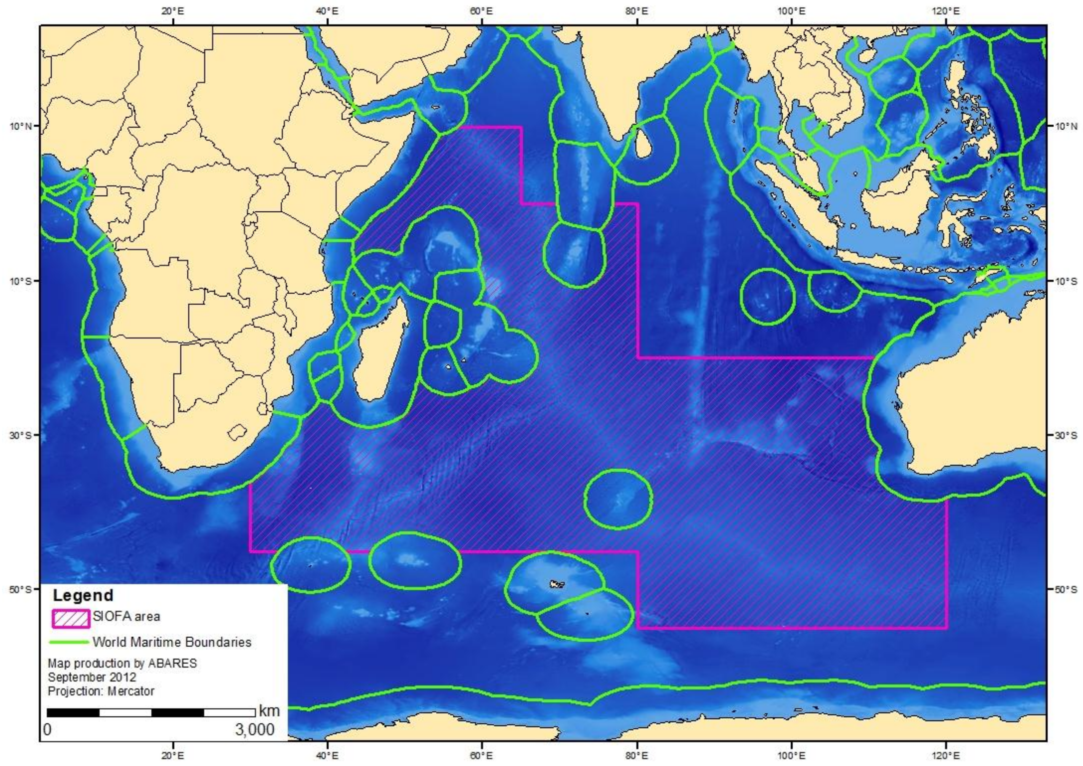
Data Sources: AFMA, high seas fishery data; Geoscience Australia, coastline and Australian Economic Exclusion Zone; Flanders Marine Institute, international EEZs; NOAA, bathymetry

Southern Indian Ocean Fisheries Agreement

The Southern Indian Ocean Fisheries Agreement (SIOFA) covers the southern Indian Ocean area where fisheries have focused on seamounts and ridges (Map 2). Deep-sea trawling started in the SIOFA Area with the then USSR in the 1970s. USSR vessels conducted periodic deep-sea trawl research cruises on a commercial scale throughout the 1980s and 1990s, with catches ranging from over 6000 tonnes in 1980s to 10 tonnes in 1990. Between one and three Ukrainian deep-sea trawl vessels operated in the SIOFA Area in the 1990s (Bensch et al. 2009; Clark et al. 2007; Romanov 2003).

Deep-sea trawlers from New Zealand and Australia were reportedly fishing in the region before 1999. In 1999 there was a major increase in deep-sea trawling in the SIOFA Area with the discovery of orange roughy stocks (Japp & James 2005).

Map 2 Southern Indian Ocean Fisheries Agreement Area



SIOFA = Southern Indian Ocean Fisheries Agreement

Data Sources: AFMA, high seas fishery data; Geoscience Australia, coastline and Australian Economic Exclusion Zone; Flanders Marine Institute, international EEZs; NOAA, bathymetry

In 2000 the combined catch of deepwater species for all vessels was estimated at 40 000 tonnes (Bensch et al. 2009). This catch was made by up to 50 vessels from more than 12 countries. Accurate catch data are unavailable due to the unreported and unregulated nature of the high seas fishery (Bensch et al. 2009). Although more vessels were thought to be fishing in 2001, only eight reported their activities to the FAO.

Six Australian licensed vessels have reported catch from the SIOFA Area since 1999. Fishing methods have been specified on Australian high seas permits since 2008. Methods include mid-water trawl, demersal trawl, auto-longline, dropline and trapping. Gillnetting was allowed before 2008, although no records of gillnet fishing by Australian operators in the SIOFA Area exist after 1999 (Williams et al. 2011b). Current Australian fishing is dominated by mid-water and bottom trawl, on or around seamounts, for alfonsino and orange roughy.

2 Objective

The objective of this report is to assess the sustainability of the harvest by Australian flagged vessels of key commercial species in high seas fisheries in the SPRFMO and SIOFA areas.

High seas fishing operations in SPRFMO and SIOFA areas take a wide variety of species, with a diverse range of gears. The project description called for consideration of blue-eye trevalla (*Hyperoglyphe antarctica*) ocean blue-eye (*Schedophilus labyrinthica*), morwong (*Nemadactylus macropterus* and *Nemadactylus* spp.), ocean perch (*Helicolenus barathri* and *H. percoides*), orange roughy (*Hoplostethus atlanticus*), smooth oreodory (*Pseudocyttus maculatus*) and spikey oreodory (*Neocyttus rhomboidalis*).

Other species are also considered in this report, based on their importance to the catch (by weight) in the high seas area. Arbitrary thresholds were set for the consideration of species in these analyses. Species taken by trawl with a total historical catch less than 200 tonnes and species taken by non-trawl methods with a total historical catch less than 100 tonnes were not considered.

3 Approach

The process of combining available information to enable status determination comprised:

- data collection, interpretation and error checking
- production of catch and effort statistics by species and by key fishing ground
- compilation and consideration of available biological data, including stock delineation and outcomes from Commonwealth ecological risk assessment process
- investigation of habitat metrics to inform conclusions on the sustainability of harvest levels (at both the regional and Australian fishery levels).

Investigation of the available reported catch and effort data, and attempts at constructing standardised catch rate series for a number of species at a number of fishing grounds, indicated that trends in catch per unit effort (CPUE) were unlikely to yield meaningful outcomes for status determination. This is largely due to the quality of data (effort units, spatial resolution and species resolution). Additionally, trends in catch rates are unlikely to provide a reliable index of abundance for some of the more important species (as indicated by quantity of catch) due to their aggregating behaviour, sporadic fishing activity in some areas and the way in which fishers target such species.

There was insufficient data to attempt conventional quantitative stock assessment approaches. Therefore, conclusions regarding the sustainability of the exploitation of high seas fish stocks by Australian vessels relied on a weight-of-evidence approach that considered the species taken, their inherent vulnerability to fishing activity, the spatial extent of Australian fishing, potential habitat extent and amount of catch. Also considered were assessments of the species of interest in other/neighbouring fisheries and available habitat information. ABARES uses a similar weight-of-evidence approach for status determination of low information stocks in the *Fisheries status reports* for fisheries and fish stocks managed by the Australian Government (Woodhams et al. 2011).

4 Methods

Data

ABARES compiled logbook data (as collected by AFMA) for high seas permits active in the SPRFMO Area from 1987 to 2010 (last record 2007) and SIOFA Area from 1992 to 2010.

Logbook data is subject to standard data cleaning routines in AFMA to remove any obvious data errors. These data were summarised by RFMO, gear, species and key fishing ground. Key fishing grounds were defined by Williams et al. (2011a, 2011b). Some data and analyses from New Zealand fisheries were also considered. Observer data and catch disposal records were not used due to their limited availability. Data from other countries that have historically fished in either SPRFMO or SIOFA areas were not available at an informative scale for inclusion in these analyses. However, catches known, or known to have occurred, have been considered.

The BFIAs for Australian high seas fishing in SPRFMO and SIOFA areas (Williams et al. 2011a, 2011b) were also considered in the stock status determination process. The BFIAs divide the area of the SPRFMO and SIOFA into fishing grounds and ecologically meaningful bathomes, or depth bands (Williams et al. 2011a, 2011b). These depth bands cover the fishable areas and reflect the depth-correlated composition and structure of marine biota and the distributions of targeted commercial fish species (Williams et al. 2011a, 2011b). The amount of area occupied by each depth band in key fishing grounds was considered for its use as a proxy for habitat. Data are provided at Appendix A.

Analysis and mapping

Australian fishery level operational data for the SPRFMO and SIOFA areas were overlayed with the key fishing grounds in a geographic information system. This enabled ABARES to generate summary statistics of catch and effort at the level of key fishing ground. These summary statistics form a key component of the weight-of-evidence information that would inform status determination.

Biological data

Available biological information and risk assessment analyses were considered in the status determination process. These are provided at Appendix B.

Status determination framework

The sustainability of harvest levels by Australian vessels is informed by the process undertaken in the compilation of the ABARES *Fishery status reports* (Woodhams et al. 2011). In these reports, the biological status of each stock is assessed in terms of its current stock size (biomass) and the rate of removals from it (fishing mortality). The reference points or thresholds associated with status determination in the *Fishery status reports* are based on the *Commonwealth Fisheries Harvest Strategy Policy* (DAFF 2007). Stocks are classified with respect to biomass status and the level of fishing mortality.

For the fish stocks considered here, very little information was available to inform status determination. In all cases, there is insufficient information or data available to develop new quantitative stock assessment models. However, information from existing Australian and New Zealand assessments were considered.

Initially, the project team intended to apply reference points advocated by the *Commonwealth Fisheries Harvest Strategy Policy*. However, this approach was largely uninformative as there were very few indices of abundance with which to compare against predetermined reference points. Instead, ABARES has considered the extent of the Australian (and broader regional) fisheries activity in the context of the potential habitat area and the likely impact of that catch on the potential broader fishery level (SPRFMO and SIOFA) stock.

5 Catch and effort statistics

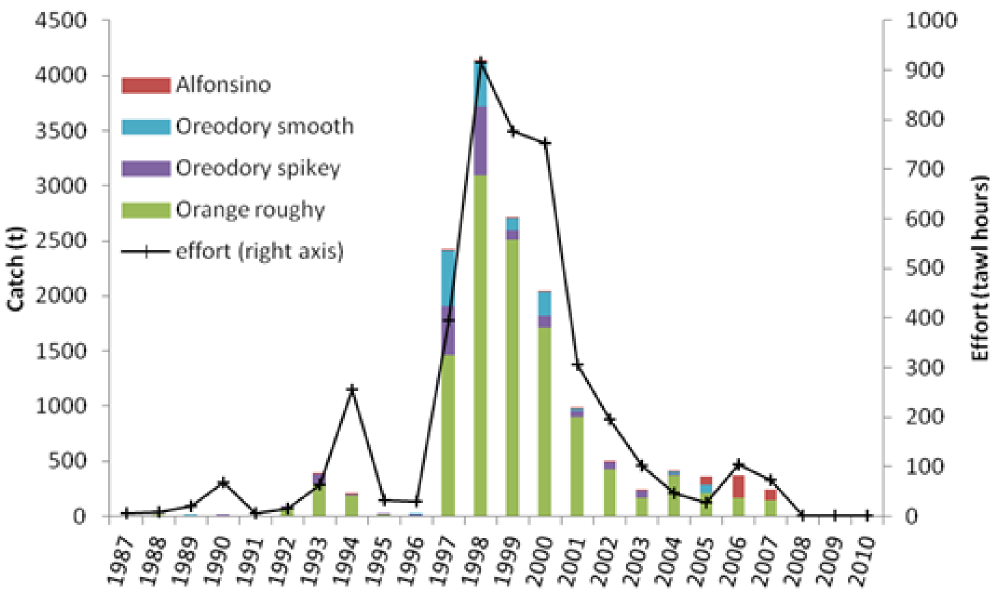
South Pacific Regional Fisheries Management Organisation Area

Trawl fishery: catch and species composition

From 1988–2007 the total reported trawl catch by Australian licensed vessels in the SPRFMO Area was approximately 15 345 tonnes. There was no trawl effort between 2008 and 2010. Four species account for around 15 126 tonnes or approximately 99 per cent of the landed catch. These species are orange roughy, spikey and smooth oreodories, and alfonsino (*Beryx splendens*). Of these four species, orange roughy contributed around 11 750 tonnes (~77 per cent), while spikey oreodory, smooth oreodory and alfonsino make up 1589 tonnes (~10 per cent), 1386 tonnes (~9 per cent) and 400 tonnes (~3 per cent), respectively (Figure 1).

Approximately 80 per cent of the catch of the four key trawl species was taken from 1997 to 2001. This peak corresponded with the peak in effort (trawl hours). Around 379 tonnes (95 per cent) of the total alfonsino trawl catch (400 tonnes) was taken between 2005 and 2007. The alfonsino catch is understood to be primarily taken by mid-water trawling, while other species are taken by demersal trawling (Williams et al. 2011a). Peaks in catch largely follow the trawl effort pattern.

Figure 1 Historic catch of the four key species and fishing effort from Australian trawl vessels, South Pacific Regional Fisheries Management Organisation Area



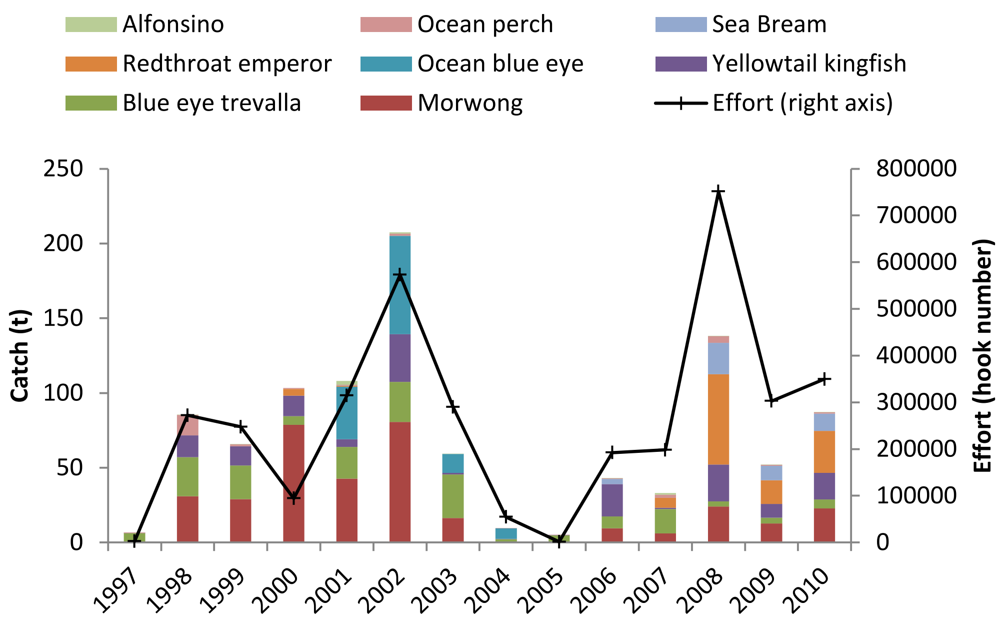
Source: ABARES

Non-trawl fishery: catch and species composition

Australian licensed non-trawl catch in the SPRFMO Area peaked in 2002 at around 200 tonnes (Figure 2). Total non-trawl catch by Australian licensed vessels was approximately 1265 tonnes, taken between 1998 and 2003. Morwong species (*Nemadactylus macropterus* and *Nemadactylus* spp.) made up the largest single component (28 per cent or ~355 tonnes) of the total non-trawl landed catch (Figure 2). Other key species include blue-eye trevalla (~180 tonnes), yellowtail kingfish (*Seriola lalandi*) at approximately 154 tonnes, ocean blue-eye (~121 tonnes) and red throat emperor (*Lethrinus miniatus*) at around 116 tonnes. The catch of red throat emperor in 2008 (~60 tonnes) was more than double that of the next highest caught species, yellowtail kingfish (~25 tonnes), and was the single largest component of catch in 2010. Catch data may be reflecting an evolution in target species in this fishery, with more recent years showing increasing catch of different species, including kingfish, emperor, rock cods and jobfish.

Non-trawl methods include dropline, autoline, trotline, gillnet and fish trapping. Approximately 372 tonnes of the non-trawl catch was taken with gillnets between 1998 and 2003, and approximately 978 kilograms of the non-trawl catch was taken with fish trap in a single year, 2001. In recent years, most of the effort has been line fishing.

Figure 2 Historic catch of the main species by Australian non-trawl vessels, South Pacific Regional Fisheries Management Organisation Area, 1997–2010



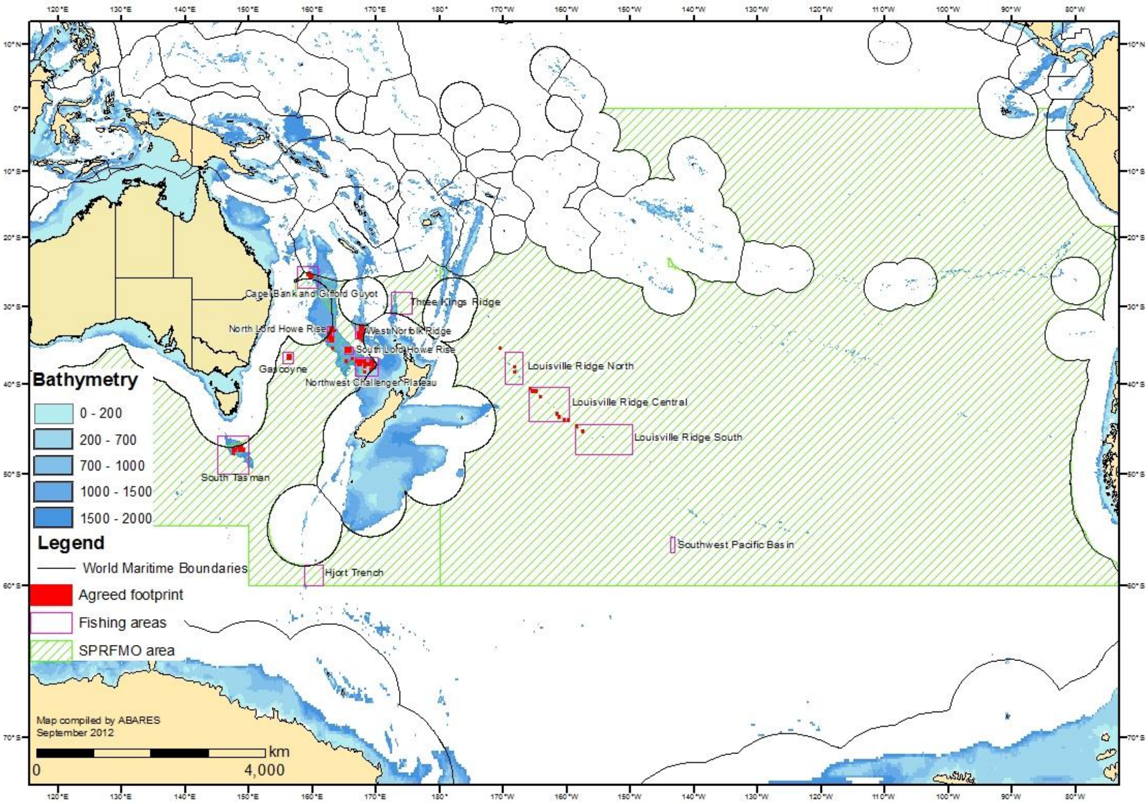
Source: ABARES

Fishing Grounds

Key fishing grounds were defined in the Australian BFIA projects (Last et al. 2010; Williams et al. 2011a, 2011b). The BFIAs define fishable areas in the SPRFMO as depths of less than 2000 metres. These areas make up around 1.1 per cent of the total SPRFMO Area (Map 3).

Operations data from Australian vessels for 1987 to 2010 was overlayed with key fishing grounds to understand the extent of fishing (Map 3). Trawl and non-trawl catch in the SPRFMO Area totalled 16 610 tonnes, of which approximately 15 381 tonnes (93 per cent) is recorded as having been taken from identified fishing grounds.

Map 3 Identified fishing grounds, South Pacific Regional Fisheries Management Organisation Area



Note: SPRFMO = South Pacific Regional Fisheries Management Organisation.

Sources: AFMA, high seas fishery data; Geoscience Australia, Coastline and Australian Economic Exclusion Zone; Flanders Marine Institute, international EEZs; New Zealand Biodiversity System, New Zealand fishing grounds; NOAA, bathymetry; SPRFMO Secretariat, SPRFMO boundary; Williams et al 2011a, fishing grounds

Trawl fishery catch by fishing ground

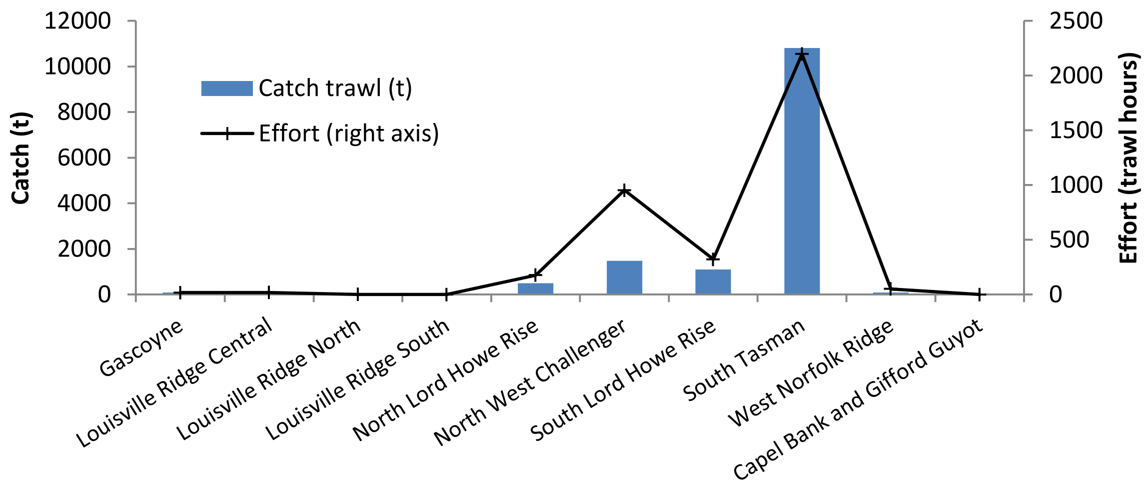
From 1988 to 2007, three fishing grounds accounted for more than 95 per cent of the total SPRFMO Area trawl catch taken by Australian licensed vessels on recognised fishing grounds. South Tasman Rise provided approximately 77 per cent (10 800 tonnes) of the Australian licensed catch (Figure 3). South Tasman Rise provided approximately 59 per cent (2198 trawl hours) of the trawl effort in the fishing grounds.

During the same period, the Northwest Challenger Plateau provided approximately 10 per cent (1474 tonnes) of the Australian vessel catch and the South Lord Howe Rise fishing ground approximately 8 per cent (1093 tonnes). Northwest Challenger Plateau provided around 26 per cent (954 trawl hours) of the total Australian effort in the recognised fishing grounds (3741 trawl hours).

Before its closure in 2007, the South Tasman Rise was the primary fishing ground for orange roughy, spikey oreodory and smooth oreodory in the SPRFMO Area. The South Tasman Rise contributed 68 per cent (7968 tonnes) of the total Australian orange roughy catch (11 750 tonnes), 91 per cent (1452 tonnes) of the spikey oreodory catch and 99 per cent (1374 tonnes) of the total Australian smooth oreodory catch in the SPRFMO Area, from 1987 to 2010. Northwest Challenger Plateau accounted for approximately 1406 tonnes (~12 per cent) of orange roughy and South Lord Howe Rise for approximately 926 tonnes (~8 per cent) of the orange roughy catch.

The key fishing ground for alfonsino in the SPRFMO Area is the North Lord Howe Rise. From 1988 to 2007, this fishing ground provided approximately 95 per cent of the total alfonsino catch taken by Australian licensed vessels, using trawl gear. This fishing ground is adjacent to the ECDTS of the SESSF in Australia's EEZ.

Figure 3 Trawl catch and effort, by fishing ground, South Pacific Regional Fisheries Management Organisation Area, 1988–2007



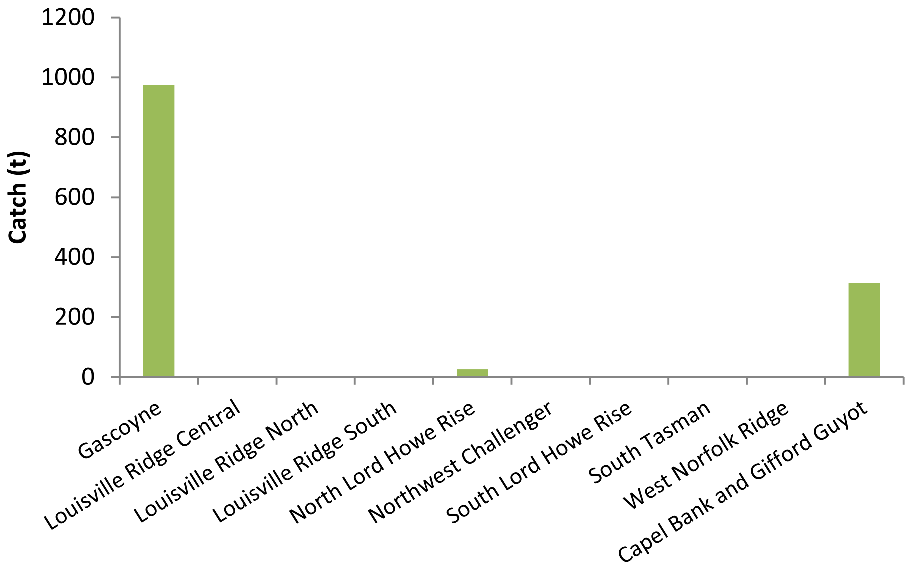
Source: ABARES

Non-trawl fishery catch by fishing ground

Between 1997 and 2010, the Gascoyne fishing ground supported approximately 73 per cent (976 tonnes) of the total non-trawl catch (1319 tonnes) taken by Australian licensed vessels across recognised fishing grounds (Figure 4). The Capel Bank and Gifford Guyot ground supported approximately 19 per cent (314 tonnes) of the total non-trawl catch. Together these fishing grounds accounted for approximately 98 per cent of the non-trawl catch taken by Australian licensed vessels across recognised fishing grounds in the SPRFMO. Effort is not included in Figure 4 due to multiple gear types.

The Gascoyne fishing ground accounted for approximately 97 per cent (344 tonnes) of the morwong catch, 91 per cent (140 tonnes) of the yellowtail kingfish catch, 91 per cent (164 tonnes) of the blue-eye trevalla catch and approximately 97 per cent (117 tonnes) of the ocean blue-eye catch. The Capel Bank and Gifford Guyot fishing ground provided 100 per cent of the red throat emperor catch (116 tonnes).

Figure 4 Non-trawl catch, by fishing ground, South Pacific Regional Fisheries Management Organisation Area, 1997–2010



Source: ABARES

Southern Indian Ocean Fisheries Agreement Area

Trawl fishery: catch and species composition

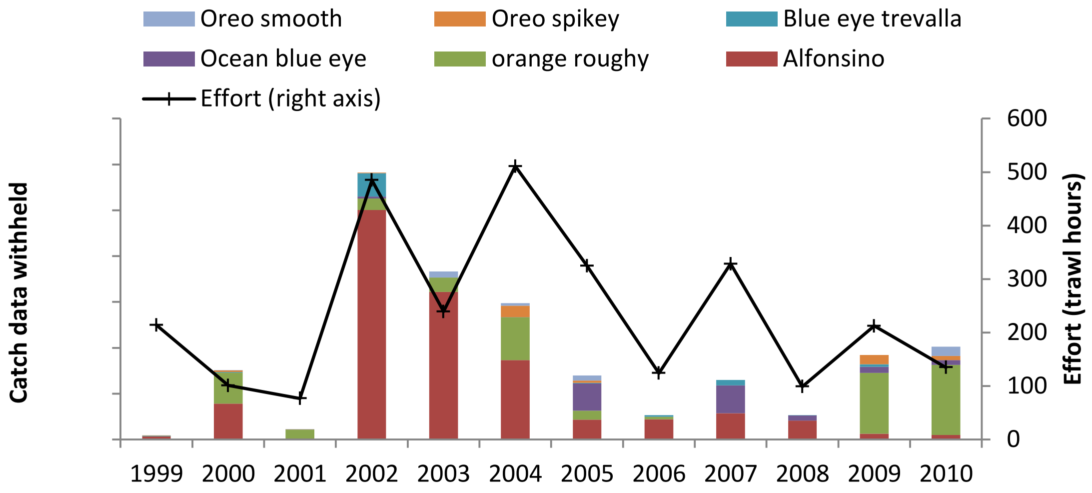
Mid-water and demersal trawl contributed most of the catch from the SIOFA Area. A small number of records (~25 or ~4 tonnes) were attributed to non-trawl methods. These were not considered further in these analyses. Australian catch in the SIOFA area is not disclosed in this report in order to protect the commercial confidentiality of the single Australian operator that fishes in the SIOFA area.

Alfonsino and orange roughy made up 73 per cent of landed catch in the SIOFA Area from 1992 to 2010. Ocean blue-eye and boarfish comprised 11 per cent.

Over half the commercial catch (61 per cent) was taken during the period 2002 to 2005. Alfonsino contributed approximately 68 per cent of this figure. More than 50 per cent of the total orange roughy catch was taken in 2009 and 2010 (Figure 5).

Two years, 2005 and 2007, account for approximately 76 per cent of the total catch of ocean blue-eye trevalla in the SIOFA Area between 1999 and 2010. The bulk of the balance of the catch was between 2008 and 2010. Approximately 70 per cent of the total boarfish catch was taken in 2000.

Figure 5 Australian catch and effort for key commercial species, Southern Indian Ocean Fisheries Agreement Area, 1999–2010

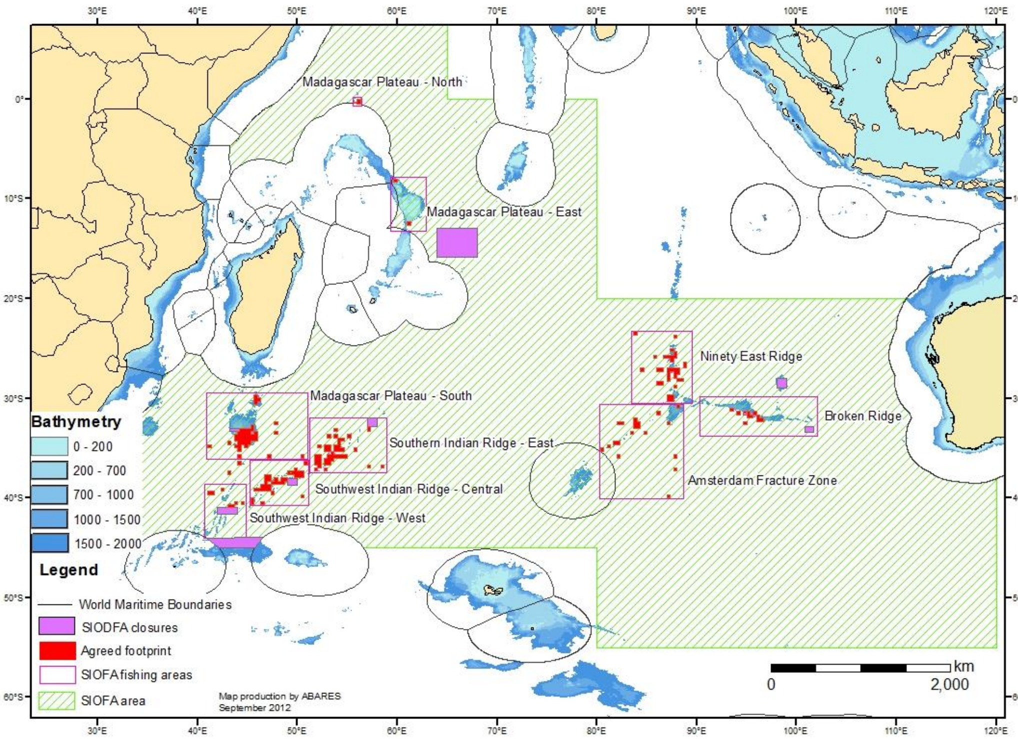


Source: ABARES

Fishing Grounds

The Australian 2010 BFIA defines fishable areas in SIOFA as depths of less than1500 metres (Williams et al. 2011b). Of the total catch in the area, around 87 per cent is recorded as having been taken at identified fishing grounds (Map 4). The Southern Indian Ocean Deepsea Fishers Association has implemented several closures for its members.

Map 4 Identified fishing grounds, Southern Indian Ocean Fisheries Agreement Area



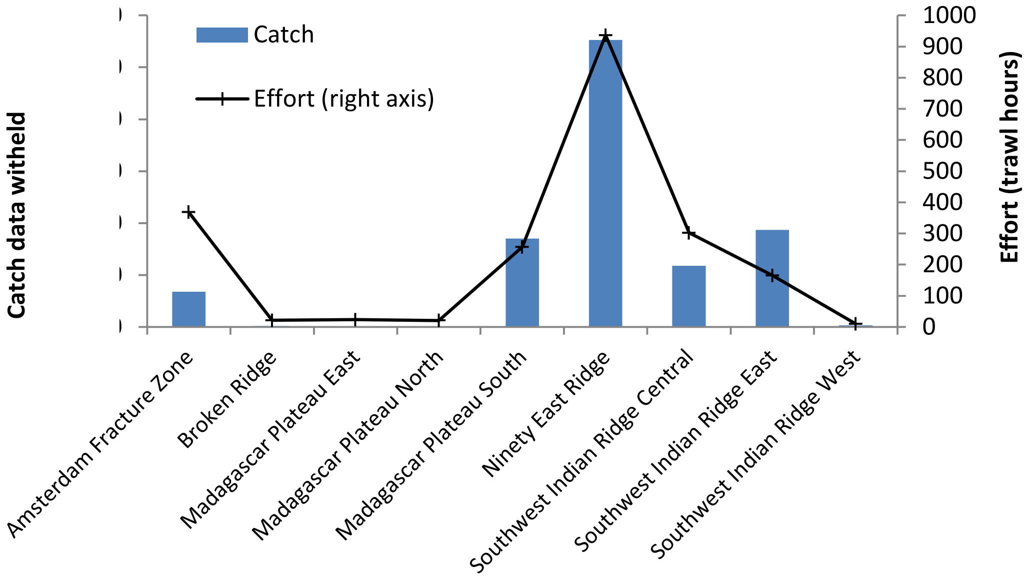
Note: SIODFA = Southern Indian Ocean Deepsea Fishers Association. SIOFA = Southern Indian Ocean Fisheries Agreement

Sources: AFMA, high seas fishery data; Geoscience Australia, Coastline and Australian Economic Exclusion Zone; Flanders Marine Institute, international EEZs; NOAA, bathymetry; SIODFA, SIODFA closures; FAO, SIOFA boundary; Williams et al. 2011a, fishing grounds

Trawl fishery catch by fishing ground

From 1999 to 2010, the Ninety East Ridge fishing ground accounted for approximately 50 per cent of the total catch from recognised fishing grounds (Figure 6). Alfonsino made up approximately 99 per cent of the total catch at this fishing ground.

Figure 6 Catch and effort, by fishing ground, Southern Indian Ocean Fisheries Agreement Area, 1999–2010



Source: ABARES

During the same period, the Southwest Indian Ridge East provided approximately 17 per cent of the SIOFA catch, followed by the Madagascar Plateau South with approximately 15 per cent. The Southwest Indian Ridge Central accounted for around 11 per cent of the catch and Amsterdam Fracture Zone around 6 per cent. The remaining fishing grounds provided less than 1 per cent of the catch.

The catch from Southwest Indian Ridge East was more diverse, with ocean blue-eye comprising approximately 37 per cent of the total catch. Orange roughy made up approximately 19 per cent, and alfonsino approximately 16 per cent of the total catch. Gemfish made up around 8 per cent and cardinalfish (Apogonidae, Dinolestidae) approximately 7 per cent of the catch.

Orange roughy accounted for around 80 per cent of the key commercial catch at the Madagascar Plateau South. Boarfish (Pentacerotidae spp.) made up approximately 9 per cent, alfonsino approximately 5 per cent and cardinalfish approximately 4 per cent of the catch at this fishing ground.

Orange roughy accounted for around 48 per cent of the total key commercial catch from Southwest Indian Ridge Central, followed by smooth oreodory at 21 per cent and spikey oreodory at approximately 18 per cent.

Blue-eye trevalla represented around 36 per cent of the total key commercial catch from the Amsterdam Fracture Zone. Cosmopolitan rubyfish and rubyfish–unspecified make up approximately 20 per cent and trevalla–unspecified and ocean blue-eye made up another 20 per cent. Alfonsino accounted for approximately 19 per cent.

All ocean perch catch in the SIOFA Area were taken in 2008 on the Southwest Indian Ridge East fishing area.

6 Status determination

South Pacific Regional Fisheries Management Organisation trawl fishery

Orange roughy—relevant Australian domestic fisheries

In the Southern and Eastern Scalefish and Shark Fishery (SESSF), the biomass of orange roughy has been classified as overfished since 2001–02 in all areas (eastern, southern and western) except the Cascade Plateau, which is classified as not overfished (Woodhams et al. 2011). Peak catches at Cascade Plateau were recorded between 1996 (972 tonnes) and 2006 (728 tonnes), with the highest catch recorded (1689 tonnes) in 1999. The most recent assessment estimates that the spawning stock biomass at the Cascade Plateau was approximately 63 per cent of unfished levels and in this area, orange roughy remains classified as not overfished and not subject to overfishing (Woodhams et al. 2011: Chapter 9).

Eastern, southern and western orange roughy stocks in the SESSF have been closed to fishing since 2006, under the 2006 Orange Roughy Conservation Program (AFMA 2006). Most areas in the SESSF deeper than 700 metres are also closed to trawl gear. In areas open to fishing, bycatch Total allowable catches (TACs) have been set to cover incidental catch of orange roughy taken while fishing for other species. The exception is Cascade Plateau, which has a dedicated commercial TAC. As a result, these stocks have been classified as not subject to overfishing since 2006 (Woodhams et al. 2011).

No quantitative stock assessment has been conducted for orange roughy in the Great Australian Bight Trawl Fishery (GABTS) because catch and effort have been sporadic (spatially and temporally) through the history of the fishery (Knuckey et al. 2010). Orange roughy cannot be commercially targeted in this fishery and can only be fished under scientific permits (AFMA, 2008). The largest recorded catches of orange roughy in the GABTS were taken in 1988 and 1989, where catches peaked at 3757 tonnes. These early catches were reported as temporary feeding aggregations, associated with cold water upwelling.

These aggregations have not been observed since. Given a zero reported catch (outside of surveys) and limited access under the deepwater management strategy (AFMA 2008), orange roughy is classified as not subject to overfishing in the GABTS. The GABTS orange roughy is classified as uncertain with regard to the level of biomass in 2010 (Woodhams et al. 2011) due to the absence of a stock assessment or other adequate information with which to determine status.

Orange roughy in the SPRFMO Area

There is limited stock assessment information for high seas stocks in the SPRFMO Area. A stock assessment exists for orange roughy on the South Tasman Rise and a number of assessment methods have been applied to orange roughy stocks at several fishing grounds, primarily accessed by New Zealand (Clark et al. 2010).

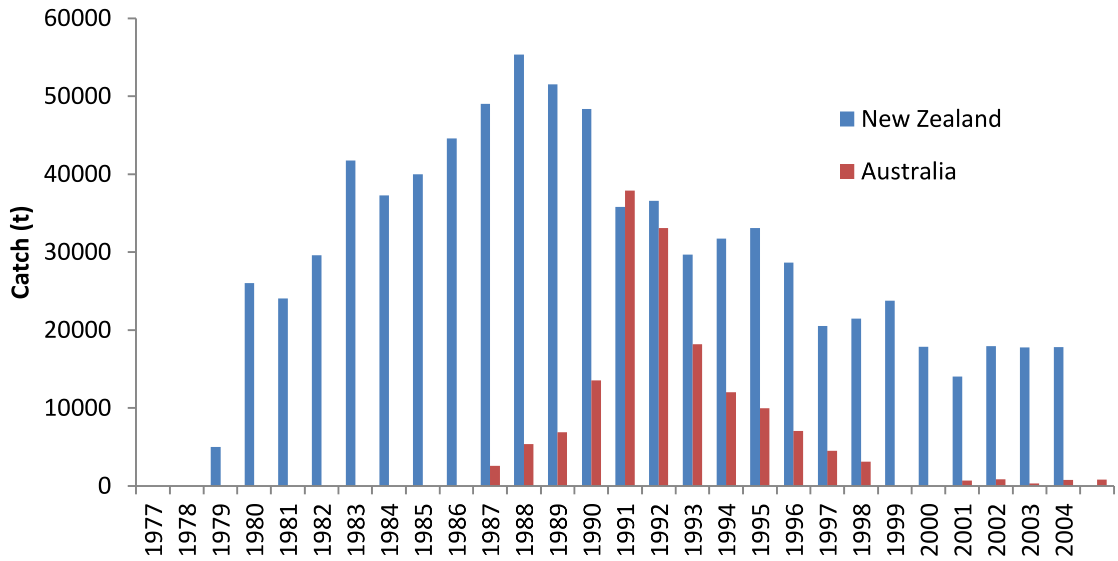
Orange roughy has been targeted using trawl gear in the south-west Pacific Ocean since 1979. The Lord Howe Rise and Northwest Challenger Plateau grounds have been the main areas of orange roughy catch in the Tasman Sea, outside the exclusive economic zones of New Zealand and Australia.

The New Zealand Lord Howe Rise fishery has supported as many as 54 vessels. The fishery has been dominated by New Zealand registered vessels, although there was some effort in earlier years by vessels registered in Norway, Korea, Russia, Japan, Belize, Panama, Cook Islands, the then USSR and Australia (Clark 2008). From 2005 to 2008, the majority of effort (~85 per cent) has been by New Zealand registered vessels.

Belize, China, Korea, Russia and Ukraine have all fished for orange roughy in the SPRFMO Area in recent years; however, there is no available data on the location of these operations.

Reported landings of orange roughy in the South Pacific Ocean by Australian and New Zealand vessels, as reported to the United Nations Food and Agriculture Organization (FAO), are presented in Figure 7. The catch of orange roughy by Australia and New Zealand for specific fishing grounds is provided at Figure 8 and Figure 9.

Figure 7 Reported landings of orange roughy, South Pacific, 1977–2004



Note: Includes catches from exclusive economic zones and on the high seas.

Source: United Nations Food and Agriculture Organization

South Tasman Rise

Between 1987 and 2006, the South Tasman Rise contributed around 68 per cent (7968 tonnes) of the total catch from Australian vessels in the SPRFMO Area (11 750 tonnes) (Figure 8). This fishery has been closed to Australian vessels and New Zealand since 2007. The peak of these catches occurred between 1997 and 2000. Orange roughy on the South Tasman Rise is assessed as part of the annual ABARES *Fishery status reports* and the most recent classification from those reports (Woodhams et al. 2011) is adopted here. This stock was classified in 2010 as **overfished** but **not subject to overfishing**.

Northwest Challenger Plateau and Lord Howe Rise

Between 1990 and 2010, approximately 1406 tonnes of the Australian orange roughy catch in the SPRFMO Area came from the Northwest Challenger Plateau. A further 926 tonnes was taken from South Lord Howe Rise (Figure 9).

Figure 8 Australia and New Zealand orange roughy catch, South Lord Howe Rise fishing ground, South Pacific Regional Fisheries Management Organisation Area, 1990–2010

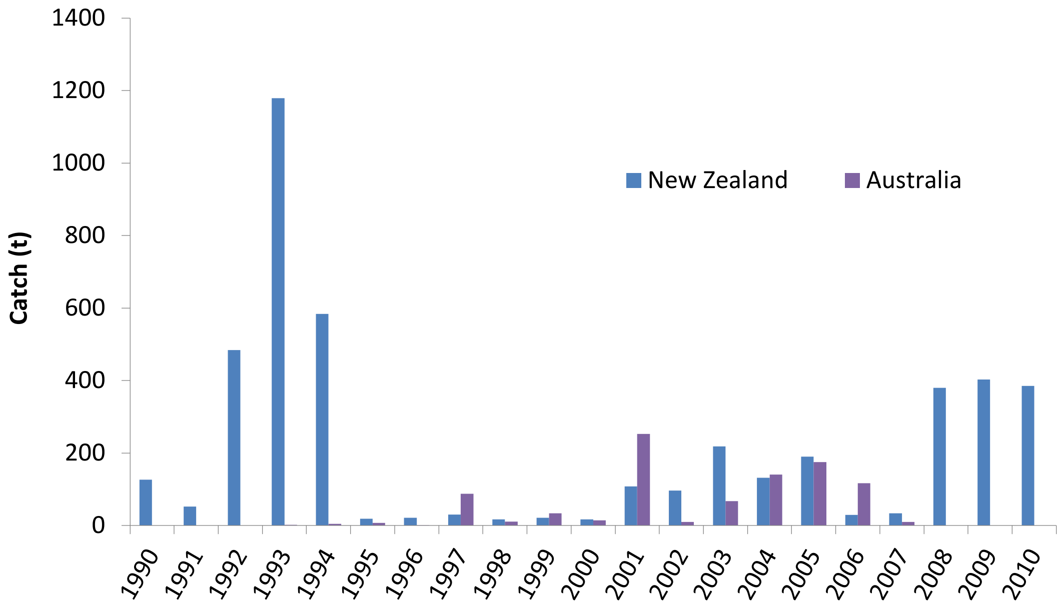
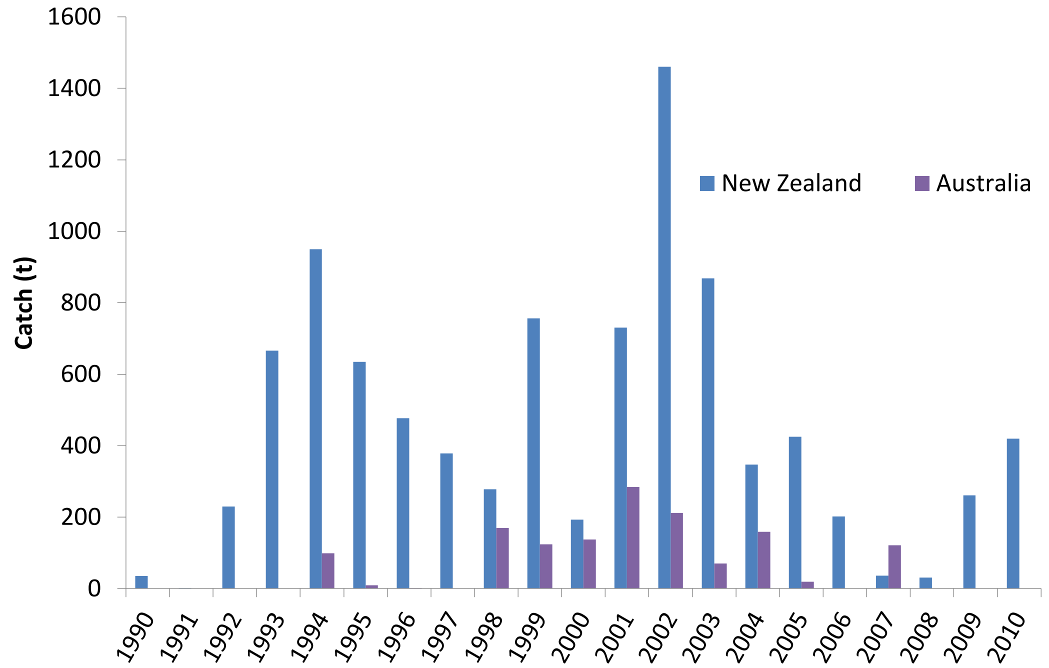


Figure 9 Australia and New Zealand orange roughy catch, Northwest Challenger Plateau fishing ground, South Pacific Regional Fisheries Management Organisation Area, 1990–2010



Source: ABARES

Data and information from Clark et al. (2010) was also considered for its relevance to status determination of orange roughy in the Northwest Challenger Plateau and Lord Howe Rise fishing grounds. Clark et al. (2010) undertook two main analyses:

1) Standardised CPUE analyses using tow-by-tow data between 1992–93 and 2006–07. The analyses fitted a generalised linear model to CPUE, using a step-wise multiple regression technique. Two sets of analyses were carried out: the first on the combined dataset, where fishing ground was a variable within the model; and the second, a series of sensitivity analyses on data from each fishing ground, considered separately.

2) A Seamounts meta-analysis that related total accumulated orange roughy catch (as a proxy for unexploited biomass) to physical characteristics of seamounts to develop a predictive model for estimated unexploited biomass per seamount, based on physical characteristics of each seamount. In the study, a total of 59 seamounts were analysed. The physical variables used in the analysis were latitude, geological association, depth at summit, and estimated slope. The dependent abundance variable was an estimate of the minimum stock size (B_{min}) for a seamount, based on the commercial catch history for New Zealand (Clark et al. 2010). The model was run to find the minimum biomass to enable the catch history to be taken, with the provision that the maximum exploitation rate in any single year would not exceed 0.67 (Clark et al. 2010). Sustainable yield estimates for each fishing area were then calculated from the predicted total biomass on all seamounts in each area, using various yield estimation methods described in the New Zealand Fisheries Assessment Plenary report for 2009 (Ministry of Fisheries 2009).

Maximum constant yield (MCY; the maximum annual catch that is sustainable for future levels of biomass) was estimated at 1.51 per cent of B_0 (unfished biomass), and maximum average yield (MAY; the long-term average annual sustainable catch, if catch is adjusted each year to account for inter-annual variability) at about 1.99 per cent of B_0 (based on values derived from the Chatham Rise).

Outcomes from the catch-rate based analyses (1) indicated that the CPUE for the Northwest Challenger Plateau ground was variable, with perhaps a slow increase overall. There was no clear trend for the Lord Howe Rise. Clark et al. (2010) concluded that standardised CPUE indices of orange roughy from New Zealand fisheries on the high seas are dubious as indices of stock abundance. The CPUE data for all sub-areas examined showed evidence of sequential fishing of locations, suggesting the overall CPUE may be biased upwards over time, with high catch rates being maintained by sequential movement to new fishing areas.

The seamounts meta-analysis (2) estimated a total biomass for orange roughy on all seamounts included in the analysis of 83 800 tonnes (Table 2). Estimated biomass by fishing ground was 8800 tonnes for the Northwest Challenger Plateau and 4130 tonnes for the Lord Howe Rise. The estimated MCY and MAY for Northwest Challenger was 130 tonnes and 170 tonnes annually, respectively. Estimated MCY for Lord Howe (north and south structures combined) was 60 tonnes annually and MAY was 80 tonnes annually.

Table 2 Biomass estimates for fishing grounds, South Pacific Regional Fisheries Management Organisation Area

Region	No. seamounts	Total Predicted biomass (t)	MCY (t)	MAY (t)
West Norfolk	10	14 520	220 (80)	290 (110)
Lord Howe Rise	3	4 130	60	80
Northwest Challenger	14	8 800	130	170
North North Louisville	5	1 390	20 (3)	30 (3)
North Louisville	11	7 510	110	150
Central Louisville	10	38 620	580	770
South Louisville	6	8 820	130 (80)	170 (100)

Note: MAY = the long-term average annual sustainable catch, if catch is adjusted each year to account for inter-annual variability. MCY = the maximum annual catch that is sustainable for future levels of biomass. t = tonnes.
Source: Clark et al. 2010

Clarke et al. (2010) state that the number of seamount features identified within the area of examination is likely to be lower than the true number. As a result, potential total biomass of orange roughy in the area could be higher than that estimated using the habitat based method. The MCY and MAY estimates obtained may therefore be minimum estimates of sustainable annual yield for each area.

However, Clarke et al. (2010) highlight a number of key uncertainties with these assessment methods, which could reduce the reliability of these analyses for status determination. These include the utility of broad scale catch-rate based analyses for spatially and temporally aggregating species, the impact of potential under or over estimation of habitat area, and the potential overestimate of productivity through the use of long-term average recruitment. This indicates that a precautionary approach should be taken to interpreting the MCY and MAY estimates.

In summary

Some evidence indicates that orange roughy is more commonly found between depths of 400 and 900 metres (Froese & Pauly 2012). The structures of the South Tasman Rise, Northwest Challenger and Lord Howe Rise (North and South) account for around 77 per cent of the total area of the 700–1000 metre depth band in the SPRFMO Area (Appendix A). Given that these structures have supported nearly 88 per cent of the orange roughy catch from recognised fishing grounds in the SPRFMO Area, that catches have substantially exceeded meta-analysis estimates of annual sustainable yields and that high catches have been maintained by continual sequential movement to new fishing positions, it is likely that the fishery has had an impact on the orange roughy stock in the western SPRFMO Area.

From 1998–2007 the average annual New Zealand orange roughy catch for the Northwest Challenger Plateau was approximately 530 tonnes. The average annual catch by Australian vessels at the Northwest Challenger Plateau during that time was around 144 tonnes. This is above the MCY (130 tonnes), but below the MAY (170 tonnes) estimated by Clarke et al. (2010). When the New Zealand catch of orange roughy from Northwest Challenger Plateau (Figure 8) is considered in concert with the Australian catch, total removals exceed both the MCY and MAY estimated by Clark et al. (2010).

A similar scenario exists for the Lord Howe Rise fishing grounds (north and south). The average annual Australian catch from 1998 to 2007 was around 83 tonnes. For the same period, New Zealand reported a similar average annual catch, of approximately 86 tonnes. This is in excess of both the MCY (60 tonnes) and MAY (80 tonnes) levels estimated by Clark et al. (2010).

The relationship between stocks at the different fishing grounds is unknown. There is evidence of population structure within the assumed stocks in the Australian Fishing Zone (AFZ), but uncertainties exist (Dunn & Forman 2011; Edmonds et al. 1991; Smith et al. 2002a, 2000b). Research is underway to investigate the orange roughy stock structure in more detail.

The catch recorded by Australia and New Zealand has exceeded the only known estimates of sustainable yield for a number of the fishing grounds in the western SPRFMO Area. However, it is **uncertain** whether these catch levels have reduced, or will reduce, the biomass on these fishing grounds to an overfished state.

Spikey oreodory

From 1990–2007 the total Australian catch of spikey oreodory in the SPRFMO Area was approximately 1589 tonnes. Two years (1997 and 1998) account for around 67 per cent of the total catch and for another five years the catch was greater than 50 tonnes. Approximately 1452 tonnes (91 per cent) was taken on the South Tasman Rise fishing ground in association with the catch of orange roughy. Australia and New Zealand established a memorandum of understanding for cooperative management of the stock in 1998; however, New Zealand vessels have not fished the South Tasman Rise since the end of the 2000–01 season. In 2007 this fishing ground was closed to Australian fishing, both inside and outside the AFZ, as part of the orange roughy stock management arrangement between Australia and New Zealand.

Spikey oreodory has a broad, subtropical distribution. The species is understood to have a depth range of between 200 and 1240 metres, being most commonly found between 450 and 800 metres (Froese & Pauly 2012). According to Williams et al. (2011a, 2011b), the South Tasman Rise fishing ground contributes around 4 per cent to the 200 to 1000 metre depth range (200–700 and 700–1000 metres combined).

Given that the vast majority of Australian spikey oreodory catch has been taken on the South Tasman Rise and this structure accounts for less than 4 per cent of the 200–1000 metre depth range in the SPRFMO Area, it is unlikely that Australian fishing operations have a substantial impact on the stock. On this basis, spikey oreodory at the South Tasman Rise is considered to be **not subject to overfishing**. Similarly, given the absence of Australian trawl activity in SPRFMO since 2007 (and before 2010), this species is considered as **not subject to overfishing** by Australian licensed vessels in the broader SPRFMO Area.

However, estimates of fishing mortality for the entire SPRFMO Area for this species remains **uncertain** until such time as total catches of the species in the area are known. Similarly, as there are no stock assessments to inform the biomass status of spikey oreodory in the entire SPRFMO Area, the state of the biomass in the SPRFMO Area is **uncertain**.

Smooth oreodory

Between 1987 and 2007 the total catch of smooth oreodory by Australian licensed vessels in the SPRFMO was approximately 1386 tonnes. The catch history of this species exhibits a similar trend to that of spikey oreodory, with a peak in activity in the late 1990's. This peak occurred at the same time as peak catches of orange roughy. While there are few years of relatively high catch, the impact of these catches on the biomass of the species is unknown.

Around 99 per cent of the smooth oreodory catch taken by Australian licensed vessels was on the South Tasman Rise. This fishery is now closed to Australian and New Zealand operators, both inside and outside the AFZ. New Zealand's last reported landing of orange roughy at this structure was in 2000. Given that there is no fishing on the South Tasman Rise, smooth oreodory on the South Tasman Rise is considered to be **not subject to overfishing**. Similarly, given the absence of Australian trawl activity in SPRFMO between 2007 and 2010, this species is considered as **not subject to overfishing** by Australian licensed vessels in the broader SPRFMO Area. However, the fishing mortality for the entire SPRFMO Area for this species remains **uncertain** until such time as total catches of the species in the area are known.

Smooth oreodory is understood to have a depth range of between 400 and 1500 metres, being most commonly found between 900 and 1100 metres (Froese & Pauly 2012). According to Williams et al. (2011a, 2011b), the South Tasman Rise fishing ground contributes around 7 per cent to the total area of the 700–1000 metre depth band and 22 per cent to the total area of the 1000–1500 metre depth band. As a result, there is a large area of the SPRFMO where smooth oreodory has not been extensively fished by Australian licensed operators.

As there are no stock assessments to inform the biomass status of smooth oreodory and the total catch by other nations was unknown at the time of compiling this report, the state of the biomass of smooth oreodory in the SPRFMO Area is **uncertain**.

Alfonsino

Between 1988 and 2007 the total trawl catch of alfonsino by Australian licensed vessels in SPRFMO was approximately 400 tonnes. Approximately 378 tonnes (95 per cent) of the total trawl catch was taken in the area of North Lord Howe Rise (Figure 1 & Figure 3). The bulk of the catch (98 per cent) was taken between 2005 and 2007, with annual catches ranging between 81 and 209 tonnes.

It is possible that the fish taken on the Lord Howe Rise (outside the AFZ) fishing ground are part of the same stock as that assessed in the East Coast Deepwater Trawl Sector (ECDTS) of the SESSF, given the continuity of the geological structure either side of the AFZ (Lehodey et al. 1997).

There was limited targeting of alfonsino in the ECDTS until 2000. Between 2000 and 2010, 1242 tonnes of alfonsino was caught in the ECDTS and 259 tonnes in the Commonwealth Trawl Sector (Woodhams et al. 2011). The highest annual catch in the ECDTS was approximately 509 tonnes in 2004.

Currently, alfonsino in the ECDTS is assessed using a catch curve analysis (Tier 3) specified in the SESSF harvest strategy framework (AFMA 2009), based on age-frequency data from otoliths collected in 2003, 2007 and 2009. The most recent assessment indicates that current fishing mortality is less than F_{48} (default proxy for the B_{MEY} target), and the stock was classified as **not overfished** and **not subject to overfishing** in the ABARES *Fishery status reports 2010* (Woodhams et al. 2011). Generally, a catch curve analysis cannot be used to provide an indication of biomass status. However, in this case the biological sampling that supports the catch-curve analysis covers most of the history of the fishery and therefore can give an indication of potential depletion. As assessments have determined that fishing mortality has not been large enough to be considered overfishing, and this has been the case for much of the history of the fishery, the stock was considered to be **not overfished** in 2010.

While the full depth distribution is understood to be from 25–1300 metres, alfonsino is thought to commonly occur at depths between 400 and 600 metres (Froese & Pauly 2012). The North Lord Howe Rise accounts for less than 4 per cent of the 200–700 metre depth band area (the closest depth band to the common distribution). Given that most of the catch was taken on this structure and that it makes up a small component of the total area of this depth band, in the SPRFMO Area, it is unlikely that alfonsino has been extensively fished by Australian licensed operators in the SPRFMO Area.

If the Australian SPRFMO catch on North Lord Howe Rise (outside the AFZ) is being taken from the same stock as that assessed in the ECDTF, the Tier 3 assessment could be assumed to reflect fishing mortality across the stock. That being the case, the stock could be classified as **not overfished** and **not subject to overfishing**. It should be emphasised that these conclusions on stock status are reliant on our assumption that there is a single stock straddling the AFZ and the Lord Howe Rise.

However, we cannot assume that all alfonsino taken in the SPRFMO Area are part of the stock assessed by the ECDTS Tier 3 analyses; further, we do not know the alfonsino catch taken by other nations. As such, the state of the biomass of alfonsino in the SPRFMO Area is **uncertain**.

Other catches of alfonsino in SPRFMO

Between 2002 and 2010 New Zealand reported 395 tonnes of alfonsino catch across all fishing grounds in the SPRFMO Area.

The then USSR reported catches between 1977 and 1980 in the South Pacific area ranging between 1783 and 5323 tonnes. The USSR reported zero catch prior to and after these years. No information is available on the location of catches or level of effort associated with these catches.

Belize also reported catches of alfonsino between 2003 and 2007. No information is available on the location of catches or level of effort associated with these catches (SPRFMO 2012).

Ukraine reported around 20 tonnes of alfonsino in the SPRFMO Area; however, the location and year of operation is not known.

Given the absence of other stock assessment information for alfonsino, it is not possible to know what impact these catches have had on the species throughout the SPRFMO Area as a whole.

South Pacific Regional Fisheries Management Organisation non-trawl fishery

Morwong species

Between 1997 and 2010 approximately 355 tonnes of morwong (*Nemadactylus macropterus* and *Nemadactylus* spp.) was taken by Australian vessels using non-trawl methods in the SPRFMO Area. Most of this catch (278 tonnes or 78 per cent) was taken between 1998 and 2003. The average annual catch of morwong in the SPRFMO was around 11 tonnes between 2003 and 2010. Approximately 97 per cent (344 tonnes) of the total Australian non-trawl morwong catch was taken at the Gascoyne structure.

While it is understood that the New Zealand stock is likely to be a separate stock to those found in Australia (Elliott & Ward 1994), the stock structure in the SPRFMO Area and the relationship between the Gascoyne fishing ground and stocks in the Australian EEZ is unknown.

In Australian waters, morwong is most commonly found between depths of 100 and 200 metres (Kailola et al. 1993). The Gascoyne fishing ground makes up less than 2 per cent of the total area of the 0–200 metre depth band in the SPRFMO Area (the closest depth range from the available data).

The most recent estimate of biomass for morwong in the SESSF is around 35 per cent of the unfished level (Wayte 2011). While there are some uncertainties with this assessment and some considerations concerning recruitment changes in the recent history of exploitation, this stock has supported annual catches in excess of 500 tonnes annually since 1947 (dropping below 500 tonnes in 2010).

Given that the majority of Australian catch has been taken from one structure (Gascoyne) and this structure makes up a small component of the total area of the depth range of the species, it is unlikely that morwong has been extensively fished by Australian licensed operators in the SPRFMO Area. As a result, SPRFMO morwong is considered **not subject to overfishing** by Australian licensed operators.

However, the total mortality of morwong throughout the SPRFMO, by fleets other than Australia, was unknown at the time of compiling this report. The status of morwong in the SPRFMO Area as a whole remains **uncertain** for biomass and fishing mortality, until such time as total catches of the species are known.

Blue-eye trevalla

From 1997 to 2010 the catch of blue-eye trevalla in the SPRFMO Area was approximately 180 tonnes. Of this total, around 91 per cent (164 tonnes) was taken on the Gascoyne fishing ground, mostly between 1997 and 2003 (129 tonnes or 78 per cent). Between 2003 and 2010, the annual catch from Gascoyne has averaged approximately 5 tonnes. These low catches could be considered reasonable evidence to determine that blue-eye trevalla in the SPRFMO has **not** been subject to overfishing by Australian licensed vessels in recent years.

While this species is treated as one stock in the SESSF for assessment purposes, there is some evidence from otolith microchemistry (Bolch et al. 1993) that blue-eye trevalla in the ECDTF and New Zealand waters form part of the same stock, with the remainder of the SESSF a separate stock. Total catches in the SESSF from 1997 to 2010 have exceeded 400 tonnes annually.

The common depth range of blue-eye trevalla is understood to be from 260–490 metres (Froese & Pauly 2012). The Gascoyne fishing ground accounts for less than 1 per cent of the total area of the 200–700 metre depth band in the SPRFMO Area. Given that most of the catch was taken on the Gascoyne fishing ground and the area of the preferred depth band for blue-eye trevalla on the Gascoyne fishing ground makes up a small component of the total area of that depth band in the SPRFMO Area, it is unlikely that the species has been extensively fished by Australian licensed operators in the area.

Further investigation of analyses of other blue-eye trevalla stocks in the South Pacific would help to build a more complete picture of stock status, particularly if there is any likelihood of linkage or movement between these stocks. Starr et al. (2008) describe large declines in CPUE for blue-eye trevalla (referred to as bluenose locally) in New Zealand fisheries, primarily in the Bay of Plenty, off east Northland and other areas since the early 1990’s (Horn & Sutton 2010).

On the basis of the information above, blue-eye trevalla in the broader SPRFMO Area is classified as **uncertain** with regard to biomass and fishing mortality.

Ocean blue-eye

Between 2001 and 2004 the total Australian catch of ocean blue-eye in the SPRFMO Area was around 121 tonnes. Approximately 55 per cent of this catch was taken in one year (2002). Approximately 97 per cent of this catch (117 tonnes) was taken on the Gascoyne fishing ground.

Given that there has been no catch since 2004, ocean blue-eye is considered **not subject to overfishing** by Australian licensed vessels.

The species is distributed between 40 and 500 metres (Froese & Pauly 2012). The Gascoyne fishing ground makes up less than 1 per cent of the total area of the 200–700 metre depth band in the SPRFMO Area, the depth band that most overlaps with the preferred depth range of the species.

Given that most of the catch was taken on one structure and the preferred depth band on this structure makes up a small component of the total area of that depth band in the SPRFMO Area, it is unlikely that the species has been extensively fished by Australian licensed operators in the area.

Stock assessment information is not available for this stock. While the total catch of ocean blue-eye in the SPRFMO Area by Australian licensed operators is low and largely contained to one structure, the total catch of the species in the SPRFMO Area was unknown at the time of compiling this report. As a result, the biomass and fishing mortality status of ocean blue-eye in the SPRFMO Area is considered to be **uncertain**.

Ocean perch

From 1999–2010 the total Australian licensed vessel catch of ocean perch in the SPRFMO Area was approximately 27 tonnes, largely taken by non-trawl methods. Approximately 89 per cent (24 tonnes) was taken on the Gascoyne fishing ground. The average annual reported catch of reef ocean perch from 1999–2010 was around 1.5 tonnes. There was one relatively large year of unspecified ocean perch catch (~14 tonnes) in 1998. In addition, around 3 tonnes were taken at the Capel Bank and Gifford Guyot fishing area.

Based on the catch history of ocean perch from the SESSF, the low catch recorded by Australian vessels in SPRFMO would not be expected to move ocean perch in the SPRFMO Area into an overfished state. As a result, ocean perch could be considered **not subject to overfishing** by Australian licensed vessels. However, the total catch of ocean perch from all nations was unknown at the time of compiling this report. As a result, the biomass and fishing mortality status of ocean perch in the SPRFMO Area remains **uncertain**.

Additional stocks of interest in SPRFMO

Yellowtail kingfish and red throat emperor

From 1997–2010 the Australian non-trawl catch of yellowtail kingfish (catch is likely to be seamount associated, but not demersal) on the Gascoyne fishing ground was around 140 tonnes. This fishing area accounted for approximately 91 per cent (154 tonnes) of the total yellowtail kingfish catch in the SPRFMO Area by Australian vessels between 1997 and 2010. Peak annual catch of yellowtail kingfish on the Gascoyne fishing ground was around 32 tonnes, averaging approximately 10 tonnes annually.

The total Australian non-trawl catch of red throat emperor in the SPRFMO Area was around 116 tonnes from 2000–2010, all of which was taken in the Capel Bank and Gifford Guyot fishing area. The majority of this catch (~90 per cent) was taken between 2008 and 2010. The peak annual catch of red throat emperor on the Capel Bank and Gifford Guyot fishing grounds was around 60 tonnes in 2008.

Catches of these species by other nations is unknown. Given the quantities taken of these two species groups in the SPRFMO Area by Australian licensed vessels, further consideration of sustainable harvest levels may be justified.

Southern Indian Ocean Fisheries Agreement trawl fishery

Stock assessments are not available for the key commercial species taken in the SIOFA Area by Australian fishers and none are known for the species in neighbouring fisheries.

Related Australian Fisheries—orange roughy

There is no formal stock assessment for orange roughy in the Western Deepwater Trawl Fishery (WDTF), and limited information with which to assess stock status (Woodhams et al. 2011). An exploratory fishing survey in 2006 from Perth to Darwin failed to detect orange roughy (Ford 2006). Consequently, there is some concern that the total biomass of orange roughy in the WDTF may be low. Peak catches of orange roughy in the WDTF were made in the early 1990's, with around 300 tonnes taken in 1994–95. However, there has been no recorded catch of the species since 2004–05. As a result, the WDTF orange roughy stock is assessed as **not subject to overfishing** in the ABARES *Fishery status reports* 2010 (Woodhams et al. 2011). There are no current estimates of biomass and relatively high levels of exploitation in the past create uncertainty regarding biomass status. As a result, it is **uncertain** if the stock is overfished.

SIOFA orange roughy

Around 50 per cent of the total catch of orange roughy by Australian licensed vessels in the SIOFA Area from 1999–2010 was taken at Madagascar Plateau South. A further 21 per cent was taken at Southwest Indian Ridge Central and around 13 per cent at Southwest Indian Ridge East.

Madagascar Plateau South recorded its peak catches in 2009 and 2010. Southwest Indian Ridge East recorded its peak catches between 2002 and 2005 and Southwest Indian Ridge Central in 2004 and 2009. This variability in peak catch years may indicate that the fishery is sustaining catches by sequentially fishing different structures in different years. While the number of sequential fishing years on each of the structures is limited, in each case, catches are only high for a few years. Catches at Southwest Indian Ridge East have not returned to their peak (2002 to 2005), despite return trips in 2009 and 2010.

Stock assessments are not available for orange roughy in the SIOFA Area, nor are they available for species in fisheries bordering the area. As such, it is not possible to know what the impact of these catches has been on stocks at the level of fishing ground or for the broader SIOFA Area. The catch of orange roughy by other nations was also unknown at the time of compiling this report. As a result, the status of orange roughy in SIOFA is **uncertain**.

Lessons from other orange roughy fisheries should be considered in the future management of this stock. There are several domestic and international examples of orange roughy stocks that have been overexploited as a result of inadequate regulation. These fisheries typically have a history of rapid depletion in the early stages, rapid decline in availability and abundance, and sequential movement to new fishing areas to sustain catches (Clark et al. 2010, Dunn & Forman 2011). Sequential fishing of orange roughy stocks to sustain profitability in New Zealand fisheries is discussed in Clarke et al. (2010) and a number of papers that support that publication.

Alfonsino

Catch rate standardisation is unlikely to provide a reliable index of abundance for a spatially and temporally aggregating species such as alfonsino, particularly if catch rates are sustained by sequential movement to new fishing areas. However, for the purposes of this report ABARES looked at catch rates for status determination. These endeavours were largely uninformative. As a result, basic comparisons of catch and effort with other similar commercial fisheries and available fishable depth ranges are used to draw conclusions on stock status.

Alfonsino accounted for around 51 per cent of the total Australian SIOFA catch between 1999 and 2010. Approximately 85 per cent of the Australian alfonsino catch in the SIOFA Area was taken on the Ninety East Ridge, most of which (around 72 per cent) occurred in 2002 and 2003. Catch declined sharply after 2003. Catch at the Amsterdam Fracture Zone showed a similar rapid decline in alfonsino catches from peaks around 2002–2004.

Alfonsino is understood to commonly occur between 400 and 600 metres (Froese & Pauly 2012). The 200–700m depth band at the Ninety East Ridge structure makes up less than 1 per cent of the total area of that depth band in the SIOFA Area. Given that most of the catch was taken on one fishing ground and the preferred depth band on this fishing ground makes up a small component of the total area of that depth band in the SIOFA Area, it is unlikely that the species has been extensively fished by Australian licensed operators across the total SIOFA area. While recent catches are low, the scale of historical catches could conceivably have reduced biomass into an overfished state at the scale of fishing ground. As a result, the stock is classified as **uncertain**. Given that the total SIOFA Area catch by other nations is unknown, the status of alfonsino in the SIOFA Area is also **uncertain.**

Ocean blue-eye

Two years (2005 and 2007) account for approximately 76 per cent of the total ocean blue-eye catch in the SIOFA Area by Australian licensed vessels between 1999 and 2010. The bulk of the remaining catch occurred between 2008 and 2010.

Southwest Indian Ridge East accounted for approximately 87 per cent of the ocean blue-eye catch in the SIOFA Area. The species is found at depths between 40 and 500 metres (Froese & Pauly 2012). Southwest Indian Ridge East makes up just over 1 per cent of the area of the 200–700 metre depth band in the SIOFA Area (the closest depth range to the species distribution).

Given that the bulk of the catch was taken on one structure and the preferred depth band on this structure makes up a small component of the total area of that depth band in the SIOFA Area, it is unlikely that the species has been extensively fished by Australian licensed operators in the SIOFA Area. As a result, ocean blue-eye in the SIOFA Area could be considered **not subject to overfishing** by Australian licensed operators.

The catch of ocean blue-eye by other nations was also unknown at the time of compiling this report. As a result, the biomass and fishing mortality status of ocean blue-eye in the SIOFA Area is **uncertain**.

Blue-eye trevalla

Approximately two thirds of the total blue-eye catch in SIOFA between 2002 and 2010 was taken in 2002. Approximately 65 per cent was taken on the Amsterdam Fracture Zone and approximately 85 tonnes was taken on the Southwest Indian Ridge East.

There was no catch of blue-eye trevalla in 2010 by Australian licensed vessels. As such, the stock is classified as **not subject to overfishing** by Australian vessels in 2010.

Blue-eye trevalla is commonly found at depths between 260 and 490 metres (Froese & Pauly 2012). The Amsterdam Fracture Zone and Southwest Indian Ridge East fishing grounds make up less than 3 per cent of the area of the 200–700 metre depth band in the SIOFA Area (the closest depth range to common distribution for the species).

Given that the bulk of the catch was taken on one structure and the preferred depth band on this structure makes up a small component of the total area of that depth band in the SIOFA Area, it is unlikely that the species has been extensively fished by Australian licensed operators in the area.

Given that the level of catch by other nations is unknown for this species, the biomass and fishing mortality status of blue-eye trevalla in the SIOFA Area is **uncertain**.

Spikey and smooth oreodory

Approximately 65 per cent of the catch of spikey oreodory in the SIOFA Area by Australian licensed vessels from 2000 to 2010 was taken at the Southwest Indian Ridge Central and another 22 per cent at Southwest Indian Ridge East.

Approximately 98 per cent of the catch of smooth oreodory in SIOFA by Australian licensed vessels from 2001 to 2010 was taken at Southwest Indian Ridge Central. With these levels of catch, predominately taken from one structure, it is unlikely that that the Australian fleet has had a substantial impact on these stocks throughout the remainder of the fishery. As a result, these species could be considered **not subject to overfishing** by Australian licensed operators in the SIOFA Area.

The absence of knowledge about total catch of these species by all nations in the SIOFA Area contributes to substantial uncertainty regarding status. As a result, the biomass and fishing mortality status of spikey and smooth oreodories in the SIOFA Area is **uncertain**.

Ocean perch and morwong

The total catch of both ocean perch and morwong in the SIOFA Area by Australian licensed vessels was minimal and taken on Southwest Indian Ridge East. These catches are unlikely to have contributed in any substantial way to a change in the overall status of these species in the SIOFA Area. No further assessment was attempted for these species.

Additional stocks of interest in SIOFA

Boarfish and cardinalfish

From 1999–2010 boarfish (*Pentacerotidae* spp.) made up the fourth largest catch category for Australian licensed vessels in the SIOFA Area. The bulk of this catch (69 per cent) occurred in 2000.

Around 38 per cent of cardinalfish (Apogonidae, Dinolestidae) catch by Australian licensed vessels in SIOFA from 2000 to 2010 occurred in 2004.

Catches of these species by other nations is unknown. Given the quantities taken of these two species groups in the SIOFA Area by Australian licensed vessels, further efforts to determine stock status and sustainable harvest levels may be justified.

7 Conclusion

Very few data are available with which to determine the sustainability of harvest levels in the high seas fisheries. However, it is has been possible to draw some conclusions about the potential impact of Australian fishing operations on high seas stocks, based on catch information and areas of available depth range fished. Where possible, ABARES has assessed stock status for both the Australian fishery and the broader fishery area. However, in most cases, insufficient information was available to assess status at the broader fishery scale, resulting in a number of uncertain classifications.

The basic approach for species or stocks accessed by Australian vessels was to look at spatial and temporal extent of catch and compare this with the total area of the preferred depth range for each species. The performance characteristics of other neighbouring fisheries that access similar species, and any other available assessment information, were also considered. For orange roughy in the SPRFMO Area, there is more information on catches taken by Australia and New Zealand, and initial estimates have been made of sustainable harvest rates for the main fishery grounds in the SPRFMO Area.

No species or stocks currently accessed by Australian operations in either SPRFMO or SIOFA were classified as overfished or subject to overfishing (Table 3). The majority of species or stocks currently accessed by Australian operations are only fished in a small proportion of the total area of the preferred depth range for each species. However, it is unclear whether the combined historical catch of orange roughy by Australia and New Zealand at a number of fishing grounds was sustainable.

Table 3 Status summary for trawl and non-trawl stocks, South Pacific Regional Fisheries Management Organisation Area and Southern Indian Ocean Fisheries Agreement Area

Fishery	Species	Status Australian fishery	Status Whole fishery area
SPRFMO trawl	Alfonsino (*Beryx splendens*)	Not subject to overfishing	Uncertain
	Orange roughy (*Hoplostethus atlanticus*)	Uncertain	Uncertain
	Smooth oreodory (*Pseudocyttus maculates*)	Not subject to overfishing	Uncertain
	Spikey oreodory (*Neocyttus rhomboidalis*)	Not subject to overfishing	Uncertain
SPRFMO non-trawl	Blue-eye trevalla (*Hyperoglyphe antarctica*)	Not subject to overfishing	Uncertain
	Morwong species (*Nemadactylus macropterus* and *Nemadactylus* spp.)	Not subject to overfishing	Uncertain
	Ocean blue-eye (*Schedophilus labyrinthica*)	Not subject to overfishing	Uncertain
	Ocean perch (*Helicolenus barathri* and *H. percoides*)	Not subject to overfishing	Uncertain
	Red throat emperor (*Lethrinus miniatus*)*	Not assessed	Not assessed
	Yellowtail kingfish (*Seriola lalandi*)*	Not assessed	Not assessed
SIOFA trawl	Alfonsino	Uncertain	Uncertain
	Blue-eye trevalla	Not subject to overfishing	Uncertain
	Boarfish, unspecified (*Pentacerotidae* spp.)*	Not assessed	Not assessed
	Cardinalfish, unspecified (Apogonidae, Dinolestidae)*	Not assessed	Not assessed
	Ocean blue-eye	Not subject to overfishing	Uncertain
	Ocean perch	Not assessed	Not assessed
	Orange roughy	Uncertain	Uncertain
	Smooth oreodory	Not subject to overfishing	Uncertain
	Spikey oreodory	Not subject to overfishing	Uncertain

Note: * additional species that may be of interest to the management of high seas fisheries.

We have included some discussion of a number of other species that were not part of the original project description. Given that the catch of some of these species was equal to, or more than the catch of some of what are currently considered to be key commercial species, these species may be of interest in future assessments and management decision-making.

An assessment of this nature is difficult to undertake for any high seas fishery. Fewer data are available for high seas than for domestic fisheries, and so many of the usual assessment approaches cannot be used. The variety of species and gears considered, the broad areas covered by SIOFA and SPRFMO and the diversity of habitats in each of those areas makes identifying a reliable assessment approach difficult. The patchy distribution of species, the complex relationship with available habitats and sequential movement of fishing effort to sustain catches essentially preclude the use of CPUE as a reliable index of abundance. It is possible that predictive demersal fish habitat modelling approaches, such as those used by Clark et al. (2010) for orange roughy, may be the only suitable approaches to estimating total abundance and sustainable yields for these high seas fisheries.

To improve our understanding of the sustainability of harvest levels in high seas fisheries, greater resolution is required in the recording and dissemination of catch and effort data. This would allow assessments to be conducted for high seas and straddling stocks by jurisdictions. Opportunities exist for joint assessments, where stocks are shared by more than one nation. Information that would allow better interpretation of the catch and effort data include a better understanding of stock structure and the level of connectivity between stocks or fishing grounds. The catch and effort statistics presented in Chapter 5 of this report identify the key species and fishing grounds that should be targeted in future research efforts. These include orange roughy and alfonsino in the SPRFMO and SIOFA areas.

Appendix A—Area of bathomes (depth band)

Table A1 Area of bathomes, South Pacific Regional Fisheries Management Organisation Area

Fishing ground	Continental shelf	Shallow upper continental slope	Deep upper continental slope	Shallow mid-continental slope	Deep mid-continental slope		Total
Depth	0–200 m	200–700 m	700–1000 m	1000–1500 m	1500–2000 m	>2000 m	
South Tasman Rise			2 619	16 272	15 485	96 482	130 858
North Lord Howe Rise		1 111	9 408	5 260	28		15 807
South Lord Howe Rise			3 379	9 404	572	8	13 363
West Norfolk Ridge	765	5 947	4 648	7 467	5 587	2 292	26 706
Northwest Challenger Plateau		18 246	12 860	22 929	8 356	2 509	64 900
Three Kings Ridge	54	940	1 316	5 931	8 893	88 721	105 855
Louisville Ridge North	82	757	1 185	1 345	1 176	99 396	103 941
Louisville Ridge Central		142	733	1 313	1 337	228 127	231 652
Louisville Ridge South	1	384	256	377	590	254 772	256 380
Hjort Trench	25	65	38	78	340	31 057	31 603
Southwest Pacific Basin			16	79	136	5 836	6 067
Gascoyne	13	269	73	112	144	24 510	25 121
Capel Bank and Gifford Guyot	69	1 108	331	922	14 802	51 251	68 483
Total (%)	1 009 (0.09)	28 969 (2.68)	36 862 (3.41)	71 489 (6.61)	57 446 (5.32)	88 496 (81.89)	1 080 736

Source: Williams et al. 2011a

Table A2 Area of bathomes, Southern Indian Ocean Fisheries Agreement Area

Fishing ground	Shelf 1–200 m	Shallow upper slope 201–700 m	Deep upper slope 701–1000 m	Shallow mid-slope 1001–1500 m	Deep mid-slope 1501–2000 m	>2000 m	
Ninety East Ridge	48	167	303	6 295	21 836	451 543	480 191
Broken Ridge		440	1 614	16 893	37 849	416 149	472 945
Amsterdam Fracture Zone		370	833	9 688	14 901	716 379	742 171
Madagascar Plateau North		20	38	126	316	6 888	7 388
Madagascar Plateau East	36 643	27 937	5 828	11 666	15 314	105 613	203 000
Madagascar Plateau South	169	1 775	13 410	32 668	51 977	600 430	700 429
Southwest Indian Ridge East	39	334	511	2 140	7 834	419 699	430 556
Southwest Indian Ridge Central	6	55	291	2 722	15 419	243 451	261 944
Southwest Indian Ridge West	75	505	968	4 838	12 859	188 422	207 666
Total (%)	36 980 (1.05)	31 602 (0.90)	23 796 (0.68)	87 035 (2.48)	178 304 (5.09)	3 148 573 (89.80)	3 506 291

Source: Williams et al. 2011b

Appendix B—Biological information on key commercial stocks

Alfonsino (*Beryx splendens*)

Parameter	Description
Range	Worldwide except in the north-east Pacific; in Australia, temperate waters from Western Australia to central Queensland, including Tasmania. Widely occurring pelagic species that aggregates around seamounts and features on the upper slope. In the AFZ, alfonsino is targeted in the ECDTS of the SESSF, where the primary area fished is a small area south-east of Lord Howe Island, part of the Lord Howe Rise that extends outside the AFZ. There is also some alfonsino catch in the upper slope area of the Commonwealth Trawl Sector.
Stock structure	No information is available on the stock structure in the AFZ or between the AFZ and adjacent high seas areas in SPRFMO. A study of stock structure in the central Atlantic showed limited gene flow between populations on relatively close archipelagos. Limited movement was also indicated by a tagging study of alfonsino in Japanese waters. Alfonsino collected in Japan and New Caledonia showed identical haplotypes, suggesting there were levels of gene flow at the transoceanic scale. Studies in New Caledonia populations suggest no differentiation between populations. Management and assessment assumes a single stock in the area of the ECDTS, but notes the continuity of Lord Howe Rise and potential for straddling stocks with the high seas.
Depth	25–1300 m
Longevity	20 years
Maturity (50%)	4–6 years; 30–35 cm (FL)
Spawning season	Spawning activity has not been recorded in the AFZ; July–August spawning recorded in New Zealand waters. It has been suggested that populations of alfonsino are associated with large oceanic eddy systems. The exact duration of the pelagic stage of alfonsino is not known; however, larvae and juveniles are frequently sampled in surface water and juveniles less than 10.5 cm have been collected by trawling near the seabed. Therefore it is presumed alfonsino maintains its pelagic stage until it grows to at least 10 cm.
Size	Maximum: ~50 cm (SL) (70 cm, fishbase.org) Recruitment into the SESSF ECDTS: 28–31 cm (FL); ~5 years of age (fully recruited)
ERA outcomes	Alfonsino was found to be at a precautionary medium risk level from commercial fishing operations under the Level 3 SAFE assessment

Note: ~ = approximately; AFZ = Australian Fishing Zone; ECDTS = East Coast Deepwater Trawl Sector; ERA = Ecological Risk Assessment; FL = fork length; PSA = Productivity Susceptibility Analysis; SAFE = Sustainability Assessment for Fishing Effects; SESSF = Southern and Eastern Scalefish and Shark Fishery; SL = standard length.

Sources: Akimoto et al. 2006; Froese & Pauly 2012; Gomon et al. 2008; Hoarau & Borsa 2000; Lehodey et al. 1997; Schönhuth et al. 2005; Slope/DeepRAG 2011; Zhou 2007

Blue-eye trevalla (*Hyperoglyphe antarctica*)

Parameter	Description
Range	In Australia, the species is found from southern Queensland to south-western Western Australia, including Tasmania; also found in South Africa and New Zealand.
Stock structure	Using an analysis of mitochondrial DNA control region sequences, testing was undertaken on the hypothesis that patterns of phenotypic structuring in blue-eye trevalla reflect underlying genetic stock structure. Samples were taken from east and west Victoria and east Tasmania. Results showed no genetic structuring. Genetic studies of stock structure have been conducted using allozyme techniques on samples from Tasmania, New South Wales and South Australia. Results suggest a single population in Australian waters. Regarded as one stock across the SESSF (including the GABTS). New South Wales catch is included in assessments, primarily from dropline methods.
Depth	400–600 m
Longevity	39–42 years
Maturity (50%)	Age: 8–12 years Size: 62–72 cm TL
Spawning season	March–April (Tasmania) and April–June (New South Wales)
Size	Maximum: ~140 cm TL; weight: ~40 kg Recruitment into the fishery: ~50 cm FL; age: 2–3 years; weight: not determined
ERA outcomes	Blue-eye trevalla was found to be at high risk under the Level 3 SAFE assessment

Note: ~ = approximately; FL = fork length; ERA = Ecological Risk Assessment; GABTS = Great Australian Bight Trawl Fishery; SESSF = Southern and Eastern Scalefish and Shark Fishery; SAFE = Sustainability Assessment of Fishing Effects; TL = total length.

Sources: Bolch et al. 1993; Gomon et al. 2008; Robinson et al. 2008; Ward & Elliott 2001; Woodhams et al. 2011; Zhou et al. 2007

Morwong (*Nemadactylus macropterus & N. spp.*)

Parameter	Description
Range	The species is found in the southern waters of Australia, from New South Wales to Western Australia, including Tasmania; also occurs in other areas of the southern hemisphere, including New Zealand.
Stock structure	Molecular phylogenetic analysis of Nemadactylus suggests high dispersal capability in this genus. Larval dispersal of jackass morwong appears linked with surface circulation patterns, and the principal ocean currents operating in southern Australia, the Leeuwin and East Australian Currents, could facilitate movement throughout much of this species' range. Alternatively, multiple stocks of jackass morwong may exist in Australia, but they have not existed long enough for any detectable signal to develop from genetic drift, regardless of sample size and marker sensitivity. Jackass morwong was sampled from eight localities around southern Australia, ranging from Western Australia to New South Wales, and from one area off the western coast of New Zealand. Stocks from New Zealand and Australia were found to be distinct using allozymes and mitochondrial DNA. In Australia, fisheries assessment assumes separate stocks east and west of Bass Strait. Otolith microstructure studies found differences between southern Tasmania and New South Wales/Victoria, but it is unclear if these indicate separate stocks. Catches of jackass morwong from the GABTS are not included in assessments of the western stock.
Depth	10–450 m, but most abundant at 100–200 m
Longevity	20–35 years
Maturity (50%)	Age: 3 years Size: 23–27 cm FL
Spawning season	Late summer and early autumn This species possesses an offshore pelagic larval phase of 8–12 months in duration, suggestive of high dispersal capability, and adult movements of up to 300 km in a year have been recorded.
Size	Maximum: ~70 cm TL; weight: ~5 kg Recruitment into the fishery: 25–30 cm FL; age: 4–6 years; weight: ~0.4 kg
ERA outcomes	Jackass morwong was found to be at low risk in the GABTS and medium risk from auto longline fishing under the Level 3 SAFE assessment

Note: ~ = approximately; ERA = Ecological Risk Assessment; FL = fork length; GABTS = Great Australian Bight Trawl Sector; SAFE = Sustainability Assessment of Fishing Effects; TL = total length.

Sources: Annala 1987; Bruce et al. 2001; Burridge & Smolenski 2003; Elliott & Ward 1994; Grewe et al. 1994; Kailola et al. 1993; Zhou et al. 2007

Ocean blue-eye (*Schedophilus labyrinthica*)

Parameter	Description
Range	The species is found in Australia, from northern New South Wales to south-western Western Australia, including Tasmania; also found in South Africa and New Zealand. This species is caught with blue-eye trevalla.
Stock structure	No stock structure studies have been conducted on this species.
Depth	400–600 m
Longevity	39–42 years
Maturity (50%)	Age: 8–12 years Size: 62–72 cm TL
Spawning season	March–April (Tasmania) and April–June (New South Wales)
Size	Maximum: ~140 cm TL; weight: ~40 kg Recruitment into the fishery: ~50 cm FL; age: 2–3 years; weight: not determined
ERA outcomes	Ocean blue-eye was found to be at low risk under the Level 3 SAFE assessment

Note: ~ = approximately; ERA = Ecological Risk Assessment; SAFE = Sustainability Assessment of Fishing Effects; TL = total length.

Sources: Gomon et al. 2008; Woodhams et al. 2011; Yearsley et al. 1999; Zhou et al. 2007

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

Parameter	Description
Range	Bigeye ocean perch (*Helicolenus barathri*) and reef ocean perch (*H. percoides*) are found in southern Australian temperate waters, from New South Wales to Western Australia, including Tasmania; also found in New Zealand.
Stock structure	There is evidence to suggest that fishing grounds could represent distinct stocks. A study conducted in New Zealand fjords indicates reef ocean perch comprise relatively distinct sub-populations. This divided stock structure is revealed by distinct patterns in morphology, length at age, stable isotopes of muscle tissue, and trace elemental fingerprints of whole otoliths. A 2009 study that looked at the age and growth of reef ocean perch from two adjacent areas off the east coast of the South Island of New Zealand found some stock differentiation between the two areas assessed (East Coast of the South Island and the Chatham Rise). This was based on differences in length–frequency distributions implying different patterns of year class strengths, but also on apparent differences in growth rates between areas. This supports the present management regime of separate commercial catch quotas.
Depth	Reef ocean perch 50–200 Bigeye ocean perch 200–800 m
Longevity	30–60 years
Maturity (50%)	Age: Not determined Size: 30 cm FL
Spawning season	Late winter to early spring
Size	Maximum: 30–40 cm (bigeye ocean perch) FL; weight: 1.5 kg Recruitment into the fishery: ~20–25 cm FL; age: ~7–10 years; weight: not determined
ERA outcomes	These species were assessed as at precautionary medium risk from commercial fishing operations under the Level 3 SAFE assessment

Note: ~ = approximately; ERA = Ecological Risk Assessment; FL = fork length; SAFE = Sustainability Assessment of Fishing Effects

Sources: Haddon 2011; Kailola et al. 1993; Lawton et al. 2010; Park 1994; Paul & Horn 2009; Rowling et al. 2010; ShelfRAG 2011; Zhou et al. 2007

Orange roughy (*Hoplostethus atlanticus*)

Parameter	Description
Range	Occurs in all temperate oceans except the north Pacific; in Australia, it occurs across the south coast from Sydney to Perth and is found in continental slope and seamount areas
Stock structure	Significant differences were found between orange roughy samples taken from Lord Howe Rise and the Northwest Challenger Plateau. These results suggest that interactions between these areas are restricted; hence the areas could be managed as separate units. The distance between Lord Howe Rise and Northwest Challenger is approximately 220 km; thus finding genetic differentiation over this relatively small spatial scale is surprising given the longevity of orange roughy and the apparent lack of oceanographic barriers to larval and juvenile dispersal between the two locations. Other fishing grounds could be assumed to be separate stocks based on the species weak dispersal potential, since their pelagic eggs remain in the water column for a relatively short period and then sink and hatch near the bottom. The species exhibit genetic differentiation at small spatial scales in the south-west Pacific Ocean and Tasman Sea. The stock structure in Australia's SESSF remains unclear, despite considerable research. New research using genetic techniques may elucidate the stock structure of orange roughy in south-eastern Australia on a finer spatial scale. Geographic and biological information indicates Orange roughy on the Cascade Plateau is a distinct stock. For management purposes, the remaining area of the CTS is divided into eastern, western and southern zones, which are assessed separately.
Depth	180–1800 m, but usually found at 700–1200 m
Longevity	90–150 years
Maturity (50%)	Age: ~30 years Size: ~29–32 cm SL
Spawning season	July–August. Fertilised eggs rise in the water column as they develop, but are thought to sink near the end of the development stage to hatch near the bottom approximately 10-20 days after fertilisation. Plankton studies on the Chatham Rise, east of New Zealand, have shown that the eggs of orange roughy ascend rapidly and only remain in the plankton for 10 days before sinking to hatch.
Size	Maximum: 50–60 cm SL; weight: ~3–4 kg Recruitment into the fishery: ~30 cm SL; age: 24–42 years; weight: not determined
ERA outcomes	This species was assessed as at low risk from commercial fishing operations under the Level 3 SAFE assessment

Note: ~ = approximately; CTS = Commonwealth Trawl Sector; ERA = Ecological Risk Assessment; SAFE = Sustainability Assessment of Fishing Effects; SESSF = Southern and Eastern Scalefish and Shark Fishery; SL = standard length.

Sources: AFMA 2008, 2006; Gomon et al. 2008; Knuckey et al. 2010; Smith et al. 2002b; Smith & Benson 1997; Smith et al. 1997; Smith 2007; Smolenski et al. 1993; SPRFMO Science Working Group 2009; Woodhams et al. 2011; Zeldis et al. 1994; Zhou et al. 2007

Smooth oreodory (*Pseudocyttus maculates)*

Parameter	Description
Range	Common in southern oceans and also found in the north-west Atlantic. In Australia, it is found across the south, from New South Wales to Western Australia, including Tasmania.
Stock structure	Smooth oreodories have extensive pelagic dispersal during the juvenile stages. No significant differentiation has been found among samples from New Zealand EEZ. Genetic (allozyme and mtDNA) and meristic studies carried out on smooth oreodory samples from Western Australia, Tasmania, New Zealand and the Lord Howe Rise showed no significant differences. Allozyme and mtDNA haplotype frequencies among samples of smooth oreodory from eastern New Zealand and Australia showed no evidence of genetic differentiation. In Australian EEZ Cascade Plateau oreodory is considered to be a distinct stock. The remaining area of the CTS comprises the non-Cascade Plateau stock.
Depth	650–1500 m, but usually found at 700–1200 m
Longevity	85–100 years
Maturity (50%)	Age: ~25 years Size: ~32–41 cm TL
Spawning season	Unknown. Smooth oreodory has extensive pelagic dispersal during the juvenile stages
Size	Maximum: ~68 cm TL; weight: ~5 kg Recruitment into the fishery: ~34 cm TL; age and weight: not determined (age 24–28)
ERA outcomes	This species was assessed as at low risk from commercial fishing operations under the Level 3 SAFE assessment

Note: ~ = approximately; CTS = Commonwealth Trawl Sector of the Southern and Eastern Scalefish and Shark Fishery; ERA = Ecological Risk Assessment; EEZ = exclusive economic zone; PSA = Productivity Susceptibility Analyses; SAFE = Sustainability Assessment of Fishing Effects; TL = total length.

Sources: Gomon et al. 2008; Smith et al. 2002a, 1997; SPRFMO 2007b; Ward et al. 1998, 1996; Woodhams et al. 2011; Zhou et al. 2007

Spikey oreodory (*Neocyttus rhomboidalis*)

Parameter	Description
Range	Generally found in cold waters of all southern oceans
Stock structure	There is no information concerning stock structure of spikey oreodory. In Australian waters the stock structure is generally unknown. For management purposes, a single stock is considered in the CTS, outside of the Cascade Plateau.
Depth	290–1520 m
Longevity	100–140 years
Maturity (50%)	Age: 27 years Size: ~20–35 cm TL
Spawning season	September–October. Spikey oreodory is a synchronous spawner. Eggs float near the surface and larvae probably also inhabit surface waters. Spikey oreodory assumed to have a pelagic juvenile phase.
Size	Maximum: 22–49 cm TL; weight: not determined Recruitment into the fishery: Not determined
ERA outcomes	This species was assessed as at low risk from commercial fishing operations under the Level 3 SAFE assessment

Note: ~ = approximately; CTS= Commonwealth Trawl Sector; ERA = Ecological Risk Assessment; PSA = Productivity Susceptibility Analyses; SAFE = Sustainability Assessment of Fishing Effects; TL = total length.

Sources: Gomon et al. 2008; Kailola et al. 1993; Lyle et al. 1992; Williams et al. 2011a; Woodhams et al. 2011; Zhou et al. 2007

References

AFMA 2011, *High seas: conservation and management measures to prevent significant adverse impacts on vulnerable marine ecosystems*, Australian Fisheries Management Authority, Canberra, available at southpacificrfmo.org/assets/10th-SWG-and-9th-DIWG-meetings-Vanuatu/SWG-10/SWG-10-DW-01b-Australian-management-arrangements-for-SPRFMO-Final-19011.pdf (pdf 76.66kb), accessed January 2012.

AFMA 2009, *Harvest strategy framework for the Southern and Eastern Scalefish and Shark Fishery*, version 1.2, Australian Fisheries Management Authority, Canberra.

AFMA 2008, *Ecological risk management*, report for the Great Australian Bight Trawl Sub-fishery of the Southern and Eastern Scalefish and Shark Fishery, Australian Fisheries Management Authority, Canberra.

AFMA 2006, *Orange Roughy Conservation Programme, Australian Fisheries Management Authority*, Canberra, available at afma.gov.au/wp-content/uploads/2010/07/n20061207. pdf (pdf 170.23kb), accessed October 2011.

Akimoto, S, Itoi, S, Sezaki, K, Borsa, P & Watabe, S 2006, 'Identification of alfonsino, Beryx mollis and B. splendens collected in Japan, based on the mitochondrial cytochrome b gene, and their comparison with those collected in New Caledonia', *Fisheries Science*, vol. 72, no. 1, pp. 202–07.

Annala, JH 1987, 'The biology and fishery of tarakihi, Nemadactylus macropterus, in New Zealand waters', New Zealand Fisheries Research Division Occasional Publication, vol. 51, pp. 1–12.

Bensch, A, Gianni, M, Gréboval, D, Sanders, J & Hjort, A 2009, 'Worldwide review of bottom fisheries in the high seas', FAO fisheries and aquaculture technical paper, no. 522, rev.1, Food and Agriculture Organization of the United Nations, Rome.

Bolch, CJS, Elliott, NG & Ward, RD 1993, 'Enzyme variation in south-eastern Australian samples of the blue-eye or deepsea trevalla, Hyperoglyphe antarctica Carmichael 1818 (Teleostei: Stromateoidei)', *Australian Journal of Marine & Freshwater Research*, vol. 44, no. 5, pp. 687–97.

Bruce, BD, Evans, K, Sutton, CA, Young, JW & Furlani, DM 2001, 'Influence of mesoscale oceanographic processes on larval distribution and stock structure in jackass morwong (Nemadactylus macropterus: Cheilodactylidae)', *ICES Journal of Marine Science*, vol. 58, issue 5, pp. 1072–80.

Burridge, CP & Smolenski, AJ 2003, 'Lack of genetic divergence found with microsatellite DNA markers on the terakihi Nemadactylus macropterus', *New Zealand Journal of Marine and freshwater Research*, vol. 37, pp. 223–30.

Clark, MR, Dunn, MR & Anderson, OF 2010, *Development of estimates of biomass and sustainable catches for orange roughy fisheries in the New Zealand region outside the EEZ: CPUE analyses, and application of the 'seamount meta-analysis' approach*, New Zealand Fisheries Assessment Report 2010/19 for the New Zealand Ministry of Fisheries, Wellington.

Clark, MR 2008, *Descriptive analysis of orange roughy fisheries in the New Zealand region outside the EEZ: Lord Howe Rise, Northwest Challenger Plateau, West Norfolk Ridge, South Tasman Rise and Louisville Ridge to the end of 2005–06 fishing year*, New Zealand Fisheries Assessment Report 2008/12 for the New Zealand Ministry of Fisheries, Wellington.

Clark, MR, Vinnichenko, VI, Gordon, JDM, Beck-Bulat, GZ, Kukharev, NN & Kakora, AF 2007, 'Large-scale distant-water trawl fisheries on seamounts', Chapter 17 *In* TJ Pitcher, T Morato, PJB Hart, MR Clark, N Haggan, & RS Santos (eds), *Seamounts: ecology, fisheries & conservation*, Fish and Aquatic Resources Series 12, Oxford, United Kingdom, Blackwell.

DAFF 2007, *Commonwealth Fisheries Harvest Strategy: policy and guidelines*, Department of Agriculture, Fisheries and Forestry, Canberra.

Dunn, MR & Forman, JS 2011, 'Hypotheses of spatial stock structure in orange roughy, Hoplostethus atlanticus, inferred from diet, feeding, condition and reproductive activity', PLoS ONE, vol. 6, no. 11.

Edmonds, JS, Caputi, N & Morita, M 1991, Stock discrimination by trace element analysis of otoliths of orange roughy (*Hoplostethus atlanticus*), a deep water marine teleost, Australian *Journal of Marine & Freshwater Research*, vol. 42, no. 4, pp. 383–389.

Elliott, NG & Ward, RD 1994, 'Enzyme variation in jackass morwong, Nemadactylus macropterus, (Schneider, 1801) (Teleostei: Cheilodactylidae), from Australian and New Zealand waters', *Australian Journal of Marine & Freshwater Research*, vol. 45, no. 1, pp. 51–67.

FAO 2012, Deep-sea fisheries in the high seas: ensuring sustainable use of marine resources and the protection of vulnerable marine ecosystems, Food and Agriculture Organization of the United Nations, Rome.

FAO 2008, *Deep-sea fisheries in the high seas: a trawl industry perspective on the International guidelines for the management of deep-sea fisheries in the high sea,* Fisheries and Aquaculture Circular, no. 1036, Food and Agriculture Organization of the United Nations, Rome.

Ford, B 2006, 'Community ecology of the Western Australian continental slope demersal Icthyofauna', honours thesis, University of Western Australia, Perth.

Froese, R & Pauly, D 2012 FishBase, version 02/2010, FishBase Consortium, available at fishbase.org/search.php.

Gianni, M 2004, *High seas bottom trawl fisheries and their impact on the biodiversity of vulnerable deep-sea ecosystems: options for international action*, International Union for the Conservation of Nature, Gland, Switzerland.

Gomon, M, Bray, D & Kuiter, R 2008, *Fishes of Australia's southern coast*, New Holland Publishers, Sydney.

Grewe, PM, Smolenski, AJ & Ward, RD 1994, 'Mitochondrial DNA diversity in jackass morwong (Nemadactylus macropterus, Teleostei) from Australian and New Zealand waters', Canadian *Journal of Fisheries and Aquatic Sciences*, vol. 51, pp. 1101–09.

Haddon, M 2011, Assorted catch and catch rate analyses for the SESSF 2010', in GN Tuck (ed.), *Stock assessment for the Southern and Eastern Scalefish and Shark Fishery 2010*, part 2, AFMA & CSIRO Marine and Atmospheric Research, Hobart.

Hoarau, G & Borsa, P 2000, Extensive gene flow within sibling species in the deep-sea fish Beryx splendens, *Comptes Rendus de l'Académie des Sciences*, vol. 323, pp. 315–25.

Horn, PL & Sutton, CP 2010, *The spatial and temporal age structure of bluenose (Hyperoglyphe antarctica) commercial catches from Fishstock BNS 1*, New Zealand fisheries assessment report 2010/8, for the New Zealand Ministry of Fisheries, Wellington.

Japp, DW & James, A 2005, 'Potential exploitable deepwater resources and exploratory fishing off the South African coast and the development of the deepwater fishery on the South Madagascar ridge', in R Shotton (ed.) 2005, *Deep Sea 2003: Conference on the governance and management of deep-sea fisheries*, part 1, conference papers, Fisheries Proceedings 3/1, 162–68, Food and Agriculture Organization of the United Nations, Rome.

Kailola, PJ, Williams, MJ, Stewart, PC, Reichelt, RE, McNee, A & Grieve, C 1993, *Australian fisheries resources*, Bureau of Resource Sciences, Canberra.

Knuckey, IA, Hudson, R & Nemec, J 2010, 'Monitoring orange roughy in the Great Australian Bight 2010', report to the Australian Fisheries Management Authority, Canberra.

Koslow, JA, Boehlert, GW, Gordon, JDM, Haedrich, RL, Lorance, P & Parin, N 2000, 'Continental slope and deep-sea fisheries: implications for a fragile ecosystem', *ICES Journal of Marine Science*, vol. 57, pp. 548–57.

Last, PR, Lyne, VD, Williams, A, Davies, CR, Butler, AJ & Yearsley, GK 2010, 'A hierarchical framework for classifying seabed biodiversity with application to planning and managing Australia's marine biological resources', *Biological Conservation*, vol. 143, issue 7, pp. 1675–86.

Lawton, RJ, Wing, SR and Lewis, AM 2010, Evidence for discrete subpopulations of sea perch (Helicolenus percoides) across four fjords in Fiordland, New Zealand, *New Zealand Journal of Marine and Freshwater Research*, vol. 44, issue 4, p. 309.

Lehodey, P, Grandperrin, R & Marchal, P 1997, 'Reproductive biology and ecology of a deep demersal fish, alfonsino Beryx splendens over the seamounts off New Caledonia', *Marine Biology*, vol. 128, issue 1, pp. 17–27.

Lyle, JM, Riley, S & Kitchener, J 1992, 'Oreos—an underutilised resource', *Australian Fisheries*, vol. 51, no. 4, pp. 12–15.

Ministry of Fisheries 2009, *Report from the Fisheries Assessment Plenary, May 2009: stock assessments and yield estimates*, New Zealand Ministry of Fisheries, Wellington.

Norse, EA, Brooke, S, Cheung, WWL, Clark, MR, Ekeland, I, Froese, R, Gjerde, KM, Haedrich, RL, Heppell, SS, Morato, T, Morgan, LE, Pauly, D, Sumaila, R & Watson, R 2012, 'Sustainabiltiy of deep sea fisheries', *Marine Policy*, vol. 36, issue 2, pp. 307–20.

Park, T 1994, 'Ocean perch Helicolenus sp.', in RDJ Tilzey (ed.) 1994, *The South East Fishery: a scientific review with particular reference to quota management*, Bureau of Resource Sciences, Canberra.

Paul, LJ & Horn, PL 2009, 'Age and growth of sea perch (Helicolenus percoides) from two adjacent areas off the east coast of South Island, New Zealand', *Fisheries Research*, vol. 95, pp. 169–80.

Roberts, CM 2002, 'Deep impact: the rising toll of fishing in the deep sea', *Trends in Ecology & Evolution*, vol. 17, no. 5, pp. 242–45.

Robinson, N, Skinner, A, Sethuraman, L, McPartlan, H, Murray, N, Knuckey, I, Smith, DC, Hindell, J& Talman, S 2008, 'Genetic stock structure of blue-eye trevalla (*Hyperglyphe antarctica*) and warehous (*Seriolella brama* and *Seriolella punctata*) in south-eastern Australian waters', *Marine and Freshwater Research*, vol. 59, issue 6, pp. 502–514.

Romanov, EV (ed.) 2003, *Summary and review of Soviet and Ukrainian scientific and commercial fishing operations on the deepwater ridges of the Southern Indian Ocean*, FAO Fisheries Circular, no. 991, Food and Agriculture Organization of the United Nations, Rome.

Rowling, K, Hegarty, A-M & Ives, M (eds) 2010, *Status of fisheries resources in NSW 2008/09*, Industry & Investment NSW, Cronulla, New South Wales.

Schönhuth, S, Álvarez, Y, Rico, V, González, JA, Santana, JI, Gouveia, E, Lorenzo, JM & Bautista, JM 2005, 'Molecular identification and biometric analysis of Macaronesian archipelago stocks of Beryx splendens', *Fisheries Research*, vol. 73, issue 3, pp. 299–309.

ShelfRAG 2011, *2010 stock assessment summaries for species assessed by ShelfRAG*, version 22 December 2010, Australian Fisheries Management Authority, Canberra.

Slope/DeepRAG 2011, *2010 stock assessment report for SESSF species assessed by SLOPE/DeepRAG*, report to the Australian Fisheries Management Authority, Canberra.

Smith, PJ 2007, 'Issues, status, and trends in deep-sea fishery genetic resources', in DM Bartley, BJ Harvey & RSV Pullin (eds) 2007, *Workshop on status and trends in aquatic genetic resources: a basis for international policy*, 8–10 May 2006, Victoria, British Columbia, Canada, FAO Fisheries Proceedings, no. 5, Food and Agriculture Organization of the United Nations, Rome.

Smith, PJ, Robertson, SG, Horn, PL, Bull, B, Anderson, OF, Stanton, BR & Oke, CS 2002a, Multiple techniques for determining stock relationships between orange roughy, *Hoplostethus atlanticus*, fisheries in the eastern Tasman Sea, *Fisheries Research*, vol. 58, issue 2, pp. 119–40.

Smith, PJ, McMillan, PJ, Bull, B, McVeagh, SM, Gaffney, PM, & Chow, S 2002b, 'Genetic and meristic variation in black and smooth oreos in the New Zealand Exclusive Economic Zone', *New Zealand Journal of Marine and Freshwater Research*, vol. 36, pp. 737–50.

Smith, PJ & Benson, PG 1997, 'Genetic diversity in orange roughy from the east of New Zealand', Fisheries Research, vol. 31, issue 3, pp. 197–213.

Smith, PJ, Benson, PG & McVeagh, SM 1997, 'A comparison of three genetic methods for stock discrimination of orange roughy, Hoplostethus atlanticus: allozymes, PCR amplified mitochondrial DNA and random amplified polymorphic DNA', *Fishery Bulletin*, vol. 95, no. 4, pp. 800–11.

Smolenski, AJ, Ovenden, JR & White, RWG 1993, 'Evidence of stock separation in southern hemisphere orange roughy (Hoplostethus atlanticus, Trachichthyidae) from restriction-enzyme analysis of mitochondrial DNA', *Marine Biology*, vol. 116, issue 2, pp. 219–30.

SPRFMO 2007a, 'Interim measures adopted by participants in negotiations to establish South Pacific Regional Fisheries Management Organisation (SPRFMO)', negotiations held 30 April to 4 May 2007, Reñaca, Chile, South Pacific Regional Fisheries Management Organisation, Auckland, New Zealand.

SPRFMO 2007b, 'Information describing Oreosomatidae (Allocyttus niger, neocyttus rhomboidalis and Pseudocyttus maculates) fisheries relating to the South Pacific Regional Fisheries Management organisation: working draft 02 September 2007', SPRFMO-IV-SWG-11, South Pacific Regional Fisheries Management Organisation, Auckland, New Zealand.

SPRFMO Science Working Group 2009, 'Information describing orange roughy Hoplostethus atlanticus fisheries relating to the South Pacific Regional Fishery Management Organisation: working draft 4 May 2007', SP-07-SWG-INF-09, updated at meeting 13 May 2009, Chile, South Pacific Regional Fisheries Management Organisation, Auckland, New Zealand.

SPRFMO 2012, Preparatory conference for the Commission of the South Pacific Regional Fisheries Management Organisation, Third Session, Santiago, Chile, 30 January to 3 February, Prepcon-03-INF-03, South Pacific Regional Fisheries Management Organisation, Auckland, New Zealand.

Starr, PJ, Kendrick, TH, Bentley, N & Lydon, GJ 2008, '2008 Review of the BNS 1 adaptive management programme, AMP-WG-2008/11', unpublished report, New Zealand Seafood Industry Council, Wellington.

Ward, RD & Elliott, NG 2001, 'Genetic population structure of species in the south east fishery of Australia', *Marine & Freshwater Research*, vol. 52, no. 4, pp. 563–73.

Ward, RD, Elliott, NG, Grewe, PM, Last, PR, Lowry, PS, Innes, BH & Yearsley, GK 1998, 'Allozyme and mitochondrial DNA variation in three species of oreos (Teleostei: Oreosomatidae) from Australasian waters', *New Zealand Journal of Marine and Freshwater Research*, vol. 32, pp. 233–45.

Ward, RD, Elliott, NG, Yearsley, GK & Last, PR 1996, *Species and stock delineation in Australasian oreos (Oreosomatidae)*, CSIRO Division of Fisheries final report to the Fisheries Research and Development Corporation, Australia.

Wayte, S 2011, 'Jackass morwong (Nemadactylus macropterus) stock assessment based on data up to 2010', in Tuck, GN (ed.) 2011, *Stock assessment for the southern and eastern scalefish and shark fishery: 2010, part 1*, Australian Fisheries Management Authority and CSIRO Marine and Atmospheric Research, Hobart.

Williams, A, Althaus, F, Fuller, M, Klaer, N & Barker, B 2011a, *Bottom fishery impact assessment: Australian report for the South Pacific Regional Fisheries Management Organisation (SPRFMO)*, SWG-10-DW-01a, CSIRO Marine and Atmospheric Research, Hobart.

Williams, A, Althaus, F, Fuller, M, Klaer, N & Barker, B 2011b, *Bottom Fishery Impact Assessment: Australian report for the Southern Indian Ocean Fisheries Agreement (SIOFA)*, CSIRO Marine and Atmospheric Research, Hobart.

Woodhams, J, Stobutzki, I, Vieira, S, Curtotti, R & Begg, GA (eds) 2011, *Fishery status reports 2010: status of fish stocks and fisheries managed by the Australian Government*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

Yearsley, GK, Last, PR, Ward, RD 1999, *Australian seafood handbook: an identification guide to domestic species*, CSIRO Marine Research, Australia.

Zeldis, JR, Grimes, PJ & Ingerson, JKI 1994, 'Ascent rates, vertical distribution and thermal history model of development of orange roughy, Hoplostethus atlanticus, eggs in the water column', *Fishery Bulletin*, vol. 93, no. 2, pp. 373–85.

Zhou, S, Smith, T & Fuller, M 2007, *Rapid Quantitative Risk Assessment for Fish Species in Selected Commonwealth Fisheries*, Report for the Australian Fisheries Management Authority, Canberra, CSIRO Marine and Atmospheric Research, Cleveland, Queensland