GASCOYNE COAST BIOREGION

ABOUT THE BIOREGION

The marine environment of the Gascoyne Coast Bioregion (Gascoyne Overview Figure 1) represents a transition between the fully tropical waters of the North West Shelf of the North Coast Bioregion and the temperate waters of the West Coast Bioregion. Offshore ocean temperatures range from about 22°C to 28°C, while the inner areas of Shark Bay regularly fall to 15°C in winter. The major fish stocks are generally tropical in nature, with the exceptions of the temperate species, pink snapper, whiting and tailor, which are at the northern end of their range in Shark Bay.

The coastline is characterised by high cliffs in the southern half changing to fringing coral reefs in the north. Coastal waters are generally high-energy in terms of wave action due to the strong trade wind system. The Exmouth Gulf section of the Gascoyne Coast Bioregion is seasonally influenced by extreme tropical summer cyclones, while the Shark Bay end of the Bioregion receives infrequent cyclones, but is affected at times by river outflows from inland cyclone-based summer rainfall. The limited local rainfall comes mostly from the northern edge of winter storm fronts.

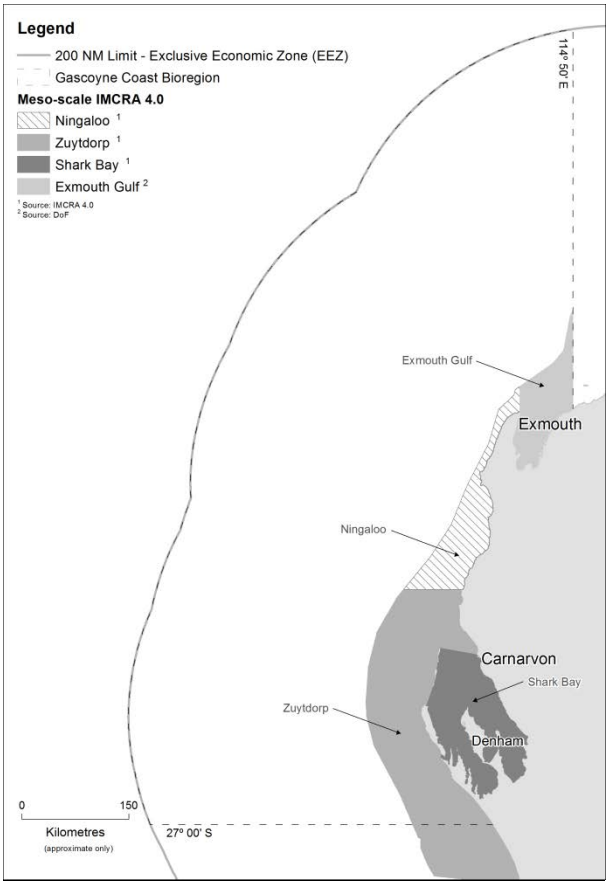
The waters off the Gascoyne Coast are also strongly influenced by the unusual southward-flowing Leeuwin Current, generated by flow from the Pacific through the Indonesian archipelago. This tropical current becomes evident in the North West Cape area and flows along the edge of the narrow continental shelf where, coupled with low rainfall and run-off plus the north flowing Ningaloo current, it supports the highly diverse Ningaloo Reef marine ecosystem.

The outer area of the large marine embayment of the World Heritage-listed Shark Bay is also influenced by the warm winter current. The inner waters of the embayment are hyper-saline, owing to the high evaporation and low rainfall of the adjacent terrestrial desert areas. The sea floor of both Shark Bay and the continental shelf is typically sandy compared to Exmouth Gulf, which has more mud areas and greater turbidity.

The Gascoyne Coast Bioregion has been identified as one of 18 world 'hotspots' in terms of tropical reef endemism and the second most diverse marine environment in the world in terms of tropical reef species.

The Ningaloo reef in the north of the Bioregion is the largest continuous reef in WA and is one the most significant fringing reefs in Australia. The Bioregion also has some areas of mangroves, mostly in Exmouth Gulf, while seagrass beds are located in a number of areas.

The ecosystem boundaries as defined by IMCRA (V 4.0) in the bioregion are depicted in Gascoyne Overview Figure 1. The potential threats and risks to these ecosystems are often similar. For simplicity risk ratings were allocated by grouping the ecosystems into two broad groups, estuarine or marine. However, if a particular ecosystem is unique and/or is exposed to different or significant threats, risk was allocated to these ecosystems separately.



GASCOYNE OVERVIEW FIGURE 1

Map showing the Gascoyne Coast Bioregion and IMCRA (V 4.0) meso-scale regions: Zuytdorp, Shark Bay, Ningaloo and Exmouth Gulf.

SUMMARY OF ACTIVITIES POTENTIALLY IMPACTING THE BIOREGION

Climate Change

Some of the key environmental trends that may be affecting ecosystems in WA include:

- Increasing frequency of El Niño/Southern Oscillation (ENSO) events;
- More years with a weaker Leeuwin Current;
- Increase in water temperature off the lower west coast of WA;
- Increase in salinity, which includes some large annual fluctuations;
- Change in the frequency and location of storms (and rainfall) affecting the lower west coast; and
- Change in the frequency of cyclones (and summer rainfall) affecting the north-west coast.

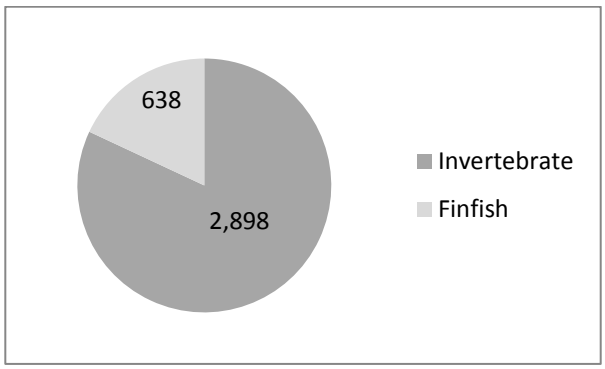
The Gascoyne Coast Bioregion is predicted to be at enhanced risk from the effects of climate given that it spans a transitional zone between tropical and temperate regions. The variables expected to drive climate change impacts include changes in water temperature, ocean currents, winds, rainfall, sea level, ocean chemistry and extreme weather conditions.

It is apparent that climate change will impact the biological, economic, and social aspects of many fisheries, and both positive and negative impacts are expected. Climate change can influence biological systems by modifying the timing of spawning, range and distribution, composition and interactions within communities, exotic species invasions and impacts, and the structure and dynamics of communities, including changes in productivity. Species distribution shifts are the most commonly reported changes and are often the easiest to recognise and measure, and are being monitored in a national citizen-science program (www.redmap.org.au) that the Department is collaborating in.

Commercial Fishing

Commercial fishing is a significant industry in the region, with three of the State's more valuable fisheries – the Shark Bay Prawn, Exmouth Gulf Prawn and Shark Bay Scallop fisheries – landing combined catches valued in the range of $40 – $50 million annually. These trawl based fisheries have operated sustainably in the region since the mid-1960s and are internationally recognised as 'best practice' in terms of both management and research. Only a relatively small number of the approximately 1,400 species of fish inhabiting this bioregion are targeted by commercial fishing activity.

The Gascoyne Demersal Scalefish Fishery (GDSF) and Shark Bay Beach Seine and Mesh Net Fishery have operated in the bioregion since the 1960s, and provide a significant proportion of the snapper and whiting catch for the State. The GDSF originally only targeted pink snapper but has developed over the past decade into a broader fishing sector taking other demersal finfish species including emperors, cods and deeper water species such as goldband snapper. The Gascoyne includes part of the Mackerel Managed Fishery (which extends the NT border and is reported on in the North Coast Bioregion chapter) with this area having lower annual catches compared to more northern areas. The region also includes some other small commercial fishing activities including the marine aquarium fishery which collects small numbers of a wide variety of species but is not permitted within some areas of the Ningaloo Marine Park, Shark Bay Marine Park or any waters closed to fishing. There is also a small beach seining fishery within Exmouth Gulf.



GASCOYNE COAST OVERVIEW FIGURE 2

Relative contribution of finfish and invertebrates to the total commercial wild fishery catch originating from the Gascoyne Coast Bioregion. Numbers represent total catch (in tonnes) based on all major assessed fisheries identified in the Overview section of this report (Gascoyne Coast Overview Table 1).

The main invertebrate species captured by fisheries in the Gascoyne Bioregion include a number of penaeid prawns, scallops, blue swimmer crabs within the two main embayments of Shark Bay and Exmouth Gulf plus deep sea crabs in the offshore region. The fishery for blue swimmer crabs which operates throughout the waters of Shark Bay had grown in the last decade to be the largest Australian crab fishery until recently affected by environmental issues. Other minor commercial fishing activities for

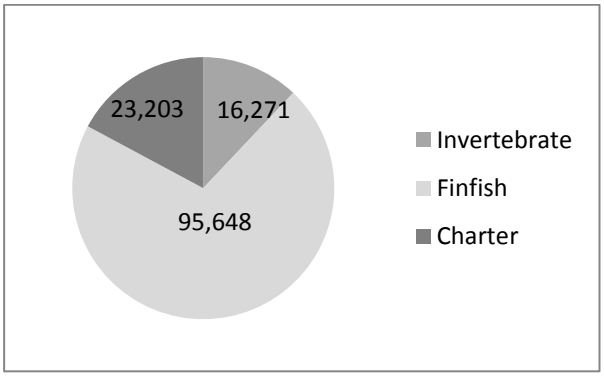
invertebrates operating in the bioregion include collecting silver lipped pearl oyster which is used in pearl culture, though most effort is focused in the North Coast Bioregion.

Recreational Fishing

The special features of the Gascoyne Coast Bioregion, coupled with the warm, dry winter climate and accessible fish stocks, have made it a focal point for winter recreation by the Western Australian community. Fishing during this season is a key component of many tourist visits. A full range of angling activities is available, including beach and cliff fishing (e.g. Steep Point and Quobba), embayment and shallow-water boat angling (e.g. Shark Bay, Exmouth Gulf and Ningaloo lagoons), and offshore boat angling for demersal and larger pelagic species (e.g. off Ningaloo).

Recreational fishing is predominantly for tropical species such as emperors, tropical snappers, groupers, mackerels, cods, trevallies and other game fish and blue swimmer crab and squid. Some temperate species at the northern end of their ranges, such as (pink) snapper, tailor and whiting, provide significant catches, particularly in Shark Bay. (Gascoyne Coast Overview Figure 3)

Improved infrastructure (e.g. sealed roads) has led to increasing levels of domestic and international tourism to the Gascoyne. Enhanced access to coastal waters via new boat ramps (e.g. Bundegi, Coral Bay, Tantabiddi) and camping sites/facilities and the sustained popularity of recreational fishing also contribute to pressure on local fish stocks.



GASCOYNE COAST OVERVIEW FIGURE 3

The Gascoyne Coast Bioregion finfish and invertebrate catch numbers as assessed in the integrated survey of boat-based recreational fishing in WA 2013/14, and the charter boat catch numbers for the same period.

Aquaculture

Aquaculture in the Gascoyne focuses on the blacklip oyster *Pinctada margitifera*. The local aquaculture sector is also focusing on the production of aquarium species, including coral and live rock.

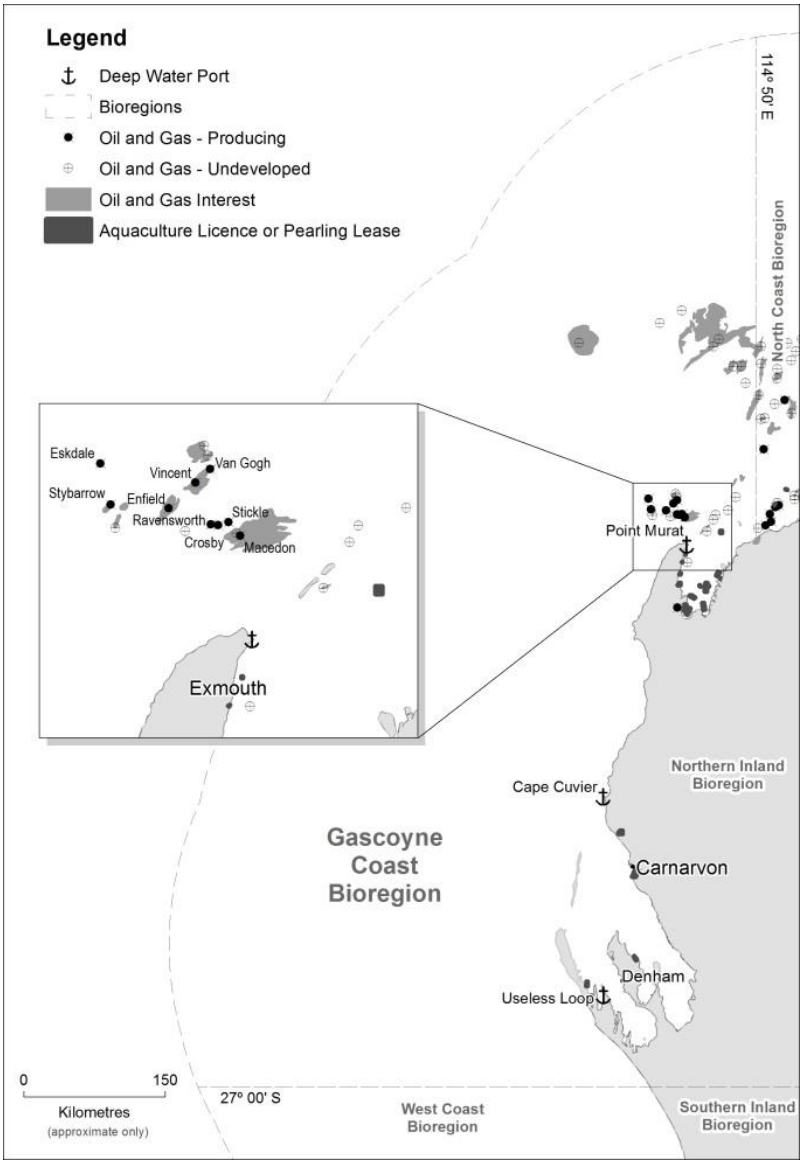
Tourism

The Gascoyne Coast Bioregion is a focal point for winter recreation by the Western Australian community. Apart from its scenic beauty, the main attraction of the coastline for tourists is the quality of marine life. The region supports extensive scuba diving and snorkelling activities, particularly inside the coral lagoons of Ningaloo. Specialised eco-tourism activities include whale shark and manta ray observation at Ningaloo and dolphin and dugong viewing in Shark Bay. Fishing is a key component of many tourist visits, and a full range of angling activities is available.

Oil and Gas Activity

Exploration and appraisal drilling has occurred mainly in the northern part of the Gascoyne Coast Bioregion (Gascoyne Overview Figure 4). There is significant oil and gas mining activity offshore of North West Cape in the Exmouth Sub-basin, and the Australian Government has also recently released two areas offshore of Carnarvon in the Southern Carnarvon Basin for further exploration.

The main disturbances associated with oil and gas exploration and production include noise pollution from seismic surveys, potential for fish movement/impact arising from seismic surveys, disturbance to the marine habitat through drilling and/or dredging activities, release of produced formation water, shipping and transport activities and oil spill accidents.



GASCOYNE OVERVIEW FIGURE 4

Exmouth Sub-basin offshore oil and gas production sites and Aquaculture Licences and Pearling Leases.

Shipping and Maritime Activity

There are three deepwater port facilities currently operating in the Gascoyne Coast Bioregion: Useless Loop, Cape Cuvier (both private facilities servicing salt fields) and Point Murat, a naval port facility at Exmouth. The majority of shipping movements involve coastal cargo vessels, shipping associated with the two salt fields in the region, large passenger cruise vessels and fishing vessels operating out of the numerous small ports along the coast.

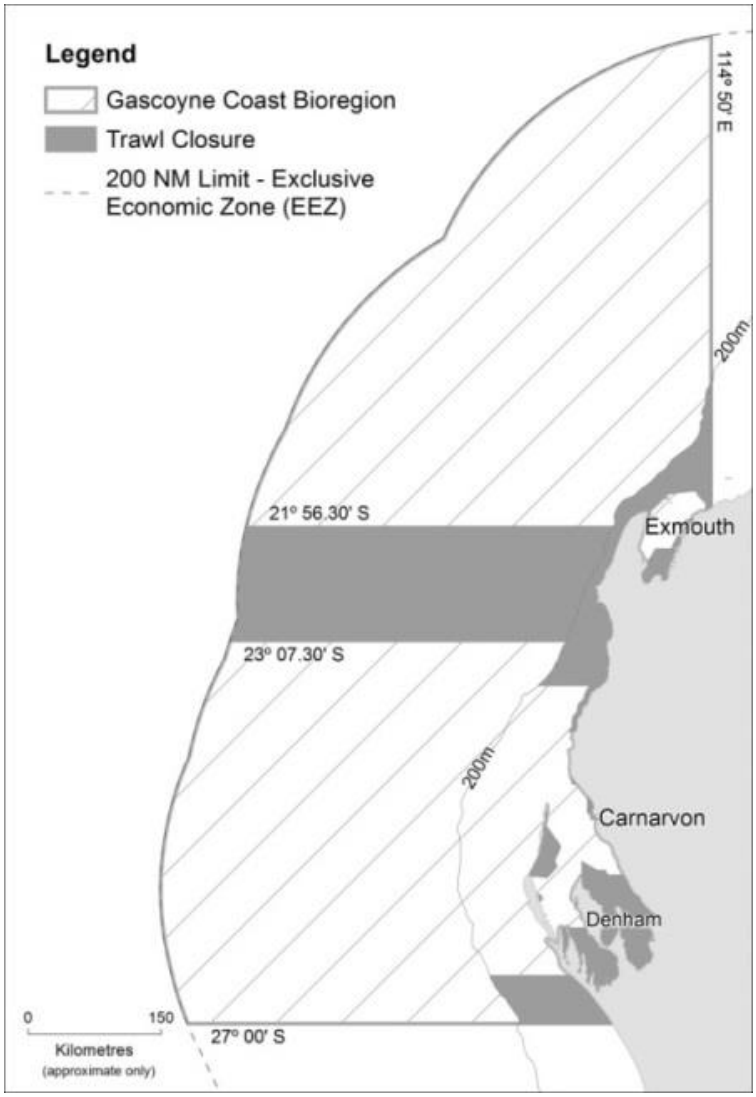
Other harbours and maritime facilities of the Gascoyne Coast Bioregion include Denham, Carnarvon, Coral Bay and Exmouth, all of which largely service local fishing and charter vessels, as well as the private vessels of local residents and tourists. The expansion of oil and gas, along with increased recreational, charter and eco-tourism activities, in the area has led to the expansion of many of these facilities.

The impacts from vessels and ships tend to be concentrated around ports and favoured anchorage areas. Impacts include physical damage to the habitat and the potential to introduce and spread marine pest species.

GASCOYNE ECOSYSTEM MANAGEMENT TABLE 1

The areas and proportions of the Gascoyne Coast Bioregion making up State Waters and all continental shelf waters, out to 200 m depth, which are consistent with IUCN criteria for classification as marine protected areas.[1]

IUCN category or equivalent	State Waters only (24,100 km^2)				All Waters (416,300 km^2 (including State Waters))			
	Fisheries		Existing MPA		Fisheries		Existing MPA	
	km^2	%	km^2	%	km^2	%	km^2	%
I	0	0	0	0	0	0	0	0
II	0	0	2,500	10	0	0	5,000	1
III	0	0	0	0	0	0	0	0
IV	3,100	13	6,400	27	13,200	3	6,400	2
V	0	0	0	0	0	0	0	0
VI	9,500	39	2,600	11	389,100	93	2,600	1



GASCOYNE OVERVIEW FIGURE 5

Map showing the Gascoyne Coast Bioregion and areas closed to trawling. The areas permanently closed to trawling are consistent with IUCN marine protected area category I.

1 Dudley N. (editor) 2008. Guidelines for applying protected area management categories. IUCN. Gland, Switzerland.

Day J. et al. 2012. Guidelines for applying the IUCN Protected Area Management Categories to Marine Protected Areas. Gland, Switzerland: IUCN. 36pp.

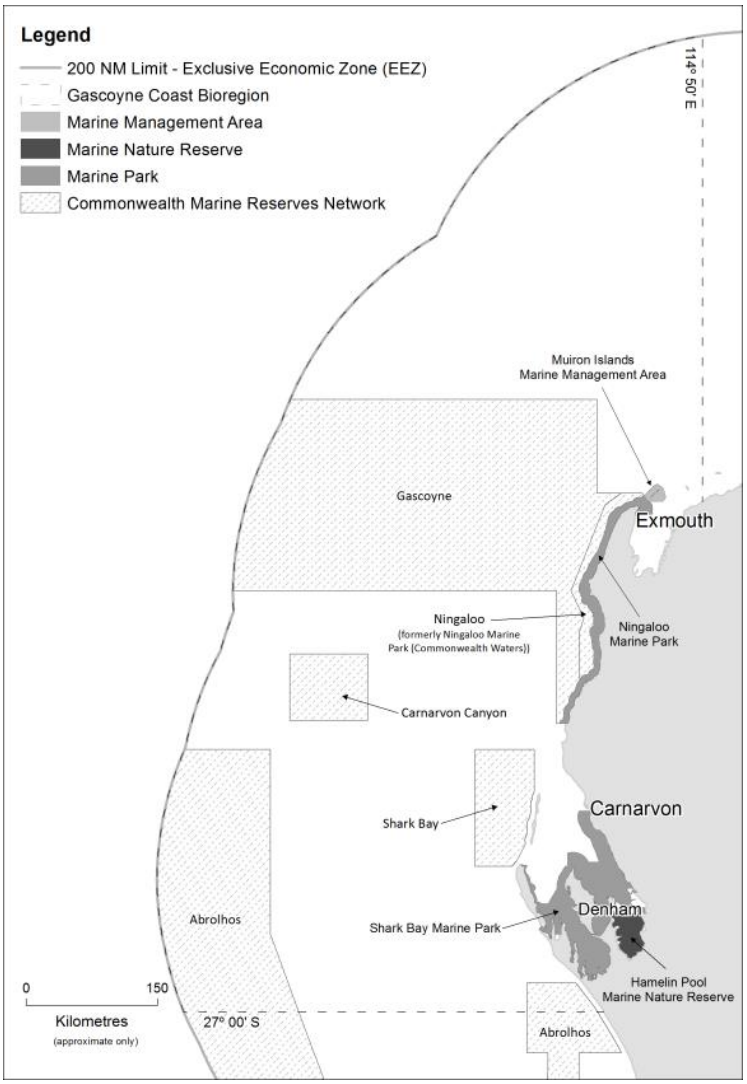
BIOREGIONAL SPECIFIC ECOSYSTEM MANAGEMENT

Within each Bioregion there are a range of management measures that have been implemented to manage the potential impact of activities (See Ecosystem Management Section for an overview). Management measures specific to the Gascoyne Coast Bioregion include:

Spatial Closures

The Department of Fisheries has established a comprehensive set of spatial management closures within the Gascoyne region that are equivalent to a number of IUCN categories for marine protected areas. Extensive trawl closures inside the 200 m depth zone in the Shark Bay and Exmouth region provide protection to sensitive benthic habitat, including coral reef, sand flats and seagrass beds of the continental shelf. These areas provide significant fish nursery, breeding and feeding habitat (Gascoyne Overview Figure 5). The extent of these areas means that most of the Gascoyne Bioregion inside 200 m depth could be classified as one of the marine protected area IUCN categories (Gascoyne Ecosystem Management Table 1; as per Dudley, 2008 and Day *et al 2012*[1]). There are also a number of other 'formal' marine protected areas in this Bioregion that have been established under both the Conservation and Land Management Act 1984 and the Fish Resources Management Act 1994 (see Gascoyne Overview Figure 6). These include the Ningaloo and Shark Bay marine parks, the Murion Islands Marine Management Area, and the Quobba and Miaboolya Beach Fish Habitat Protection Areas. Commercial and recreational fishing activities are restricted in these regions.

The Commonwealth Government has identified a number of potential protected areas for Commonwealth waters between Shark Bay and the Northern Territory border.



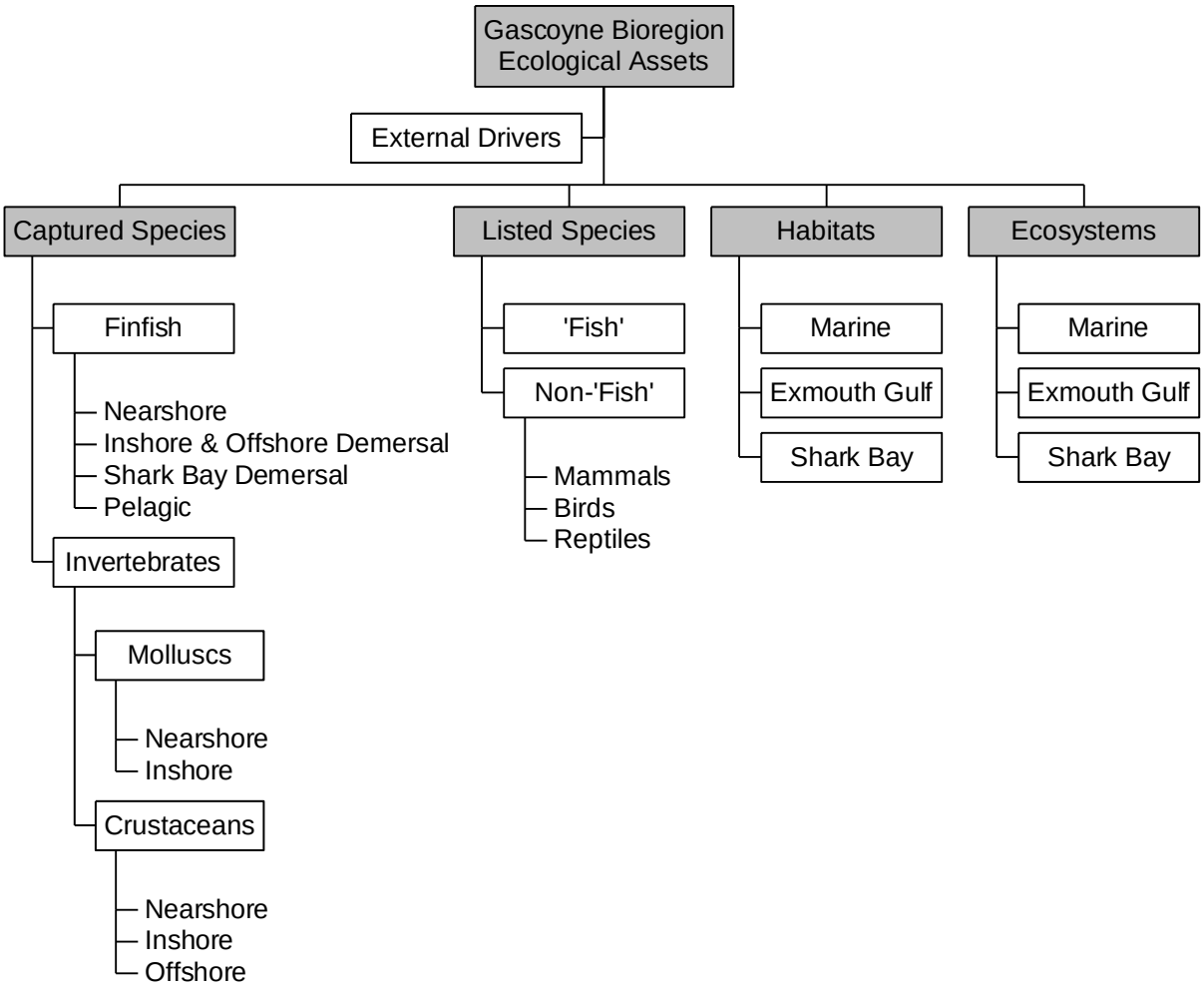
GASCOYNE OVERVIEW FIGURE 6

Map showing the Gascoyne Coast Bioregion and current and proposed state and Commonwealth marine parks and reserves in the Gascoyne Region.

ECOSYSTEM MONITORING AND STATUS

In order to assess the adequacy of management arrangements aimed at ensuring sustainability of the ecological assets within the Gascoyne Coast Bioregion, the Department must identify and monitor trends in the condition of these resources. This is achieved through application of an Ecosystem Based Fisheries Management (EBFM) framework (Fletcher, *et al*., 2010) (see How to Use section for more details) to identify, in a hierarchical manner, the key ecological resources that require ongoing monitoring and assessment.

These key ecological assets identified for the Gascoyne Bioregion are identified in Gascoyne Overview Figure 7 and their current risk status reported on in the following sections.



GASCOYNE OVERVIEW FIGURE 7

Component tree showing the ecological assets identified and separately assessed for the Gascoyne Coast Bioregion.

External Drivers

External factors include those impacting at the bioregional-level that are likely to affect the ecosystem as whole and may not fall within the direct control of Fishery legislation (e.g. climate change). An understanding of these factors, which are typically environmental (cyclones, ocean currents) is necessary to fully assess the performance of the ecological resource. The main external drivers identified with potential to affect the Gascoyne Coast Bioregion include climate and introduced pests and diseases.

Climate

External Drivers	Current Risk Status
Climate	MODERATE in short term HIGH in medium term

Being a transitional zone between tropical and temperate regions, the biota of the Gascoyne Bioregion is at enhanced risk of being affected by climate change. Climate change can influence fisheries and biological systems by affecting the timing of spawning, range and distribution, composition and[1] interactions within communities, exotic species invasions and impacts, community structure and productivity. Waters off the Gascoyne coast are strongly influenced by the Leeuwin Current which brings warm low salinity water southward. After experiencing a weakening trend from the 1960's to the early 1990's, the strength of the Leeuwin Current has rebounded in the past two decades which has been driven by changes in frequency of El Niño/La Niña Southern Oscillation (ENSO) patterns. During the summer of 2010/11, a significant warming event took place off the coast of Western Australia, with widespread reports of fish kills and of tropical species being found further south than their normal range.

Sea-surface temperatures were > 3 °C above the normal summer averages in some regions. The "marine heat-wave" was associated with extremely strong La Niña conditions, leading to a record strength Leeuwin Current for that time of year, which resulted in record high summer sea levels along the mid-west and Gascoyne coast. The heat wave resulted in what is considered to be the first WA regional-scale coral bleaching event, affecting corals south to Rottnest Island and north to the Montebello and Barrow Islands. This warming event may also have contributed to a significant decline in blue swimmer crab and scallop stocks in Shark Bay and a subsequent recruitment failure for both of these species in 2011.

A preliminary assessment of fisheries-dependent indicators of climate change in WA was undertaken in 2010. This work is being completed as part of a three-year FRDC-funded project (2010/535) that will assess the effects of climate change on the marine environment and key fisheries, as well as management implications. The first phase of the project was to understand how environmental factors, such as water temperature and salinity, affect fish stocks in Western Australia based on available historical data. The second phase was to look at historical trends and possible future scenarios of Western Australian marine environments using climate model projections. Lastly, existing management arrangements will be reviewed to examine their robustness to climate change effects and new management policies will be developed in consultation with stakeholders to deal with climate change effects of fish stocks.

Introduced Pests and Diseases

External Drivers	Current Risk Status
Introduced Pests	LOW
Introduced Diseases	LOW

The Department is the lead agency with responsibility for managing the threat posed by introduced marine species to our marine environment. As such it implements a range of risk-based policy, research, monitoring and compliance measures aimed at preventing introduction and establishment of marine pests in State waters.

The Gascoyne represents a transition between tropical and temperate regions and is an increasing focus of oil and gas exploratory activity. As such, there is an increasing risk of introduction and establishment of numerous nationally listed pest species to inhabit this region. Currently, recreational vessel movements, practices and the fouling present on these vessels represents one of our biggest gaps in marine biosecurity knowledge. The Marine Biosecurity Research and Monitoring Group is implementing research activities in the Bioregion focussed on vessel risk analysis. Further details for these projects may be found in the Appendix section entitled "Activities of the Marine Biosecurity Research Group during 2015/16". A summary of pest detections resulting from surveillance at major ports is provided in the Overview section of this report (Table 3).

Captured Species

Finfish

The Gascoyne supports a diverse fish fauna and is noted for its high quality of both commercial and recreational fishing. Approximately 1400 species of fishes could be expected to inhabit this region. Of these only a relatively small number are targeted by commercial fishing activities with demersal finfish species (e.g. pink snapper) captured in the Zuytdorp region and nearshore finfish species (e.g. whiting) within the Shark Bay region.

Due to the broad spatial distribution of both species and fisheries, the majority of finfish species in this area are managed at the Bioregional scale within recognized aquatic zones. Indicator species which reflect the characteristics of the broader exploited stocks are monitored in order to assess ecological

risk to the suite of species targeted. The major fishery operating at the bioregional level is the Gascoyne Demersal Scalefish Fishery. This line fishery originally targeted pink snapper but has been developed over the past decade into a broader fishing sector targeting other demersal finfish species including emperors, cods and deeper water species and is managed as the Gascoyne Demersal Scalefish (Managed) Fishery.

The Gascoyne Coast Bioregion also has the Shark Bay-based beach seine fishery (the Shark Bay Beach Seine and Mesh Net Managed Fishery) that since the 1960s has provided most of the whiting catch for the state.

Nearshore (0-20m depth)

Captured Species	Aquatic zone	Ecological Risk
Finfish	Nearshore (0-20m depth)	MODERATE

The indicator species for this suite (e.g. whiting) are all considered to have adequate breeding stocks, fishing catch and effort has been occurring at the same acceptable levels for over 40 years and there are no additional risks that have been identified. Annual catch and effort monitoring is continuing.

Inshore and Offshore demersal

Captured Species	Aquatic zone	Ecological Risk
Finfish	Inshore and Offshore Demersal	MODERATE

The main fishery operating in this region is the Gascoyne Demersal Scalefish Fishery, for which a detailed status report is provided at the end of this chapter. The indicator species for fishery are pink snapper spangled emperor, and goldband snapper.

Shark Bay Demersal

Captured Species	Aquatic zone	Ecological Risk
Finfish	Shark Bay Gulf Demersal	MODERATE

The main fishery operating in this ecosystem is the Inner Shark Bay Scalefish Fishery, for which a detailed status report is included at the end of this chapter.

Pelagic

Captured Species	Aquatic zone	Ecological Risk
Finfish	Pelagic	MODERATE

The stock status and fishing levels of these species (e.g. Spanish mackerel) are at acceptable levels.

Invertebrates

Commercial fishing for invertebrates is a very significant industry within the Gascoyne Coast Bioregion; three of the State's most valuable fisheries (the Exmouth Gulf Prawn, Shark Bay Prawn and Shark Bay Scallop Managed Fisheries) land combined catches valued in the range of $AUD 40-50 million annually. These trawl-based fisheries have operated in the region since the mid-1960s and are internationally recognised as 'best practice' in terms of both management and research (Fletcher and Santoro 2012). A fishery for blue swimmer crabs (the Shark Bay Crab [Interim] Managed Fishery), based primarily in Carnarvon but operating throughout the waters of Shark Bay, has grown in the last decade to be the largest Western Australian crab fishery. The Gascoyne also supports the majority of the catch of deep sea crabs off the coast of Western Australia as part of the West Coast Deep Sea Crustacean Managed Fishery.

Molluscs

Captured Species	Aquatic zone	Ecological Risk
Molluscs (Pearl Oysters)	Nearshore	MODERATE
Molluscs (Scallops)	Inshore	HIGH

The recent levels of pearl oysters in the bioregion have been low. Recovery management arrangements have been implemented and minimal catches have been taken in recent years.

The Shark Bay Scallop Managed Fishery is currently in a recovery phase. The stock has fully recovered in Denham Sound but is recovering more slowly in northern Shark Bay. The current status is the result of a series of poor recruitment events associated with sustained unfavourable environmental conditions resulting from the marine heat wave in 2010/11.

Crustaceans

Captured Species	Aquatic zone	Ecological Risk
Crustaceans (Crabs)	Nearshore	MODERATE
Crustaceans (Prawns)	Inshore	MODERATE
Crustaceans (Deep Sea Crabs)	Offshore	MODERATE

Blue swimmer crab stocks in Shark Bay are currently considered to be recovering following declines in 2011/2012 that were attributed to the impacts of anomalous environmental conditions.

Stocks in both the Exmouth and Shark Bay Prawn Managed Fisheries are considered adequate with both fisheries gaining Marine Stewardship Certification in 2015.

However, there are a number of issues related to resource sharing and gear conflicts between the Shark Bay crab trap and Shark Bay prawn and scallop trawl fisheries.

Stocks in the West Coast Deep Sea Crustacean Managed Fishery, that operates primarily in the Gascoyne bioregion, are considered adequate with the fishery gaining Marine Stewardship Certification in 2016.

Listed species

A variety of endangered, threatened and protected[1] (ETP) species can be found within the Gascoyne Coast Bioregion, including cetaceans, dugongs, marine turtles, sea snakes, elasmobranchs, seahorses and pipefish and sea/shore birds. These species are protected by various international agreements and national and state legislation. Primary pieces of legislation include the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*, the *Western Australian Wildlife Conservation Act 1950*, and the *Fish Resources Management Act 1994*.

Specific commercial fishing regulations implemented in the 1970s and 1980s preclude the use of large-mesh gillnets and long-lines throughout the region, to prevent the incidental entanglement of dugongs and turtles. These controls have also provided protection for the large shark species which are a feature of this region. More recently, bycatch reduction devices ('grids') installed in all trawl nets in this bioregion have further increased the protection for sharks, rays and any turtles encountered on the trawl grounds. In a further effort to protect sharks and rays, line-fishery vessels are not permitted to use wire snoods.

Fish

Listed species	Risk
Fish	MODERATE

Statutory reporting indicates there are a low number of interactions with sawfish. However, increasing the understanding of the number and nature of the interaction of trawl fisheries in the bioregion with sawfish was raised as an issue through the MSC process.

Non-Fish

Listed species	Risk
Birds and Reptiles	MODERATE
Mammals	LOW

While there are a number of listed species in the Gascoyne bioregion, only sea snakes and occasionally turtles are encountered in the trawl catches. The number of turtles captured now is very low and most of these are returned alive Both groups are typically returned to the sea alive.

Captures of both turtles and sea snakes are recorded and their status at release are monitored and reported.

However, increasing the understanding of the number and nature of the interaction of trawl fisheries in the bioregion with sea snakes was raised as an issue through the MSC process.

There are no recorded captures of mammals by the trawl fisheries in this bioregion.

Habitats and Ecosystems

A high level of protection of the ecosystems and habitats within the Gascoyne Coast Bioregion is ensured based on the limited area of the Bioregion that is available to commercial fishing activity.

If the areas that are not trawled is taken into account, more than 90 % of statewide benthic habitats out to the 200 m depth contour are, in practical terms, fully protected and may never have been trawled (Ecosystem Management Table 1). There are extensive trawl closures inside the 200 m depth zone in both Shark Bay and Exmouth Gulf that provide protection to sensitive benthic habitats

1 It must be noted that merely being on the listed species list does not automatically indicate that a species is either threatened or endangered.

including coral reef, seagrass and sand flats. These areas also provide significant nursery, breeding and feeding habitats for many retained and listed species. There is also a large area from Point Maud to Tantabiddi Well off the Ningaloo Coast (23° 07.30' S to 21° 56.30' S) that is closed to all commercial fishing activities (Gascoyne Overview Figure 5).

The Department identifies and monitors trends in the condition of ecosystems and their associated habitats to ensure the long term sustainability of both these key ecological assets and the fisheries that depend on them. Utilising the Integrated Marine and Coastal Regionalisation for Australia (IMCRA) scheme, the bioregion has been divided into four meso-scale ecosystems; the Ningaloo Coast, Shark Bay and Zuytdorp and Exmouth Gulf ecosystem (Gascoyne Overview Figure 1).

The key habitats occurring in depths of less than 40 m (where the vast majority of relevant fisheries resources are located and fishing activities are undertaken in this bioregion) include:

- **Coral reefs**: The Ningaloo ecosystem has the only major coral reef system in the bioregion. The Ningaloo Reef the largest continuous reef area in Western Australia and is considered one of Australia's most significant fringing coral reef systems.
- **Mangroves**: The eastern coast of Exmouth Gulf supports one of the largest areas of mangroves in the region. These areas are thought to be significant sources of nutrients that contribute to the prawn fishery of the Gulf and provide nursery areas for juvenile fish and invertebrates.
- **Seagrasses**: The central Gascoyne coast and Shark Bay support major seagrass communities, which play important roles in sedimentary processes, food chains and nutrient cycling. Smaller seagrass beds also occur in the eastern and southern sections of Exmouth Gulf. Seagrass beds provide important nursery habitats for many finfish and invertebrate species, such as spangled emperor.
- **Sand banks**: Extensive sand areas support seagrasses and provide substrate for microalgae in all areas, particularly Ningaloo Reef. In both Exmouth Gulf and Shark Bay, shallow sand banks provide productive habitat and nursery areas for local prawn and finfish stocks. Within the deeper central areas of Shark Bay and Exmouth Gulf, bare sandy/muddy bottom habitats provide the main habitat for juvenile and adult prawns within the trawl areas.
- Other habitats that are located in the ecosystems within the Gascoyne Coast Bioregion include algal communities, rocky shore communities, hard- and soft-bottom benthic communities, and pelagic mid-water communities.

In depths beyond 40 m, ecosystems include hard- and soft-bottom benthic communities, sand banks and pelagic communities. Given the low levels of activities in these depths, there is little detailed information on these environments.

Gascoyne Marine

Ecosystem/Habitat	Aquatic zone/category	Current Risk Status
Gascoyne benthic habitat	Sand, Coral	LOW
Gascoyne ecosystem	Marine	LOW

Habitats

Protection of habitats within Ningaloo occurs mainly through the use of spatial zoning throughout the Ningaloo Marine Park. There are no trawl activities conducted in this area. The main risk is to coral habitat results from tourism and other boating related activities. There are no major pressures on seagrass communities, which are general small and patchily distributed in this region.

The remainder of the bioregion is dominated by mud/sand bottoms. The majority of non-trawl based fishing takes place over sand habitats in depths of 20-250 m, depending on which species is being targeted. The Gascoyne Demersal Scalefish Fishery operates in this ecosystem and is based on using hook and lines, resulting in virtually no impact on benthic habitats. Fishing typically occurs over harder patches of hard bottom around the entrance to Shark Bay and the adjacent ocean. Fishing does not normally occur over sensitive seagrass or hard coral habitats. The West Coast Deep Sea Crustacean Fishery also operates in this area in depths from 150-1200m. Crab traps are mainly set over mud bottom and occasionally bring up solitary corals or sponges that get entangled in the pot. The footprint of the pots and effort levels are both extremely small in relation to the extent of this habitat. There are thus few direct impacts of fishing activity to these habitats.

Ecosystems

Ningaloo is protected via establishment of the Ningaloo Marine Park (NMP) which covers a total area of 4,566 km^2 from the shoreline to continental slope. No commercial fisheries operate in the waters of the NMP and 34% of the park is zoned as no-take sanctuary areas. A significant level of research and monitoring is being undertaken in the Ningaloo marine park region by DPaW, CSIRO, AIMS

and universities. This reflects the main pressures on the ecosystem which are largely not fishing-related.

The remainder of the ecosystem is largely protected due to the lack of trawling that occurs in this area.

An assessment of the community structure and trophic level of all commercially caught fish species in the Gascoyne Bioregion over the past 30 years through an FRDC project found no evidence of systematic changes that could be evidence of an unacceptable impact on this ecosystem (Hall and Wise, 2011)[1].

Exmouth Gulf

Ecosystem/Habitat	Aquatic zone/category	Current Risk Status
Exmouth Gulf benthic habitat	Sand, Mud, Sponge, Seagrass	HIGH
Exmouth Gulf ecosystem	Marine	MODERATE

Habitats

There is significant protection in place for all sensitive habitats and restrictions on the level of impacts that can occur in less sensitive habitats. Trawling is focused in the deeper central and north-western sections of the Gulf which is primarily mud. The total area trawled each year is monitored and has to remain below 40%.

Seagrass beds are spatially separated from trawling activities and are protected within the permanent nursery area closure along the southern and eastern sections of the Gulf. However, there are concerns over seagrass habitats after substantial die backs were associated with the marine heatwave in 2010/11. A better understanding of benthic habitats is also a key component of maintaining Marine Stewardship Council certification for the Exmouth Gulf Prawn Managed Fishery.

Ecosystems

Approximately 29 % (335 nm^2) of Exmouth Gulf is trawled. Trawling is prohibited in a designated nursery area in the southern and eastern section of the Gulf. The nursery area covers 344 nm^2 and represents 28 % of Exmouth Gulf. A major project surveying biodiversity on and off the trawl grounds in Exmouth indicated that trawled areas have similar diversity to the larger adjacent untrawled areas, indicating that the current level of trawling activity does not affect overall biodiversity and cannot be distinguished from other sources of variation in community structure.

The ecosystem in this region could be at increased risk if a number of proposed developments are implemented.

Shark Bay

Ecosystem/Habitat	Aquatic zone/category	Current Risk Status
Shark Bay Gulfs habitat	Sand, Sponge, Seagrass	MODERATE
Shark Bay Gulfs ecosystem	Marine	MODERATE

Habitats

Benthic habitats and communities of Shark Bay have been described and mapped (CALM 1996). There is extensive seagrass throughout the eastern and western gulfs, while corals can be found primarily along the eastern coast of the western gulf, and the eastern coasts of Dirk Hartog, Dorre and Bernier Islands. Almost all of these areas are part of the Shark Bay Marine Park and are permanently closed to trawling activities. In addition, permanent trawl closures protect the majority of seagrass and coral habitats in the eastern and western gulfs. The few unprotected areas where coral occur (e.g. Egg Island and Bar Flats) are not part of the actively trawled areas. The main areas where trawling occurs, in the central bay, north Cape Peron and in the northern area of Denham Sound are sand/shell habitat.

A better understanding of benthic habitats is also a key component of maintaining Marine Stewardship Council certification for the Shark Bay Prawn Managed Fishery.

Ecosystems

The current level of fishing by all methods has not noticeably affected the trophic/community structure in Shark Bay. A study of biodiversity in Shark Bay found no significant difference in the fish and invertebrate abundance, species richness, evenness or diversity between trawled and untrawled areas (Kangas *et al.* 2007)[2]. Therefore, the closed areas provide protection to those species more vulnerable to trawling (Kangas *et al.* 2007).

1 Hall NG, and Wise BS. 2011. Development of an ecosystem approach to the monitoring and management of Western Australian fisheries. FRDC Report – Project 2005/063. *Fisheries Research Report* No. 215. Department of Fisheries, Western Australia. 112 pp.

2 Kangas MI, Morrison S, Unsworth P, Lai E, Wright I, and Thomson A. 2007. Development of biodiversity and habitat monitoring systems for key trawl fisheries in Western Australia. Final FRDC Report 2002/038. Department of Fisheries, Western Australia. *Fisheries Research Report,* No. 160. 333 pp.

GASCOYNE SHARK BAY PRAWN RESOURCE STATUS REPORT 2016

M. Kangas, E. Sporer, S. Wilkin, P. Cavalli and R. Oliver

OVERVIEW

The Shark Bay Prawn Managed Fishery uses low opening, otter prawn trawl systems within inner Shark Bay (Kangas *et al*. 2015) to target western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*) and lesser quantities of endeavour (*Metapenaeus endeavouri*) and coral prawns (*Metapenaeopsis sp*). This is a managed fishery (SBMF Management Plan, 1993) which is based on input controls, including limited entry, gear controls (maximum headrope units), seasonal and area openings and closures and moon closures designed to keep fishing effort at levels that will maintain a sufficient spawning biomass of prawns. Bycatch reduction devices (BRDs) are mandatory in this fishery, with all boats required to fish with a 'grid' and a secondary fish escape device (FED) fitted in each net.

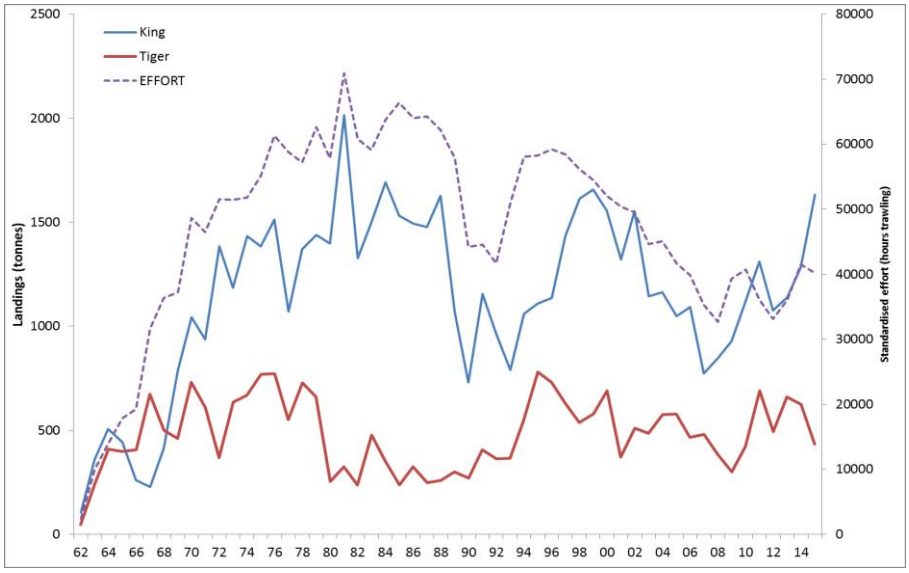
In October 2015 this fishery received Marine Stewardship Council (MSC) certification and it was also accredited for export under the provisions of the EPBC Act (1999) in 2015 for ten years.

SUMMARY FEATURES 2016

Fishery Performance	Commercial	Recreational	
Total Catch 2015	2089 t	Not applicable	
Fishing Level	Acceptable		
Stock/Resource Performance	**Stock Status**	**Assessment Indicators**	
Brown Tiger Prawn	Adequate	Level 4 - Direct Survey/Catch Rate	
Western King Prawn	Adequate	Level 4 - Direct Survey/Catch Rate	
EBFM Performance			
Asset	**Level**	**Asset**	**Level**
Bycatch	Low Risk	**Listed Species**	Low Risk
Habitat	Moderate Risk	**Ecosystem**	Low Risk
Social	Amenity Score 1 Risk Level 1	**Economic**	GVP Risk Level 4 - ($28.7 million)
Governance	Stable	**External Drivers**	Risk Level 4 (Western king prawn) for climate

CATCH AND LANDINGS

The total landings of target prawns in Shark Bay in 2015 were 2,089 t (Shark Bay Prawn Figure 1). The recorded landings of byproduct were 188 t of blue swimmer crab (*Portunus armatus*), 125 t of coral prawns, 58 t of mixed finfish, 23 t of cuttlefish, 6 t of squid, 5 t of bugs (*Thenus orientalis*) and 0.8 t of octopus. Scallop landings are reported in see Saucer Scallop Resource Status Report.



SHARK BAY PRAWN FIGURE 1. *Annual prawn landings (t) and fishing effort (total adjusted hours to twin gear units) for the Shark Bay Prawn Managed Fishery 1962-2015.*

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS (*Sustainable-Adequate*)

Western king prawns

The western king prawn is distributed throughout the Indo-West Pacific region and within Australian waters, from South Australia, WA, Northern Territory, Queensland and northern New South Wales (Grey *et al*. 1983). In Western Australia, two major fisheries for western king prawns occur in Shark Bay and Exmouth Gulf, with smaller quantities landed off Onslow and Broome.

Western king prawns live between 2-3 years with sexual maturity being reached around 6-8 months. This species can spawn all year round with peaks during spring and autumn. Post-larval and juveniles can be found inshore on shallow tidal flats with salinities higher than seawater (i.e. hypersaline). The juveniles prefer this habitat, unlike most other prawn species, which prefer estuarine conditions.

The status of the stock is assessed annually using a weight-of-evidence approach primarily based on fishery-independent indices of recruitment and spawning stock levels relative to specified reference points (DoF 2014). Although these abundance indices represent key indicators for the stocks, other information collected throughout the season (e.g. commercial catches, effort, grade categories and environmental data) is also evaluated to provide insight on, for example, environmental factors affecting prawn recruitment.

Western king prawns are comparatively more resilient to fishing than the brown tiger prawn (the other key target species) because they are less catchable (strongly nocturnal and they readily bury) and they have a protracted spawning period (Penn 1980, 1984, Kangas *et al*. 2015). The two species overlap in their spatial distribution within Shark Bay, therefore the rates of fishing that maintain the spawning biomass of the brown tiger prawn is well below that which could result in western king prawn becoming recruitment overfished (Kangas *et al*. 2015).

There are more than 40 years of catch and effort data supporting the assessment that this stock has never been reduced to levels considered to be recruitment overfished (Caputi *et al*. 1998) and current effort levels are below the level of effort previously applied (Shark Bay Prawn Figure 1). Analysis of a stock-recruitment relationship for western king prawns showed that the spawning stock was never reduced to levels where it had a significant effect on recruitment. This is supported by there being no significant correlation between spawning stock and recruitment indices derived from fishery independent surveys since 2000 (Kangas *et al*. 2015).

The fishery-independent recruitment surveys assess prawn abundance and size structure, and are used for catch predictions (Caputi *et al*. 2014a,

Kangas *et al*. 2015) and management decisions such as spatial-temporal opening of fishing areas.

There is no evidence of a declining trend in recruitment in fishery independent survey indices since 2000 (Kangas *et al*. 2015) with the annual recruitment indices being well above the target reference level each year (25 kg/hr), indicating most of recruitment variability is driven by environmental factors (e.g. water temperature, Caputi *et al*. 2014b, 2016). Furthermore, the introduction of seasonal, moon and area-closures since the early 1990's provides even more restrictions on the overall fishing effort, which increases protection for the breeding stock (Kangas *et al*. 2015). The fishery-independent recruitment survey in 2015 indicated a mean catch rate which was the fourth highest since surveys commenced in 2000 with a catch prediction between 940 and 1,410 t. The spawning stock surveys target key brown tiger prawn areas but they also cover some of the western king prawn spawning areas and are considered to be indicative of overall spawning stock abundance for this species (Kangas *et al*. 2015). In 2015 the mean spawning stock survey catch rate (mean of 54.1 kg/hr) was the highest since surveys commenced.

Historical catch and catch rates from 1989 to 1998, when it was known that recruitment was not affected by fishing effort, were used as the basis for calculating target catch ranges for this stock (950 to 1,350 t) and mean catch rate (21 kg/hr; range 16 to 29 kg/hr). Total commercial catch for 2,015 of 1,633 t was above the target catch range and an overall mean catch rate of 40.7 kg/hr was well above the target and the highest on record.

Brown tiger prawns

Brown tiger prawns are endemic to tropical and subtropical waters of Australia and are distributed around the northern coast, from central New South Wales in the east to Shark Bay in Western Australia. They are relatively short-lived, 2-3 years, become sexually mature around 6-8 months and primarily spawn in spring and early summer. The eggs hatch within 24 hours and the larvae go through a series of moults and remain in the water column for 2-3 weeks after which they settle into inshore nursery areas with a preference for structured habitats (seagrass and algae). Juvenile prawns remain in the nursery areas until around 4-6 months of age when they migrate into deeper water and become available for capture (Kangas *et al*. 2015).

The status of brown tiger prawns is assessed annually using a weight-of-evidence approach similar to that of western king prawns. A spawning stock–recruitment relationship exists for brown tiger prawns (Penn *et al*. 1995, Caputi *et al*. 1998), and the maintenance of adequate spawning stock (using a target catch rate) is the key management objective (Kangas *et al*. 2015). Brown tiger prawns are managed to reference levels (catch rates) and accompanying control rules (DoF 2014, 2015). A mandatory closure of the brown tiger prawn northern spawning area is enforced on a set date (around June to July), to protect the spawning stock. As fishing ceases, fishery-independent surveys are then conducted to verify catch rates in the northern (as well as the southern) spawning areas.

The June 2015 spawning stock survey showed a mean standardised catch rate of 7.0 kg/hr in the northern spawning area. This was well below the target level of 25 kg/hr. A survey in August indicated a catch rate of 13 kg/hr just above the limit level (10 kg/hr), so it is still considered that the biomass of this management unit is unlikely to be recruitment overfished and it appears that overall there was an adequate spawning stock during the key spawning period in 2015. This conclusion was supported by very high catch rates of brown tiger prawns in the southern spawning area (148 kg/hr in June and 56 kg/hr in August) which were also protected during the spawning period.

The harvest strategy has an annual target catch range of 400 to 700 t. The brown tiger prawn catch prediction (based on fishery independent recruitment surveys) was 410 to 615 t. The total catch (434 t) was within the target catch range and the catch prediction. The level of fishing effort since 2007, when all boats adopted quad gear (4 standardised nets), has remained between 33 and 41 thousand trawl hours (standardised to twin nets) with fishing effort in 2015 being 40 thousand trawl hours. This evidence indicates that the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

BYCATCH AND PROTECTED SPECIES INTERACTIONS (*Low Risk*)

Bycatch composition is dominated by dead wire weed, which breaks off from the extensive shallow Wooramel seagrass bank annually over summer. The bycatch also contains a number of small size fish species mostly not taken by other sectors. Small blue swimmer crabs (under commercial size) and other crustacean species are taken in significant quantities but are generally returned alive. Overall bycatch taken in Shark Bay trawl nets is moderate relative to other subtropical trawl fisheries; with quantities ranging from 4–8 times the prawn catch. A study on the bycatch of trawled and untrawled areas of Shark Bay indicated highly diverse fish and invertebrate fauna (Kangas and Morrison 2013, Kangas *et al*. 2007) with no significant differences between trawled and untrawled areas for species richness, diversity or evenness for the major faunal assemblages within Shark Bay. Grid and secondary bycatch reduction devices (square mesh panels in cod-ends) have been fully implemented since 2003 and reduce the quantity of small fish and invertebrates retained in trawls.

Protected species including whales, dolphins, dugongs, turtles and sea snakes are particularly abundant in Shark Bay. However, only sea snakes are seen in the trawl catches in any numbers. Most are returned to the sea alive. The full implementation of bycatch reduction devices (grids) in the fishery has generally reduced the occasional capture of turtles in trawl nets (Shark Bay Prawn Table 1).

Shark Bay Prawn Table 1. *Protected species interactions recorded in the daily logbooks during 2015*

Species	Alive	Dead
Turtles	35	
Syngnathids	20	
Sea Snakes	1133	143
Saw Fish	3	2

HABITAT (*Moderate Risk*) AND ECOSYSTEM INTERACTIONS (*Low Risk*)

As a result of the extensive permanent and temporary closures first introduced in the 1960s, the fleet operates in approximately 5-7% of the overall licensed area of the fishery. Inside Shark Bay, trawl fishing is focused in the deeper areas (predominantly sand/shell habitats) of the central bay; north of Cape Peron; and in the northern area of Denham Sound. The majority of sponge/coral habitats are contained within specific trawl closures to protect these areas (Kangas *et al*. 2015).

Due to the predominantly mud and sand habitats of the trawl grounds, the trawl gear has relatively little physical impact. Overall, the nature of this trawl fishery and the controls on effort indicate that its environmental effect is likely to be moderate. Performance measures for habitat impact relate to the spatial extent of trawling within the Shark Bay Prawn Managed Fishery. In 2015 the total area trawled, at approximately 798 square nautical miles was 17% of inner Shark Bay, and 7% of the total fishery.

Although the prawn species are managed at relatively high levels of annual harvest, the impact of the catch on local food chains is unlikely to be significant in view of the high natural mortality, extent of non-trawled nursery areas and variable biomass levels of prawns resulting from variable environmental conditions. Because of this natural variation in prawn populations most prawn predators are opportunistic, and it is unlikely that the commercial take of prawns impacts significantly on the upper trophic levels of the Shark Bay ecosystem. The reduced levels of effort within the fishery now, combined with the gear modifications to reduce unwanted catch, have further lessened the impact the fishery has on the wider Shark Bay food chain.

SOCIAL AND ECONOMIC OUTCOMES

Social

This industry is a major contributor to regional employment. During 2015, approximately 100 skippers and crew were employed in the fishery. There are also approximately 55 processing and support staff employed at Carnarvon. One of the key operators with 10 licences is based in Carnarvon with administration, wharf and engineering staff based at the small boat harbour and a processing factory at Babbage Island. The prawn sector also utilises, wherever possible, Western Australian service companies providing engineering supplies, packaging, transport logistics, ship stores and fuel.

Economic

The value of the fishery including coral prawns, cuttlefish, squid and bugs is $28.7 million. This value excludes scallops and blue swimmer crabs which are separate Managed Fisheries. (see Saucer Scallop Resource and Blue Swimmer Crab Resource Status Reports). Ex-vessel (beach) prices for prawns vary, depending on the type of product and the market forces operating at any one time. Average prices per kg for 2015 were: western king prawns $11.42, brown tiger prawns $14.25, blue endeavour prawns $9.48, coral prawns $3.53.

GOVERNANCE SYSTEM

The total landings, plus the western king prawn and brown tiger prawn annual landings in 2015 were all within their respective tolerance ranges. The annual fishing level is considered **acceptable**.

Shark Bay Prawn Table 2. *Annual catch tolerance levels (acceptable)*

Total Prawn Catch	1,350-2,150 t
Western King Prawns	950-1,450 t
Brown Tiger Prawns	400-700 t
Blue Endeavour Prawns	1-30 t
Coral Prawns	80-280 t

Harvest Strategy (Formal)

The fishery is managed in accordance with the Shark Bay Prawn Managed Fishery Harvest Strategy, 2014-2019 (DoF 2014). The primary management objective is to maintain the spawning biomass above the historically determined biological reference points.

The key stock indicator for each primary species was above their respective target levels hence no changes to management arrangements will occur for 2016/17.

Compliance

It is a requirement that all vessels in the fishery are fitted with an Automatic Location Communicator (ALC). The implementation of an ALC enables the Department of Fisheries (Department) to monitor the fleet using a Vessel Monitoring System (VMS) and manage compliance with temporal and spatial closures. The Department also undertakes regular vessel inspections to ensure fishing is being undertaken in accordance with the governing legislation (e.g. gear requirements, catch reporting).

Consultation

Annual Management Meetings are held between the Department and licensees, in conjunction with the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC). These meetings provide an opportunity for the Department, WAFIC and industry to discuss research outcomes and initiatives, management of the fishery and industry issues.

Season arrangements are developed each year in consultation between the Department and licensees. During the season, the Department and licensees undertake collaborative in-season management to ensure the protection of smaller prawns and to maintain the spawning stock biomass.

Management Initiatives (Stable)

Management initiatives for 2015/16 include undertaking work to address conditions of certification.

EXTERNAL DRIVERS

External drivers for this fishery include increasing costs of fishing, lower returns due to the current global economic climate, and competition from imported and locally aquaculture produced small prawns. This has shifted harvesting practices to focus on targeting larger prawns during high catch rate periods to maximise efficiency. The drop in the value of the Australian dollar has shifted the emphasis from solely domestic markets to include international markets. Industry has been seeking the opportunity to maximise the return from all species taken (including byproduct) in the fishery where possible, particularly saucer scallops and blue swimmer crabs.

The major environmental factor influencing these stocks appears to be the flow of the Leeuwin Current along the outside of the embayment such that increases in water temperature associated with the Leeuwin Current has shown an increase in growth and catchability of prawns.

REFERENCES

Caputi N, Kangas M, Hetzel Y, Denham A, Pearce A, and Chandrapavan A. 2016. Management adaptation of invertebrate fisheries to an extreme marine heat wave event at a global warming hotspot. Ecology and Evolution. doi: 10.1002/ece3.2137 http://onlinelibrary.wiley.com/doi/10.1002/ece3.2137/full

Caputi N, de Lestang S, Hart A, Kangas M, Johnston D, and Penn J. 2014a. Catch Predictions in Stock Assessment and Management of Invertebrate Fisheries Using Pre-Recruit Abundance—Case Studies from Western Australia, Reviews in Fisheries Science & Aquaculture, 22:1, 36-54.

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2014b. *Management implications of climate change effect on fisheries in Western Australia*: Part 1, Fisheries Research and Development Corporation project 2010/535. *Fisheries Research Report*, Western Australian Department of Fisheries.

Caputi N, Penn JW, Joll LM, and Chubb CF. 1998. *Stock–recruitment–environment relationships for invertebrate species of Western Australia*, in: Jamieson GS and Campbell A. (eds) Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management, *Canadian Special Publication of Fisheries and Aquatic Sciences*, 125: 247–255.

DoF. 2014. Shark Bay Prawn Managed Fishery Harvest Strategy 2014 – 2019. *Fisheries Management Paper*, No. 267. Department of Fisheries, WA.

DoF. 2015. Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia. *Fisheries Management Paper*, No. 271. Department of Fisheries, WA.

Grey DL, Dall W, and Baker A. 1983. *A Guide to the Australian Penaeid Prawns*. Northern Territory Department of Primary Production, Darwin.

Kangas MI, Sporer EC, Hesp SA, Travaille KL, Brand-Gardner SJ, Cavalli P, and Harry AV. 2015. Shark Bay Prawn Managed Fishery, *Western Australian Marine Stewardship Council Report Series* 2: 294 pp.

Kangas M and Morrison S. 2013. Trawl impacts and biodiversity management in Shark Bay, Western Australia, *Marine & Freshwater Research*, 64: 1135–1155.

Kangas M, Morrison S, Unsworth P, Lai E, Wright I, and Thomson A. 2007. *Development of biodiversity and habitat monitoring systems for key trawl fisheries in Western Australia*, final report, Fisheries Research and Development Corporation project 2002/038. *Fisheries Research Report*, 160. Fisheries Western Australia, North Beach.

Penn JW, Caputi, N, and Hall NG. 1995. Stock–recruitment relationships for the tiger prawn (*Penaeus esculentus*) stocks in Western Australia, *ICES Marine Science Symposium*, 199: 320–333.

Penn JW. 1984. The behaviour and catchability of some commercially exploited penaeid species and their relationship to stock and recruitment, in: *Penaeid shrimp – their biology and management. Fishing News Books* – England.

Penn JW. 1980. Spawning and fecundity of the western king prawn, *Penaeus latisulcatus*, Kishinouye, in Western Australian waters. Aust. J. Mar, Freshwat. Res. 31: 21-35.

SAUCER SCALLOP RESOURCE STATUS REPORT 2016

M. Kangas, E. Sporer, S. Wilkin, P. Cavalli and R. Oliver

OVERVIEW

Saucer scallops, *Ylistrum balloti* (formerly *Amusium balloti*), are fished using otter trawls in four separate fisheries in Western Australia. The Shark Bay Scallop Managed Fishery (SBSMF) is usually Western Australia's most valuable scallop fishery with boats licensed to take only scallops (11 Class A licenses) and boats that also fish for prawns (18 Class B licenses). The second largest scallop fishery is the Abrolhos Islands and Mid-West Trawl Managed Fishery (AIMWTMF). The South West Trawl Managed Fishery (SWTMF) and the South Coast Trawl fishery (SCTF) are multi-species fisheries that primarily target scallops.

Management is generally based on limited entry, gear controls and seasonal closures however Shark Bay has been undertaking a catch quota trial with an allocation between the Class A and B sectors.

Catches in these fisheries vary widely depending on the strength of recruitment, which is thought to be influenced by the strength of the Leeuwin Current and water temperature. Extreme environmental events, as was observed with a marine heat wave in the summer of 2010/11 had a significant impact on scallop stocks, particularly in Shark Bay and the Abrolhos Islands.

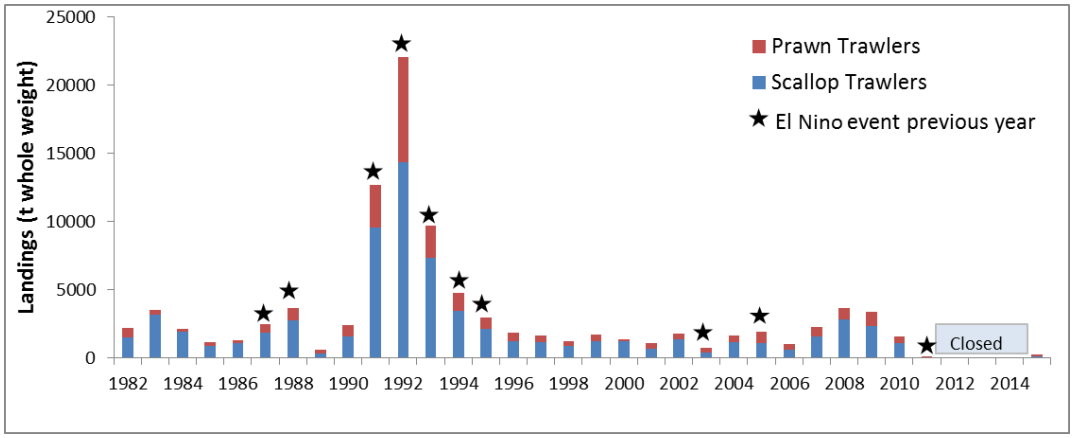
SUMMARY FEATURES 2016

Fishery Performance	Commercial	Recreational
Total Catch 2015	121 t meat weight (603 t whole weight)	Not applicable
Fishing Level	Acceptable	
Stock/Resource Performance	**Stock Status**	**Assessment Indicators**
Saucer Scallop	Recovering	Direct survey/catch rate
Shark Bay Abrolhos:	Environmentally limited	Recruitment survey, catch and effort
South-west	Adequate	Catch and effort
South coast	Adequate	Catch and effort

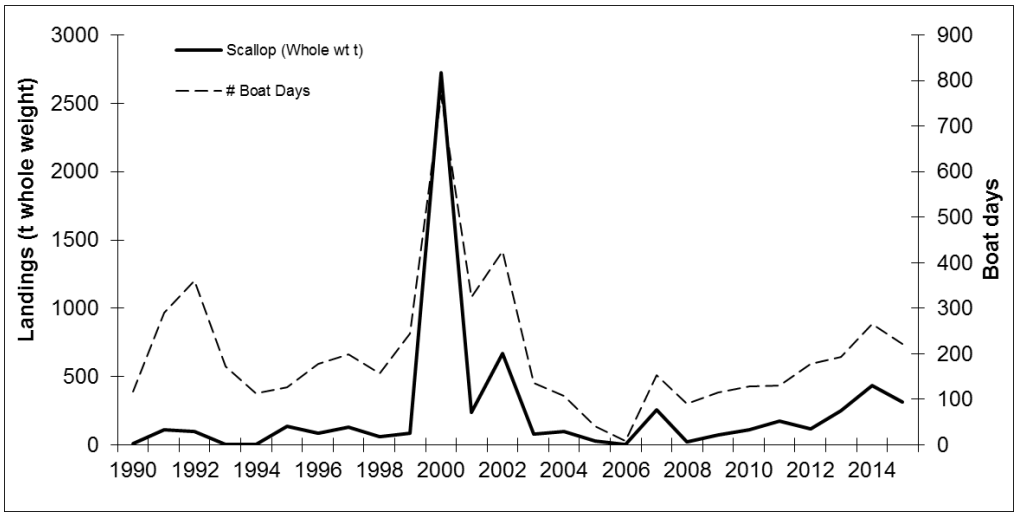
EBFM Performance Asset	Level	Asset	Level
Bycatch	Low Risk	**Listed Species**	Low Risk
Habitat	Low Risk	**Ecosystem**	Low Risk
Social	Amenity Score 1	**Economic**	GVP ($4.2 million)
	Risk Level 1		Risk Level 4
Governance	Plan review	**External Drivers**	Risk Level 5 (climate)

CATCH AND LANDINGS

The total scallop landing was 121 t meat weight (603 t whole weight) in WA in 2015. There was 57.6 t meat weight (287.8 t whole weight) taken in Denham Sound out of a quota with 100 t meat weight. The A Class boats landed 24.8 t (43.2 %) and the B Class boats landed 32.8 t (Saucer Scallop Figure 1). Minimal by-product was retained by A Class boats. The landings in the South Coast Fishery were 57.6 t meat weight (287.8 t whole weight, Saucer Scallop Figure 2). The Abrolhos Island fishery was closed and no fishing took place in the South-West Fishery.



SAUCER SCALLOP FIGURE 1: *Annual scallop catch (t whole weight) for the Shark Bay scallop fishery, 1982 to 2015. The fishery was closed between 2012 and 2014.*



SAUCER SCALLOP FIGURE 2: *Annual scallop catch (t whole weight) and number of boat days fished for the South Coast fishery, 1990 to 2015.*

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Saucer scallops are distributed from Esperance in Western Australia, across the tropics, to the southern coast of New South Wales. The genus was recently revised (Mynhardt *et al*. 2014). The Western Australian stock spans most of the coast of Western Australia but, given the vast length of this coastline and the potential for regional differences in recruitment, these four fisheries are considered independent management units.

Shark Bay Scallop Managed Fishery *(Recovering)*

The status of the stock in Shark Bay is determined from the annual pre-season fishery independent survey of recruitment and residual stock (Caputi *et al*. 2014a) carried out in November–December. This survey enables the management arrangements of the fishery to maintain adequate level of breeding stocks.

The fishery is currently in a recovery phase because the stock biomass had fallen to a level where there was a significant risk of recruitment failure. This low stock biomass was not due to overfishing or lack of appropriate fisheries management but from a series of poor recruitment events associated with sustained unfavourable environmental conditions dating back to in the marine heat wave that begun in late 2010 (Caputi *et al*. 2014a,b, 2016).

The stock has now fully recovered in Denham Sound but is recovering more slowly in northern

Shark Bay. The estimated spawning biomass in northern Shark Bay remains at record low levels but recruitment of 0+ scallops has increased in November 2015. Continued favourable environmental conditions for recruitment during 2015-16 is expected to further improve spawning biomass levels.

Abrolhos Islands and Mid-West Trawl Managed Fishery *(Environmentally Limited)*

The scallop numbers during the 2015 survey were low, however showed slight improvement on recent years (2012-2014). The numbers indicated that the landings would be less than the limit reference level and target range (95-1830 t whole weight) at which no fishing will occur. The stock continues to be considered as **environmentally limited**.

South West Trawl Managed Fishery (*Adequate*)

Effort has been related to either the abundance of western king prawn or saucer scallop in any given year, which can be highly variable due to sporadic scallop recruitment. Only 2-4 vessels have operated in the fishery since 2005 and have only covered approximately 1-3 per cent of the allowable fishery area. Since 2005 an average of 168 boat days have been recorded annually with a catch range between 1 and 217 t whole weight compared to 490 boat days on average the previous ten years (1995 to 2004) for a catch range between 3 and 23 t whole weight. The level of fishing pressure is unlikely to adversely impact the spawning biomass of saucer scallop. The scallop numbers during limited sampling in the key 'Rottnest' fishing grounds were low and industry chose not to fish this season.

South Coast Trawl Fishery *(Adequate)*

Effort is related to the abundance of scallops in any given year, which can be highly variable due to sporadic recruitment. The few vessels (up to four) that operate in the fishery only fish over 1-3 per cent of the allowable fishery area. In 2015 a total of 315 t whole weight was landed for 222 boat days. The mean catch rate in 2015 was 1419 kg whole weight per boat day compared to a mean of 1168 kg per boat day (range 669 to 1643 kg per boat day) for the previous five years. The above evidence indicates that the biomass of this stock is unlikely to be recruitment overfished. It also indicates that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished.

BYCATCH AND PROTECTED SPECIES INTERACTIONS (*Low Risk*)

Limited and restricted fishing occurred in Shark Bay in 2015. Owing to the legislated 100 mm mesh mesh size of the nets and the relatively short duration of this fishery, the total bycatch landed is minimal. Grids have been fully implemented in this fishery since 2003. Protected species are occasionally captured but generally are released alive due to the relatively short duration of trawls and there were no reported interactions with protected species in 2015.

Protected species that are susceptible to capture by trawling do not occur regularly in the fishing areas of the SWTMF and the SCTF and while turtles occur in the Abrolhos Islands, these are towards the southern extent of their range, and do not breed in the area because water temperatures are too low. Consequently, interactions with turtles were always minimal, and now that grids are compulsory in the fishery their capture should be eliminated. No fishing took place in the AIMWTMF and SWTMF in 2015.

HABITAT AND ECOSYSTEM INTERACTIONS (*Low Risk)*

Habitat effects are considered **low risk**, with trawl boats generally sweeping a small proportion of the designated trawl area. Because these areas are sandy habitats, and trawling activity has low impact on the substrate (Laurenson *et al*. 1993); the overall habitat effects are **low**. In Shark Bay only 4.4% of the allowable trawl area was fished in 2015 (noting northern Shark Bay was closed to scallop fishing). Only 1.9% of the legislated boundary of the fishery was trawled on the South Coast with no fishing in the other two fisheries.

The ecosystem impacts of scallop fisheries are considered to be **low risk**, with the total biomass taken by these operations being small. The high natural recruitment variability and therefore scallop stock abundance and short life span (up to 3 years) also means that few predators will have become highly dependent on the species.

SOCIAL AND ECONOMIC OUTCOMES

Approximately 20 skippers and crew were employed in scallop fishing the Shark Bay and

South Coast fisheries, with support staff in Geraldton and Fremantle. In Shark Bay, an additional 70-80 crew are employed in the prawn fishery (B Class) that can also retain scallops. The overall GVP for the two fisheries that operated in 2015 (including B Class boats in Shark Bay) was $4.2 million.

GOVERNANCE SYSTEM

Annual Catch Tolerance Levels (Not Applicable)

Shark Bay: Not applicable for season 2015 (trial quota).

Abrolhos Islands: No fishing in 2015.

South West: Catch range not developed.

Harvest Strategy

The harvest strategy for Shark Bay and the Abrolhos Islands fisheries is based on the abundance of scallop found during annual recruitment/spawning stock surveys. Catch predictions for 2015, derived from surveys in November 2014 were very low for northern Shark Bay but moderate recovery was evident in Denham Sound. Consequently, to provide protection to the breeding stocks and aid recovery, management measures used in 2015 included a ban on scallop harvest from northern Shark Bay and a trial quota of 100 t meat weight for Denham Sound.

Compliance

It is a requirement that all vessels in the fishery are fitted with an Automatic Location Communicator (ALC). The implementation of an ALC enables the Department of Fisheries (Department) to monitor the fleet using a Vessel Monitoring System (VMS) and manage compliance with temporal and spatial closures. The Department also undertakes regular vessel inspections to ensure fishing is being undertaken in accordance with the governing legislation (e.g. gear requirements, catch reporting).

Consultation

Annual Management Meetings are held between the Department and licensees, in conjunction with the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC). These meetings provide an opportunity for the Department, WAFIC and industry to discuss research outcomes and initiatives, management of the fishery and industry issues. Season arrangements are developed each year in consultation between the Department and licensees.

Management Initiatives

Catch quota trial will be continued in 2016 for both A and B Class boats in Shark Bay.

EXTERNAL DRIVERS *(Major Risk)*

Strong La Niña events that are typically associated with strong Leeuwin Currents and warm sea-surface temperatures, often result in below-average scallop recruitment and may necessitate the closure of the Shark Bay Scallop Managed Fishery and/or the Abrolhos Island and Mid-West Trawl Managed Fishery. Between 2012 and 2015 fishery closures in these two fisheries also occurred due to a marine heat wave event in 2010/11 (associated with a strong La Niña) which resulted in mortality of breeding stock and subsequent very poor recruitment for a number of years (Caputi *et al*. 2014 b, 2016). Further research continues into understanding recruitment variation (including the collapse) of scallop stocks.

REFERENCES

Caputi N, de Lestang S, Hart A, Kangas M, Johnston D, and Penn J. 2014a. Catch predictions in stock assessment and management of invertebrate fisheries using pre-recruit abundance case studies from Western Australia. Reviews in *Fisheries Science & Aquaculture*, 22:36-54. http://dx.doi.org/10.1080/10641262.2013.832144.

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2014b. Management implications of climate change effects on fisheries in Western Australia. Part I. Fisheries Research and Development Corporation project 2010/535. *Fisheries Research Report*, Western Australian Department of Fisheries, Perth. http://www.fish.wa.gov.au/Documents/research_reports/frr260.pdf.

Caputi N, Kangas M, Hetzel Y, Denham A, Pearce A, and Chandrapavan A. 2016. Management adaptation of invertebrate fisheries to an extreme marine heat wave event at a global warming hotspot. *Ecology and Evolution*. http://onlinelibrary.wiley.com/doi/10.1002/ece2/2137/full.

Laurenson LJB, Unsworth P, Penn JW, and Lenanton, RCJ. 1993. The impact of trawling for saucer scallops and western king prawns on the benthic communities in coastal waters off South Western Australia. *Fisheries Research Report*, Fisheries Department, Western Australia. 100 : 1-93.

Mynhardt G, Alejandrino A, Puslednik L, Corrales J, and Serb JM. 2014. Shell shape convergence masks biological diversity in gliding scallops: Description of Ylistrum n. gen. (Pectinidae) from the Indo-Pacific Ocean. *Journal of Molluscan Studies 80(4): 400-411*. Available online at http://dx.doi.org/10.1093/mollus/eyu038

SHARK BAY BLUE SWIMMER CRAB RESOURCE STATUS REPORT 2016

A. Chandrapavan, E. Sporer, R. Oliver and P. Cavalli.

OVERVIEW

The blue swimmer crab (*Portunus armatus*) resource in Shark Bay is harvested commercially by the Shark Bay crab trap, Shark Bay prawn trawl and Shark Bay scallop trawl fisheries. This crab stock also supports a small (~2.2 t) but regionally important recreational fishery. The management moved from an effort-controlled system to a notional quota management system in 2013/14. The Individual Transferable Quota management system was formally implemented for the fishery in the 2015/16 season. The Shark Bay crab resource was allocated across the various sectors based upon proportional catch histories: trap – 66.0%; prawn trawl – 33.8%; and scallop trawl – 0.2%.

Recreational fishing for blue swimmer crabs mainly use drop nets or scoop nets. This sector is managed through a combination of input and output controls including a minimum size limit that is well above the size at sexual maturity along with a bag and boat limits.

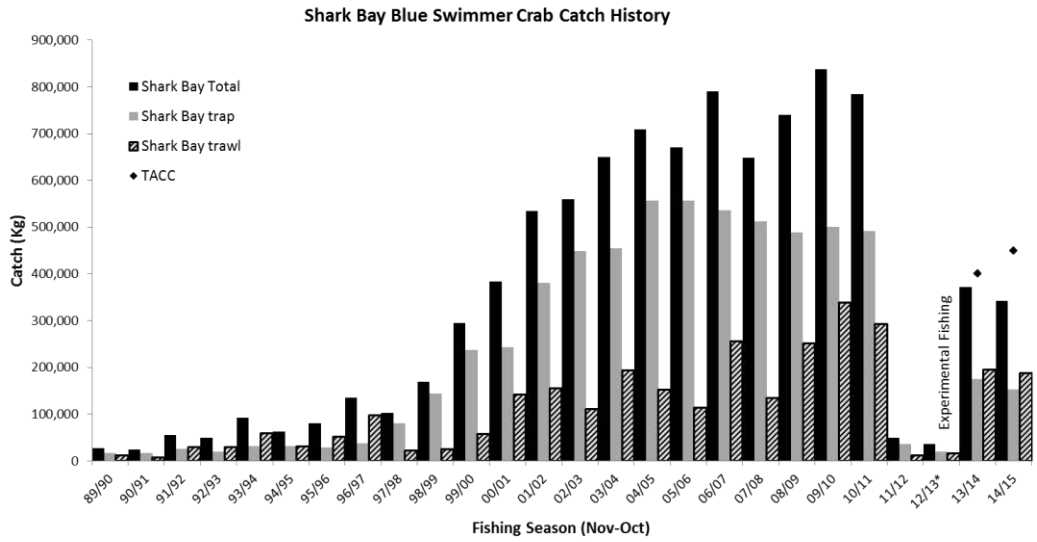
The fishery was assessed under the provisions of the Commonwealth's EPBC Act in 2015 and has been accredited for export for a period of ten years (re-assessment in 2025).

SUMMARY FEATURES 2016

Fishery Performance	Commercial	Recreational	
Total Catch 2015	341 t (2014/15)	~2.2 t (Gascoyne bioregion boat estimate 2013/14)	
Fishing Level	Acceptable	Acceptable	
Stock/Resource Performance	**Stock Status**	**Assessment Indicators**	
Shark Bay Blue Swimmer Crab	Recovering	Direct survey/catch rate	
EBFM Performance			
Asset	**Level**	**Asset**	**Level**
Bycatch	Negligible Risk (trap) Low Risk (trawl)	**Listed Species**	Low Risk
Habitat	Low Risk	**Ecosystem**	Low Risk
Social	Amenity Score 2 Risk Level 3	**Economic**	GVP Risk Level 5 ($1.83 million)
Governance	New Management plan (Nov 2015)	**External Drivers**	Risk Level 5 (climate)

CATCH AND LANDINGS

A TACC of 450 tonnes was set for 2014/15 fishing season (1 November 2014 to 19 November 2015) and in accordance with the catch share arrangement between the trap and trawl sectors outlined above and some quota was transferred between the trap and trawl sectors. The total catch achieved for the 2014/15 season was 341 t (~76% of the TACC) with a total of 109 tonnes of unfished quota allocation (Shark Bay Blue Swimmer Crab Figure 1). The trap sector's total catch was 153 t over a total of 353 fishing days (all taken in the northern fishing grounds). This represented 45% of the total landings for this season. The prawn trawl sector's total catch was 188 t which represented 55% of the total landings, while the scallop trawl sector's total catch was 143 kg.



SHARK BAY BLUE SWIMMER CRAB FIGURE 1. *Commercial catch history for the blue swimmer crab (Portunus armatus) between trap and trawl sectors since 1989/90. *The catch for 2012/13 is generated from the experimental commercial fishing trial. A TACC of 400 and 450 tonnes was set for the 2013/14 and 2014/15 fishing seasons respectively.*

SPECIES ASSESSMENTS AND STOCK STATUS

Blue swimmer crabs in Shark Bay have an approximate 18-month life cycle from spawning to becoming commercial sized crabs. The peak spawning period occurs during the cooler autumn/winter months and is captured in the Department's June research survey which provides an index of peak spawning levels. The peak recruitment from this spawning period is during the warmer summer months and is captured during the February survey, approximately 9 months after spawning. Crabs attain sexual maturity within 12 months (between 100 - 110 mm CW) and reach commercial sizes (voluntary minimum size limit of 135 mm CW) between 12 and 18 months of age.

The Shark Bay crab stock experienced a significant stock decline in late 2011, following a series of adverse environmental conditions between 2010 and 2011 (coldest winter on record in 2010 followed by an extreme marine heat wave event and flooding events during the summer of 2010/11). These environmental conditions are believed to have caused a major recruitment decline for the following season. The fishery was closed for a period of 18 months in 2012 to promote stock recovery and is currently in a stock rebuilding phase. Limited commercial fishing resumed under a notional quota management system for the 2013/14 (400 t) season, and continued for the 2014/15 season with a Total Allowable Commercial Catch (TACC) of 450 t.

Indices of spawning biomass levels (survey data and modelling data), while partially recovering, have not increased from the level in 2013 which appears partly due to relatively stable recruitment levels (survey data) since fishing had resumed. If the current level of catch and environmental conditions continue, further spawning stock recovery is not likely to be achieved. Moreover, if landed catches are close to 450 t (the current TACC), it is likely that the spawning biomass will further decline and it is possible that recruitment may be even further affected.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Hourglass traps are purpose-designed to minimise the capture of undersized blue swimmer crabs and non-target species, the majority of which are able to escape through the entrance gaps when the pot is soaking or being hauled. The number of bycatch species recorded in the fishery (mainly finfish and other invertebrates) is low and considered to pose a negligible risk to these stocks. The trap fishery is conducted in a manner that avoids mortality or injuries to endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities. Bycatch from

the prawn and scallop trawl fleets are described in the relevant status reports specific to the trawl fisheries (see Gascoyne Shark Bay Prawn Resource and Saucer Scallop Resource Reports).

HABITAT AND ECOSYSTEM INTERACTIONS

As the commercial take of crabs represents a relatively small portion of the biomass, which is effectively renewed annually, secondary food chain effects are likely to be minimal in these fisheries.

Fishing with traps results in limited habitat disturbance, as only minor dragging of traps on the sea bottom occurs during trap retrieval. Sand and associated biota does not get brought to the surface in commercial blue swimmer crab traps, as the mesh used on traps is sufficiently large to allow the escape of any sand-dwelling macro-benthos. Although seagrasses are occasionally uprooted and brought to the surface with the trap, the infrequent nature of this occurrence, and the small amount of living seagrass removed, results in minimal habitat damage. The impact on habitat and ecosystem interactions are described in the relevant status reports specific to the trawl fisheries (see Gascoyne Shark Bay Prawn Resource and Saucer Scallop Resource Reports).

SOCIAL AND ECONOMIC OUTCOMES

Social

Prior to the closure, the trap sector employed approximately 15 people as skippers and crew on vessels fishing for blue swimmer crabs in the Gascoyne Coast Bioregion and additional employment for some 30-35 workers through the development of post-harvest processing of the crab catch were inactive. The closure of the Shark Bay crab fishery during 2012/13 had a significant socio-economic impact on both the trap and trawl sectors. Resumption of fishing has relieved some economic pressure but there are ongoing logistical issues with retaining crew and staff.

Economic

The average beach price for uncooked crabs across WA was $5.36/kg. The estimated value of the commercial blue swimmer crab resource from Shark Bay was $1.83 million which was a combination of $1.01 million from the trawl sector and $0.82 million from the trap sector for 2014/15.

GOVERNANCE SYSTEM

Annual Catch Tolerance Levels

TACC of 450 t: The total catch for 2014/15 was 341 t (~76% of TACC). Non achievement of this TACC was largely due to unused quota in trap sector.

Harvest Strategy

The formal harvest strategy is currently under development. The TACC setting process currently takes into account information from fishery-independent surveys, commercial catch and effort, environmental conditions and also results from a biomass dynamic model.

Compliance

The Department undertakes regular vessel and landing inspections to ensure fishing is being undertaken in accordance with the governing legislation (e.g. gear requirements, catch reporting and size and bag limits). It is also a statutory requirement that commercial fishers submit Catch and Disposal Records outlining the weight of crabs landed after each fishing trip. This information enables the Department to monitor the TACC and investigate any breaches of entitlement.

Consultation

The Department undertakes consultation directly with commercial licensees on operational issues. Annual Management Meetings between the Department and licensees are convened by the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC) under a Service Level Agreement (SLA) with the Department. These meetings provide an opportunity for the Department, WAFIC and industry to discuss research outcomes and initiatives, management of the fishery and industry issues.

Recreational consultation processes are facilitated by Recfishwest under a SLA.

Management Initiatives/Outlook Status

On 20 November 2015, the Shark Bay Crab Managed Fishery Management Plan 2015 (new Plan) commenced providing the management framework for the take of blue swimmer crab by all three commercial sectors (i.e. by the prawn

trawl, scallop trawl and crab trap). Concurrently, the Shark Bay Crab Fishery (Interim) Management Plan 2005 was revoked and the Fishing Boat Licence condition which permitted operators to fish in the inner gulfs of Shark Bay was removed, given these arrangements are encompassed under the new Plan. The new Plan is based on an Individual Transferable Quota (ITQ) system of entitlement and includes two zones to maintain the previous access arrangements.

The Department will also be developing a harvest strategy for the fishery in consultation with the relevant stakeholders during 2016/17 outlining the long and short term management objectives for the fishery and the performance indicators, reference levels and harvest control rules required to achieve these objectives.

EXTERNAL DRIVERS

Warmer sea surface temperatures (SSTs) during the winter spawning period and cooler SSTs during the summer months have been identified to be favourable for recruitment of blue swimmer crabs in Shark Bay. Shark Bay experienced the coldest winter SSTs on record prior to the hottest summer SSTs on record between 2010 and 2011, which led to a significant recruitment decline in 2012. Environmental conditions in Shark Bay have since improved but cooler than average winter and warmer than average summer temperatures have been identified as a unique phenomenon that persists within Shark Bay. There is now an ongoing risk associated with the current environmental conditions in Shark Bay on the full recovery of the crab stock and thus it is being closely monitored.

Furthermore, blue swimmer crabs are ranked “high risk” under the current climate change scenario impacting the WA coastline.

GASCOYNE EXMOUTH GULF PRAWN RESOURCE STATUS REPORT 2016

M. Kangas, E. Sporer, S. Wilkin, I. Koefoed, P. Cavalli and L. Pickles

OVERVIEW

The Exmouth Gulf Prawn Managed Fishery uses low opening, otter prawn trawl systems within the sheltered waters of Exmouth Gulf (Kangas *et al*. 2015) to target western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus endeavouri*) and banana prawns (*Penaeus merguiensis*). Management of this fishery is based on input controls, including limited entry, gear controls (maximum headrope units) seasonal and area openings and closures and moon closures. Management arrangements are designed to keep fishing effort at levels that will maintain a sufficient spawning biomass of prawns (particularly brown tiger prawns). Bycatch reduction devices (BRDs) and a secondary fish escape device (FED) are mandatory.

This fishery received Marine Stewardship Council (MSC) certification in October 2015. The Commonwealth Government's Department of the Environment and Energy (DEE), assessed the fishery in 2015 under the provisions of the Environmental Protection and Biodiversity Act 1999 (EPBC Act), and has accredited the fishery for a period of ten years (re-assessment in 2025), allowing product from the fishery to be exported from Australia (https://www.environment.gov.au/marine/fisheries/wa/exmouth-gulf-prawn).

Industry, in association with the Department, successfully gained certification from the US Department of State in 2008 and was re-certified in 2012 which will be reviewed in 2016. This certification allows licensees to export product to the US market.

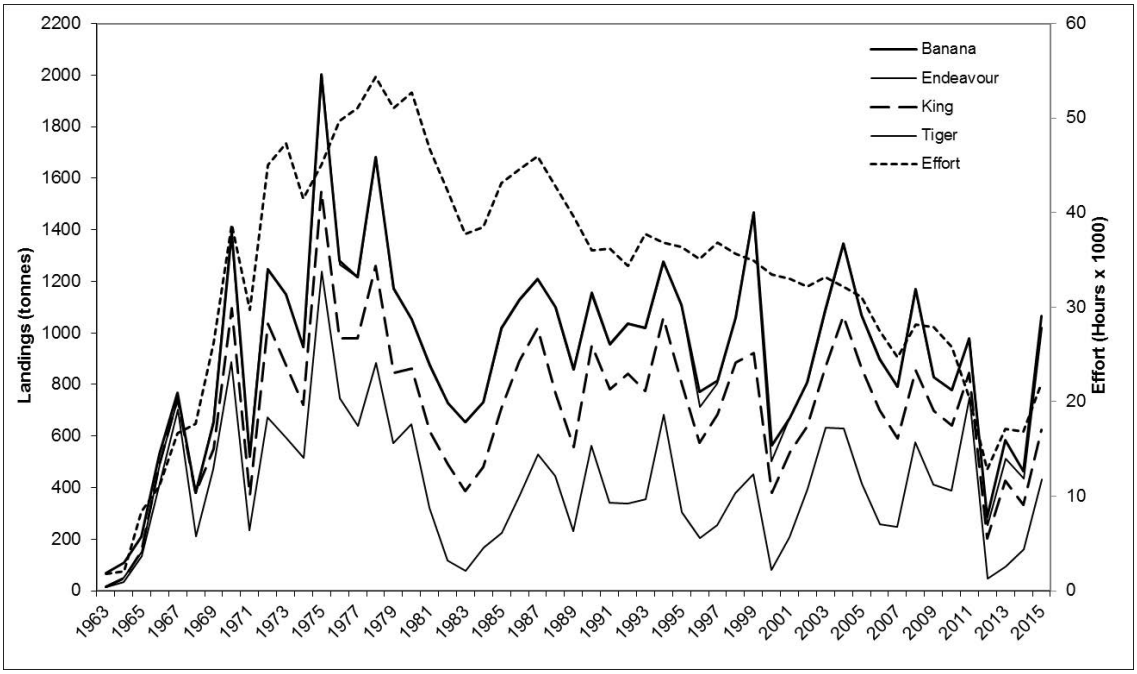
SUMMARY FEATURES 2016

Fishery Performance	Commercial	Recreational
Total Catch 2015	Commercial: 1,067 t	Not applicable
Fishing Level	Acceptable	
Stock/Resource Performance	**Stock Status**	**Assessment Indicators**
Brown Tiger Prawn	Adequate	Level 4 - Direct Survey/Catch Rate
Western King Prawn	Adequate	Level 4 - Direct Survey/Catch Rate
Blue Endeavour Prawn	Adequate	Level 2 - Catch and Survey/Catch Rate

EBFM Performance Asset	Level	Asset	Level
Bycatch	Low Risk	**Listed Species**	Low Risk
Habitat	Low Risk	**Ecosystem**	Low Risk
Social	Amenity Score 1 Risk Level 1	**Economic**	GVP Risk Level 4 ($13.9 million)
Governance	Stable	**External Drivers**	Risk Level 5 (climate)

CATCH AND LANDINGS

The total landings of prawns in 2015 were 1,067 t (Exmouth Gulf Prawn Figure 1) and recorded landings of by-product were; 6.6 t of blue swimmer crab (*Portunus armatus*), 1.8 t of squid, 3.0 t of bugs (*Thenus australiensis*), 0.3 t of coral prawns, 0.2 t of cuttlefish and 0.2 t of octopus. Historical landings are provided in Kangas *et al.*2015.



EXMOUTH GULF PRAWN FIGURE 1. *Annual prawn landings (t) and fishing effort (total adjusted hours) for the Exmouth Gulf Prawn Managed Fishery 1963-2015.*

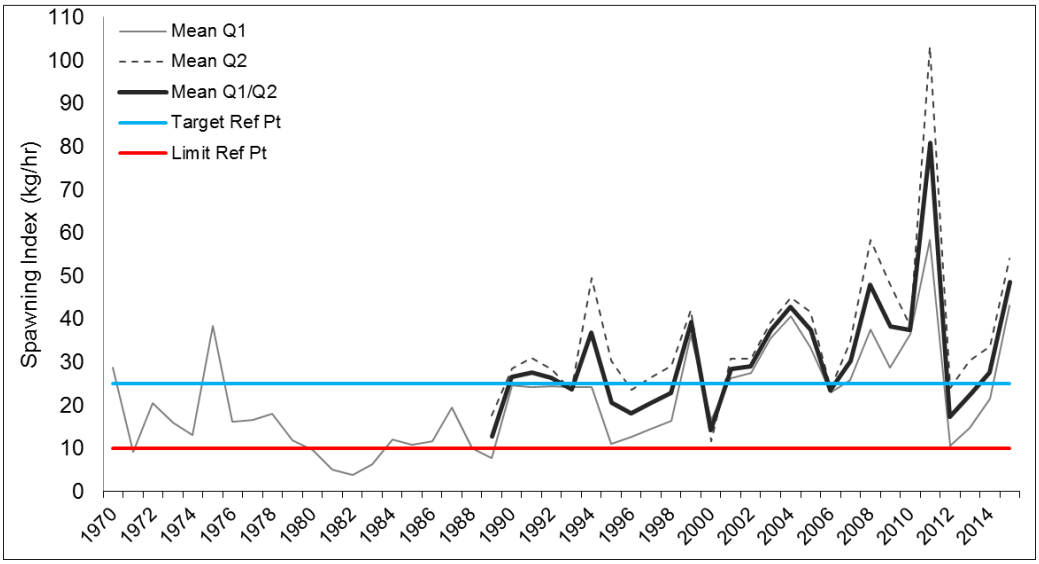
INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS *(Sustainable-Adequate)*

Brown tiger prawns

Brown tiger prawns are endemic to tropical and subtropical waters of Australia and are distributed around the northern coast, from central New South Wales in the east to Shark Bay in Western Australia (Grey *et al.* 1983). They are relatively short-lived (2-3 years), become sexually mature around 6-8 months and primarily spawn in spring and early summer.

The status of the stocks is assessed annually using a weight-of-evidence approach primarily based on monitoring of fishery-independent indices of recruitment and spawning stock levels relative to specified reference points. Recruitment surveys provide the basis of an annual catch prediction (Caputi *et al*. 2014a). Other information collected throughout the season (e.g. commercial catches, effort and environmental data) is also evaluated to provide insight on, for example, any environmental factors affecting prawn recruitment.

The management objective is to maintain the spawning biomass above the historically determined biological reference points, with the present target of 25 kg/hr and a limit of 10 kg/hr in the spawning stock surveys (DOF 2014). Daily monitoring of commercial catch rates ensures cessation of fishing at the target catch rate within the key spawning area. Fishing ceases in early August even if catch rates are above the target level. The standardised spawning stock surveys carried out from August to October 2015 had an average catch rate of 48.5 kg/hr, well above the target level (Exmouth Gulf Prawn Figure 2). The fishery has fully recovered from the effects of the marine heat wave (Caputi *et al*. 2015) that may have affected the structured inshore nursery habitat indicating that the this stock is highly unlikely to be recruitment overfished.



EXMOUTH GULF PRAWN FIGURE 2. *Brown tiger prawn spawning stock mean catch rate (kg/hr) for August, September and October combined and target and limit reference levels.*

With respect to fishing mortality, temporal and spatial closures (based on fishery independent and industry surveys) ensure that brown tiger prawns are not harvested at sub-optimal sizes. The annual catch tolerance range for brown tiger prawns is 250 to 550 t (DOF 2014) with the catch prediction of 220 to 330 t for 2015. The total catch (433 t) was within the target catch range but above the catch prediction. The standardised fishing effort in 2015 was 22 thousand trawl hours which is reduced from historical levels (35 to 50 thousand hours standardised to twin gear) with all boats adopting quad gear (4 nets) and total boat number being reduced from 12 to six (Kangas *et al*. 2015). The current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

Western king prawns

The western king prawn is widely distributed throughout the Indo-West Pacific region (Grey *et al*. 1983). Two major fisheries occur in Shark Bay and Exmouth Gulf, with smaller quantities landed off Onslow and Broome.

Western king prawns live between 2-3 years with sexual maturity being reached around 6-8 months. This species can spawn all year round with peaks of spawning during the spring and autumn. Post-larval and juvenile western king prawns can be found inshore on shallow tidal flats with sand or mud sediments, such inshore areas can have salinities higher than seawater (i.e. hypersaline waters) and juveniles prefer this habitat, unlike most other prawn species, which prefer estuarine conditions western king prawns are nocturnal and highly sensitive to light, with their activity and catchability influenced by lunar cycles as well as temperature (Penn 1984).

Fishery-independent recruitment surveys are undertaken each year to assess their abundance and size structure and are used for catch predictions (Caputi *et al*. 2014a, 2016) and management decisions such as spatial-temporal opening of fishing areas. In 2015 the recruitment index was 25.4 kg/hr which was below the target (30 kg/hr) and therefore fishing was delayed in key western king prawn grounds until August when catch rates were above the target. The spawning stock index for 2015 (commercial catch rates in key western king prawn fishing ground in August and September) was 35.0 kg/hr which was above the target (25 kg/hr).

With respect to fishing mortality, catch and catch rate levels from 1989 to 1998 have been used as the basis for calculating target catch ranges of 350 to 500 t and a catch rate of 12 kg/hr (range 8 to 14 kg/hr). This target catch range is being reviewed due to the apparent negative impacts of increased water temperature on recruitment and with the level of effort having declined for the fishery as a result of fleet restructures and targeting larger prawns. The commercial catch for 2015 of 192 t was well below the target range with a mean catch rate (8.7 kg/hr) at the lower end of the target range. The above evidence indicates that the biomass of the stock is unlikely to be recruitment overfished and

that the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished.

Blue endeavour prawn

Endeavour prawn fisheries are located in Shark Bay, Exmouth Gulf, on the north coast of Western Australia, the Gulf of Carpentaria, the Torres Strait and on the east coast of Queensland. This species is generally found in coastal waters down to approximately 50 m and is commonly trawled over muddy or sand/mud sediment substrates. They are generally found inshore of the main fishing grounds for the brown tiger and western king prawns.

Blue endeavour prawn catches have ranged between 120 and 300 t in most years, mainly related to the effort applied to brown tiger prawns in areas where endeavour prawns also occur. The breeding stocks of endeavour prawns are considered to be at a lower level of vulnerability to the fishery compared to brown tiger prawns. Therefore, the current strong management controls designed to ensure the sustainability of brown tiger prawns should ensure the maintenance of adequate levels of endeavour prawns. The main part of their distribution is inshore and overlaps with the extensive brown tiger prawn permanent nursery and temporal spawning closures. This protects a significant portion of the blue endeavour prawn breeding stock. In addition, blue endeavour prawns are considered to be more resilient to fishing pressure due to their smaller size and lower catchability. It is therefore unlikely that they are being fished to levels associated with maximum acceptable fishing levels, which represents a **low risk**.

Fishery-independent recruitment surveys of brown tiger and western king prawns also record the abundance of blue endeavour prawns providing an annual recruitment abundance index for this species. In 2015 the mean abundance index (catch rate) for the blue endeavour prawn on the brown tiger prawn grounds of 17 kg/hr was above the 15 year mean (1997-2011) of 15 kg/hr and within the range observed during these years (6 to 35 kg/hr). On the western king prawn grounds the mean abundance index of 22 kg/hr, was well above the 6-year mean (2007-2012) of 14 kg/hr and within the range observed (2 to 38 kg/hr) during those years. There has been no declining trend in the fishery independent survey catch rates over the periods sampled in either of these fishing grounds. As a result, the biomass of the stock is not considered to be recruitment overfished.

With respect to fishing mortality, a target catch range is set at 120 to 300 t, based on historical catches between 1989 and 1998. The total catch in 2015 (397 t) was above the target catch range and the average catch over the past 15 years (201 t) reflecting the higher recruitment observed. The current level of effort is unlikely to cause the stock to become recruitment overfished.

BYCATCH AND PROTECTED SPECIES INTERACTIONS (*Low Risk*)

Bycatch levels for Exmouth Gulf are relatively low by tropical trawl fisheries standards, with few species of significance to other fishing sectors being taken. In addition to grids, secondary bycatch reduction devices (square mesh panels) were implemented in all nets in 2005. All boats also use hoppers (in-water catch sorting systems), which adds another level of improvement for bycatch survival and product quality.

While protected species including dugongs, turtles and sea snakes occur in the general area, only sea snakes and occasionally turtles are encountered in the trawl catches (Exmouth Gulf Prawn Table 1). Both species are typically returned alive (Kangas *et al*. 2015). Grids have largely eliminated turtles and other large animal captures.

EXMOUTH GULF PRAWN TABLE 1. *Protected species interactions recorded in the daily logbooks during 2015.*

Species	Alive	Dead	Unknown
Turtles	14	1	NA
Sea Snakes	496	74	NA
Seahorses	4	0	NA
Pipefish	2	0	NA
Saw Fish	4	1	1

HABITAT AND ECOSYSTEM INTERACTIONS *(Low Risk)*

Owing to the predominantly mud and sand habitats of the trawl grounds, the trawl gear has relatively little physical impact. Overall, the nature of this fishery and controls on effort indicate that its environmental effect is likely to be low (Kangas *et al* 2015). Performance measures for habitat impact

relate to the spatial extent of trawling within the licensed area of the Exmouth Gulf fishery. In 2015 the performance measure was met as the total area trawled, at approximately 353 square nautical miles (31.0%) per cent of trawlable grounds in Exmouth Gulf was below the 40% level.

Although the prawn species are managed at relatively high levels of annual harvest, the impact of the catch on local food chains is unlikely to be significant given the high natural mortality, extent of the non-trawled areas and variable biomass levels of prawns resulting from changing environmental conditions such as cyclone events.

SOCIAL AND ECONOMIC OUTCOMES

The estimated employment in the fishery for the year in 2015 was 18 people including skippers and other crew. Twenty three additional support staff were based in Exmouth Gulf with additional support staff based in Fremantle for refitting of boats. Within the Exmouth area, the fishery is an important regional employer contributing to the economic viability of the Exmouth township.

Ex-vessel (beach) prices for prawns vary, depending on the type and quality of product and the market forces operating at any one time. In this fishery there is a high degree of vertical integration, with the licensee undertaking direct marketing of the product into domestic and overseas markets. For this reason, the prices quoted for prawns and byproduct are provided by the licensee on an overall average price taking into account each grade landed. The total estimated value of the fishery, including byproduct is $13.9 million.

GOVERNANCE SYSTEM

Total landings of 1,067 t were within the tolerance range as were the landings of brown tiger prawns with blue endeavour prawns above their acceptable range. The catch range for western king prawns is under review. The annual fishing level is considered **acceptable**.

EXMOUTH GULF PRAWN TABLE 2. *Annual catch tolerance levels (acceptable)*

Total Prawn Catch	721–1,410 t
Western King Prawns	(under review)
Brown Tiger Prawns	250–550 t
Blue Endeavour Prawns	120–300 t
Banana Prawns	1–60 t

Harvest Strategy (Formal)

The fishery is managed in accordance with the Exmouth Gulf Prawn Managed Fishery Harvest Strategy, 2014-2019 (DoF 2014). The primary management objective is to maintain the spawning biomass above the historically determined biological reference points.

The key stock indicator for each primary species was above their respective target levels hence no changes to management arrangements will occur for 2016/17.

Compliance

It is a requirement that all vessels in the fishery are fitted with an Automatic Location Communicator (ALC). The implementation of an ALC enables the Department of Fisheries (Department) to monitor the fleet using a Vessel Monitoring System (VMS) and manage compliance with temporal and spatial closures. The Department also undertakes regular vessel inspections to ensure fishing is being undertaken in accordance with the governing legislation (e.g. gear requirements, catch reporting).

Consultation

The Department, in conjunction with the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC) have established an Annual Management Meeting (AMM) for this fishery. The AMM is an opportunity for the Department, WAFIC and Industry to discuss research outcomes, initiatives and management of the fishery and industry issues. Season arrangements are develop each year in consultation between the Department and the license holder. During the season, the Department and the license holder undertake collaborative in-season management to ensure the protection of smaller prawns and to maintain the spawning stock biomass.

Management Initiatives (Stable)

No specific management initiatives are planned for this resource. Stakeholder engagement arrangements will be amended.

EXTERNAL DRIVERS (*High Risk*)

External drivers for this fishery include; increasing costs of fishing, lower returns due to the global economic climate and competition from imported and Australian aquacultured small prawns. This has shifted fishing strategies to focus on targeting larger prawns during high catch rate periods to maximise efficiency. The main emphasis for this fishery is on

domestic markets. Export of product to international export markets is maintained but at lower profit margins.

Cyclones also appear to have a significant effect on the productivity of Exmouth Gulf. Cyclones can either have a positive or negative impact on prawns depending on the timing and severity of the cyclone, the species of prawn and their location in the fishery.

Brown tiger prawns were ranked as a high risk to climate change effects and western king prawns as medium-high so both these species need to be monitored closely (Caputi *et al*. 2014b, 2015). The heat wave event of 2010/11 may have contributed to the recent extremes in abundance of brown tiger prawns in Exmouth Gulf. The cause of the low recruitment is being investigated in regard to nursery habitats and environmental factors (including temperature).

Higher than average water temperatures in the last five years are also having a negative effect on western king prawn catches (Caputi *et al.* 2014b, 2015) and will be further investigated.

REFERENCES

Caputi N, Kangas M, Hetzel Y, Denham A, Pearce A and Chandrapavan A. 2016. Management adaptation of invertebrate fisheries to an extreme marine heat wave event at a global warming hotspot. Ecology and Evolution. http://onlinelibrary.wiley.com/doi/10.1002/ece3.2137/full

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2015. Management implications of climate change effect on fisheries in Western Australia, Part 2: Case studies. FRDC Project 2010/535. *Fisheries Research Report*, No. 261. Department of Fisheries, Western Australia. 156pp.

Caputi N, de Lestang S, Hart A, Kangas M, Johnston D, and Penn J. 2014a. Catch Predictions in Stock Assessment and Management of Invertebrate Fisheries Using Pre-Recruit Abundance—Case Studies from Western Australia, Reviews in: *Fisheries Science & Aquaculture*, 22:1, 36-54.

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2014b. Management implications of climate change effect on fisheries in Western Australia: Part 1, Fisheries Research and Development Corporation project 2010/535. *Fisheries Research Report*, Western Australian Department of Fisheries, Perth.

DoF. 2014. Exmouth Gulf Prawn Managed Fishery Harvest Strategy 2014 - 2019. *Fisheries Management Pape*r, No. 265. Department of Fisheries, WA.

Grey DL, Dall W, and Baker A. 1983. A Guide to the Australian Penaeid Prawns, Northern Territory Department of Primary Production, Darwin.

Kangas MI, Sporer EC, Hesp SA, Travaille KL, Moore N, Cavalli P, and Fisher EA. 2015. Exmouth Gulf Prawn Fishery, Western Australian Marine Stewardship Council Report Series 1: 296 pp.

Loneragan NR, Kangas M, Haywood MDE, Kenyon RA, Caputi N, and Sporer E. 2013. Impact of cyclones and aquatic macrophytes on recruitment and landings of tiger prawns *Penaeus esculentus* in Exmouth Gulf, Western Australia. Estuarine Coastal and Shelf Science 127: 46-58.

Penn, JW. 1984. The behaviour and catchabilities of some commercially exploited penaeid species and their relationship to stock and recruitment, in: *Penaeid shrimp – their biology and management.* Fishing News Books - England.

WEST COAST DEEP SEA CRAB RESOURCE STATUS REPORT 2016

J. How and M. Yerman

OVERVIEW

The West Coast Deep Sea Crustacean Managed Fishery (WCDSCF) targets crystal (snow) crabs (*Chaceon albus*), giant (king) crabs (*Pseudocarcinus gigas*) and champagne (spiny) crabs (*Hypothalassia acerba*) using baited pots operated in a long-line formation in the shelf edge waters (>150 m) of the West Coast and Gascoyne Bioregions (see How *et al*. 2015). The fishery is primarily managed using a total allowable catch. In 2016 the WCDSCF achieved MSC certification, confirming the stock assessment, ecosystem impact and governance credentials of the fishery. For more details on the fishery and assessment methodology see How *et al*. 2015.

SUMMARY FEATURES 2016

Fishery Performance	Commercial	Recreational	
Total Catch 2015	154 t	Nil	
Fishing Level	Acceptable	NA	
Stock/Resource Performance	**Stock Status**	**Assessment Indicators**	
	Sustainable - Adequate	Annual: Catch, Catch Rates	
EBFM Performance			
Asset	**Level**	**Asset**	**Level**
Bycatch	Low Risk	**Listed Species**	Low Risk
Habitat	Low Risk	**Ecosystem**	Low Risk
Social	Low Amenity Low Risk	**Economic**	GVP Level 2 ($3.8 million) Moderate Risk
Governance	Minor Adjustments	**External Drivers**	Low Risk

CATCH AND LANDINGS

The total landings from this west coast offshore resource in 2015 as targeted by the WCDSCF was 154.1 t. Catches are dominated by crystal crabs, where 153.7 t (99% of the TAC) was landed. No champagne crabs and only 0.3 t of giant crabs were landed in 2015. Landings of giant crabs predominantly occur off the south coast, as accessed by the South Coast Crustacean Managed Fishery (SCCF). In the 2014-15 season, the SCCF landed 10.2 t of giant crabs and 2.1 t of champagne crabs. For more information on SCCF landings see South Coast Crustacean Resource Status Report.

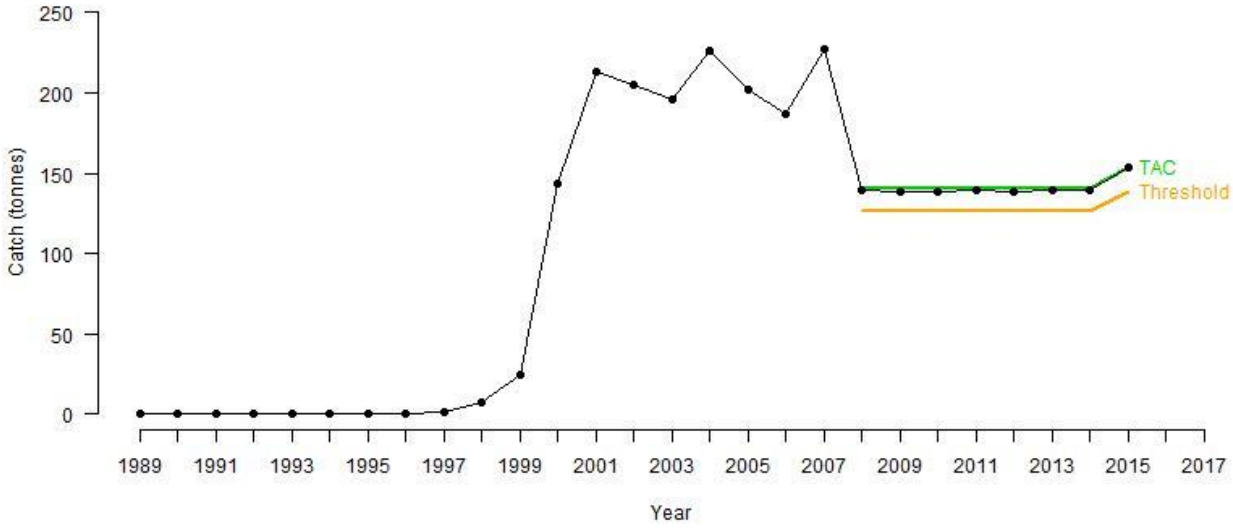
INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Crystal crab

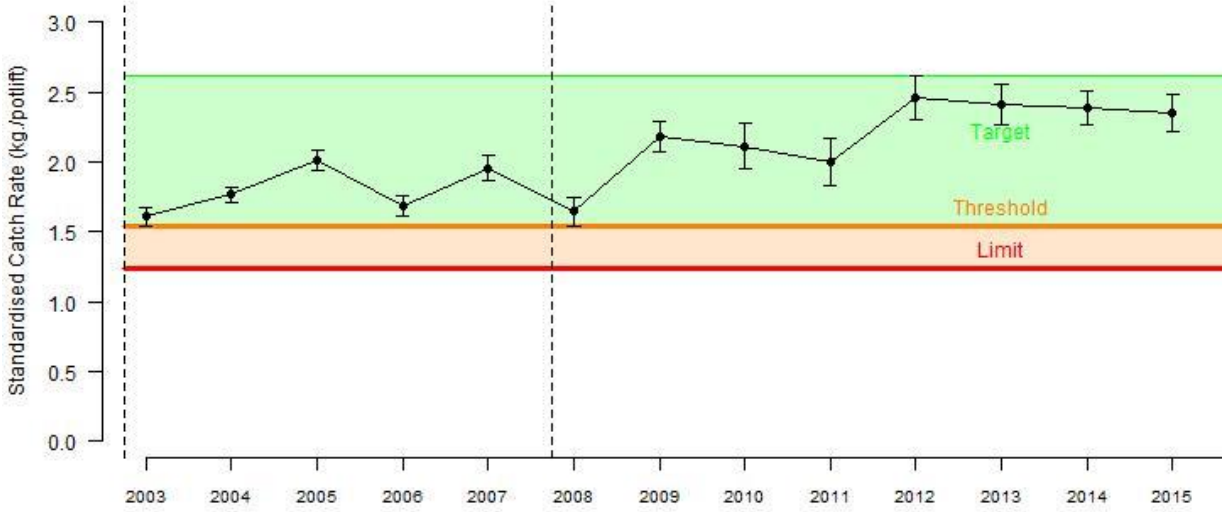
Crystal crabs are a deep-water species occurring on the continental shelf at depths of 300 – 1200 m. On the west coast of WA crystal crabs are caught primarily in depths of 500 – 800 m, although they are found over a broader range on the south coast of WA (i.e. 400 – 900 m depths; Melville-Smith *et al*. 2006). The habitat within these depth ranges are generally sand / mud or broken shell (Wadley and Evans 1991; Jones and Morgan 1994). They are considered a single management unit in the West Coast and Gascoyne Coast Bioregions. Detailed information on the biology and fishery can be found at How *et al*. (2015). Female crystal crabs mature below the

legal minimum size (Melville-Smith *et al*. 2007) and berried females are totally protected.

All lines of evidence, with the exception of spawning biomass, indicate that it is likely the stock biomass is above its threshold level and therefore **adequate**. The standardised catch rate of legal crystal crabs in 2015 was 2.35 kg/pot-lift (Deep Sea Crustacean Figure 2) which was a slight decline from 2014 (potentially due to changes in fishing personnel) but still within the upper end of the target range. Similarly, an examination of video camera comparisons of actual discards compared to those from logbooks, show an underestimate of actual discards in 2015 which may account for the apparent decline in spawning biomass.



DEEP SEA CRUSTACEAN FIGURE 1. *Annual landings of crystal crab in the West Coast Deep Sea Crustacean Fishery and its associated total allowable catch (TAC, green) and catch threshold level (orange).*



DEEP SEA CRUSTACEAN FIGURE 2. *Annual standardised catch rate (kg / pot-lift) of legal crystal crabs (± 95 CI) with their associated target (green) and threshold region (orange) and limit reference point.*

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch: The gear used in this fishery generates minimal bycatch and the design of the pots is such that their potential to 'ghost fish' if lost is negligible.

Protected Species: There have been no reported interactions of WCDSC gear with protected species in 2015.

The by-catch and protected species performance measures for the fishery are that:

a) Fishing impacts are considered to generate an acceptable level of risk to all bycatch species' populations, i.e. moderate risk or lower;

b) Less than three interactions with any particular ETP species in a year; and

c) Fishing impacts are considered to generate an acceptable level of risk to all ETP species' populations, i.e. moderate risk or lower.

All of the measures were met.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat: Potting is also considered to have a low impact on the habitat over which the fishery operates.

Ecosystem: The effects of the removal of deep sea crabs has been assessed for the West Coast Deep Sea Crustacean Fishery as having negligible food chain effects by the removal of crabs. Therefore, at current catch levels, it is unlikely that removal crabs is likely to result in food chain effects.

The habitat and ecosystem performance measures for the fishery are that:

a) Fishing impacts are considered to generate an acceptable level of risk to ecological processes within the ecosystem, i.e. moderate risk or lower;

b) Fishing impacts on each ecological resource / asset impacts are considered to generate an acceptable level of risk, i.e. moderate risk or lower.

c) The area fished is ≤ 113 (10' x 10') blocks; and

d) Fishing effort is ≤ 169 000 trap lifts

All of the measures were met.

SOCIAL AND ECONOMIC OUTCOMES

Social

The WCDSC is considered to have a low social amenity. This fishery is based on vessels that employ a skipper and two or three crew with no recreational fishery. The product is landed live at ports between Carnarvon and Fremantle, generating some additional economic activity and benefits. There were two vessels operating in 2015.

Economic

The beach value of the fishery was about $3.8 million in 2015 with the majority of the catch sold live to Asian markets both locally and internationally.

GOVERNANCE SYSTEM

Annual Catch Tolerance Levels (Acceptable)

For the 2015 season (1 January 2015 – 31 December 2015) the quota was 154 t. With an annual tolerance range of > 90%, based on the catch of 153t, the TAC is considered taken and therefore the annual fishing level is **acceptable**.

Harvest Strategy

The West Coast Deep Sea Crustacean Harvest Strategy 2015-2020 (see Fisheries Management Paper No. 272) has been formally adopted by industry and is the basis for the setting of the Total Allowable Catch (TAC) for the West Coast Deep Sea Crustacean Managed Fishery (the fishery). For 2015:

- The TAC was achieved
- The standardised catch rate of legal crystal crabs is within the target range
- The standardised catch rate of the secondary performance indicators; berried females were below but undersized crabs were above their respective threshold reference points which resulted in a **"Review Triggered"**. A summary of the review outcomes are presented in the stock assessment section.

Consequently, for 2016 the TAC remained at 154 tonnes for crystal crabs, and 14 tonnes for giant and champagne crabs combined.

Compliance

Compliance program is developed using a risk assessment process, and intelligence led investigations, particularly TAC verification.

Consultation

Consultation occurs between the department and the commercial sector either through Annual Management Meetings convened by WAFIC. Consultation with other interested stakeholders is conducted through specific meetings and the Department's Website.

Management Initiatives (Minor Adjustments)

Management initiatives will primarily focus addressing conditions raised as part of the MSC assessment process. These include separation of the B Class TAC into separate quotas for each of giant and champagne crabs as well as the establishment of a memorandum of understanding with the industry regarding the use of approved bait sources.

EXTERNAL DRIVERS (*Low Risk*)

Given product is exported; fluctuation in the Australian dollar can have impacts on the economic performance of the fishery. The fishery is thought to be relatively robust to environmental change due to the depth of fishing operations.

REFERENCES

Department of Fisheries. 2015. West Coast Deep Sea Crustacean Resources Harvest Strategy 2015-2020. *Fisheries Management Paper*, 272. Department of Fisheries Western Australia.

How JR, Webster FJ, Travaille KL, Nardi K, and Harry AV. 2015. Western Australian Marine Stewardship Council Report Series No. 4: West Coast Deep Sea Crustacean Managed Fishery. Department of Fisheries, Western Australia. 172pp.

Jones DS and Morgan GJ. 1994. *A field guide to crustaceans of Australian waters*. Reed. Sydney Australia. 216pp.

Melville-Smith R, Gould R, and Bellchambers L. 2006. *The crystal crab fishery in Western Australia: first steps in the development of a sustainable deepwater crab fishery.* Ed. Shotton R. DeepSea2003: conference on the governance and management of deep sea fisheries. Part II: Conference poster papers and workshop papers. FAO Fisheries Proceedings Rome, Italy.

Melville-Smith R, Norton SMG, and Thomson WA. 2007. *Biological and Fisheries Data for Managing Deep Sea Crabs in Western Australia.* Final report to Fisheries Research and Development Corporation on Project No 2001/055. *Fisheries Research Report*, No 165. Department of Fisheries Western Australia. 248pp.

Wadley V and Evans D. 1991. *Crustaceans from the deepwater trawl fishery of Western Australia*. CSIRO Division of Fisheries, Australia. 44pp.

GASCOYNE DEMERSAL SCALEFISH RESOURCE STATUS REPORT 2016

G. Jackson, H. Zilles and S. Turner

OVERVIEW

The Gascoyne Demersal Scalefish Resource (GDSR) includes 60+ demersal species inhabiting marine waters deeper than 20 m in the Gascoyne Coast Bioregion. Commercial vessels in the Gascoyne Demersal Scalefish Managed Fishery (GDSMF) fish with mechanised handlines and target pink snapper (*Chrysophrys auratus*) and goldband snapper (*Pristipomoides multidens*).Other demersal species caught include other tropical snappers, emperors, cods, mulloway and trevallies. A limited number of licensed charter vessels and a large number of recreational vessels fish out of Denham, Carnarvon and around the Ningaloo-Exmouth area and catch a similar range of demersal species.

SUMMARY FEATURES 2016

Fishery Performance	Commercial	Recreational
Total Catch 2015	353 t	92-104 t*
Fishing Level	Unacceptable	Acceptable
Stock/Resource Performance	**Stock Status**	**Assessment Indicators**
Inshore Demersal	Sustainable - Recovering	Annual: Catch Periodic**: Spawning Biomass, Fishing Mortality, SPR
Offshore Demersal	Sustainable - Adequate	Annual: Catch

EBFM Performance			
Asset	**Level**	**Asset**	**Level**
Bycatch	Negligible Risk	**Listed Species**	Negligible Risk
Habitat	Negligible Risk	**Ecosystem**	Low Risk
Social	High Amenity Moderate Risk	**Economic**	GVP Level 2 ($1-5 million) Moderate Risk
Governance	Stable	**External Drivers**	Moderate Risk

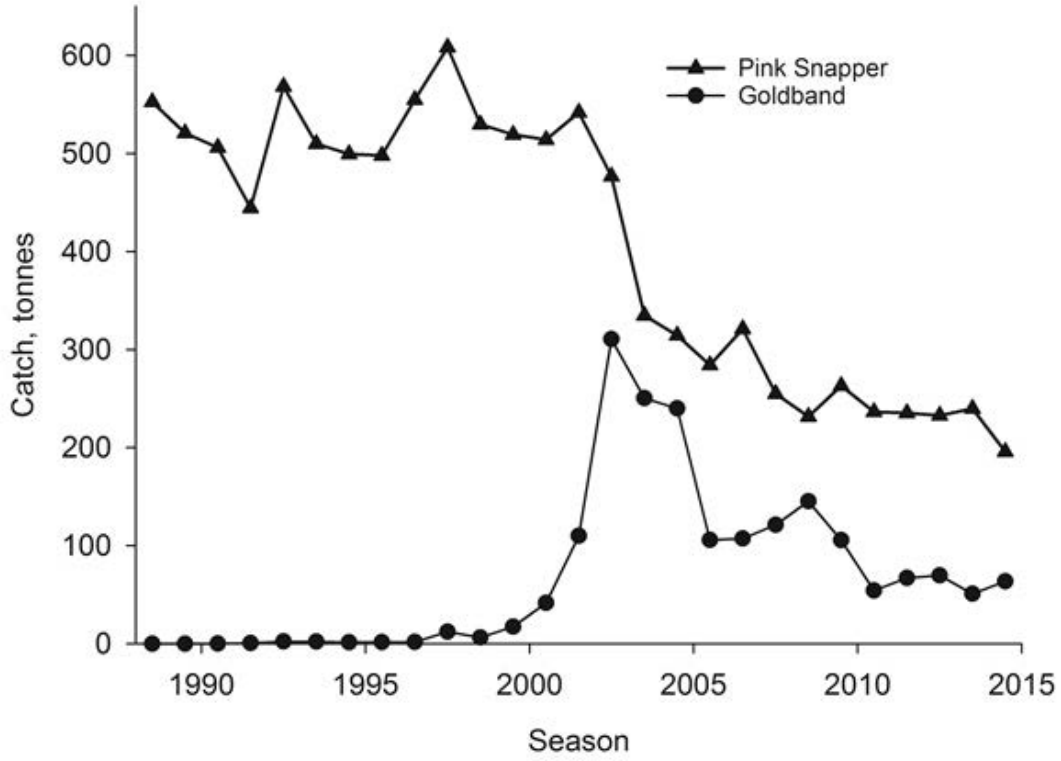
**Top 10 demersal species only from 2013/14 survey (Ryan et al. 2015); ** pink snapper stocks only.*

CATCH AND LANDINGS

In 2014/15, the total commercial catch reported by the GDSMF was 353 t, comprising 196 t pink snapper, 64 t goldband snapper and 93 t of other mixed species (Gascoyne Demersal Scalefish Table 1). In 2013/14, the boat-based recreational catch of demersal species was estimated to be 98 t (se 6.2 t) (top 10 species only) (Ryan *et al*. 2015). The charter catch of demersal species (same 10 species) reported in 2015 was 40 t.

GASCOYNE DEMERSAL SCALEFISH TABLE 1. *Total catches of scalefish taken by GDSMF in previous five years.*

Species	2010/11	2011/12	2012/13	2013/14	2014/15
Pink Snapper	228.1	235.5	232.8	240.0	195.8
Goldband Snapper	37.4	61.0	69.5	50.9	63.5
Other Jobfish	4.3	4.9	3.8	3.4	4.3
Red Emperor	9.0	13.2	8.0	10.1	10.9
Ruby Snapper	8.4	7.3	2.8	4.2	5.1
Other Snappers	1.7	1.6	1.0	1.1	1.7
Spangled Emperor	3.7	0.4	2.3	2.0	2.5
Redthroat Emperor	9.0	10.5	5.0	6.1	10.9
Other Emperors	0.5	1.1	0.2	0.3	1.3
Rankin Cod	6.2	12.2	6.2	6.9	8.0
Other Cods	6.6	11.7	8.3	11.2	11.3
Eightbar Grouper	2.0	4.0	4.3	3.5	1.9
Mulloway	4.6	3.0	4.0	8.6	9.0
Trevallies	6.1	5.6	4.6	6.8	7.9
Other Species	15.4	16.7	13.9	18.0	18.6
Total	343.0	388.7	366.7	373.1	352.7



GASCOYNE DEMERSAL SCALEFISH FIGURE 1. *Commercial catches of pink and goldband snapper taken in oceanic waters of the Gascoyne Coast Bioregion from 1988/89-2014/15.*

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Pink snapper Oceanic Stock (Sustainable-Recovering)

In Western Australia, pink snapper are divided into six management units, four of which are in the Gascoyne Coast Bioregion (Fowler *et al*. 2014). The Gascoyne oceanic stock is mostly fished by the GDSMF with the three separate biological stocks in inner Shark Bay predominantly fished by the recreational and charter sectors (see Inner Shark Bay Scalefish Resource Status Report).

In the Gascoyne, pink snapper live to a maximum age of approximately 30 years, mature around 3-5 years of age and, in the oceanic waters outside Shark Bay, form spawning aggregations on inshore reefs (~20-80 m depth) during May-August. Commercial fishing for pink snapper on these aggregations has a long history rising steadily from the early 1900s to an all-time peak of ~1,300 t in 1985. This triggered creation of the limited entry Shark Bay Snapper Managed Fishery (in 1987) that sustained catches at ~450-550 t through the 1980s-1990s (Marriot *et al.* 2012). The snapper component of the fishery became fully quota managed in 2001 with a Total Allowable Commercial Catch (TACC) set at 564 t.

Following the first integrated age-based assessment in 2002 which indicated this spawning stock was below the threshold (20% of unfished level) the TACC was reduced in 2003/04 from 564 t to 338 t and then again in 2006/07, to 277 t, to assist stock rebuilding.

The most recent (2016) assessment, which incorporates catch-at-age data up to 2014/15, indicated that the spawning biomass had been slowly rebuilding and was estimated to be 32-38% - i.e. above the threshold (30% unfished) but below the target (40% unfished).

Based on the weight of evidence available, especially with the recent declines in catch and catch rate, although the oceanic stock is still **recovering**, it is possible that under the current management settings, the stock may breach the threshold level during the next 5-year period.

Goldband snapper (Sustainable-Adequate)

Goldband snapper inhabit hard bottom mostly in depths of 80-150 m, live to approximately 30 years, mature around 4-5 years of age, and spawn in October-April in the Gascoyne. They are considered to be a separate stock from goldband snapper found in the Pilbara and Kimberley.

Commercial fishing for goldband snapper in the Gascoyne is relatively recent and began as the Shark Bay Snapper Managed Fishery developed into a more year-round fishery from around 2000 onwards with vessels moving offshore and outside the traditional peak pink snapper season (May-August) (Marriot *et al.* 2012). This resulted in a wider range of demersal species contributing to the overall catch with the commercial goldband snapper catch increasing rapidly over a few years to peak at ~300 t in 2002-2003 before stabilising in recent years at around 50-60 t.

Based on biological data collected during 2005-2008, the SPR was above threshold level. Based on the weight of evidence approach, the goldband snapper stock in the Gascoyne is considered to be **adequate** at the current levels of fishing.

BYCATCH

The GDSMF catch consists of a large number of demersal species of medium to high market value with very few species captured that are not retained and therefore is a **negligible risk**.

PROTECTED SPECIES INTERACTIONS

As line fishing is highly selective, direct interactions with protected species by commercial, charter and recreational fishers in the waters of the GDSMF are a **negligible risk**.

HABITAT

Line fishing for demersal scalefish by the commercial, recreational and charter sectors has virtually no direct impact on benthic habitats and represents a **negligible risk**.

ECOSYSTEM INTERACTIONS

Food chain effects due to commercial line fishing for demersal species are considered to be low because the quota system restricts overall GDSMF catches to a relatively small percentage of the total biomass available.

The juvenile components of demersal fish stocks are likely subject to large, mostly-environmentally driven fluctuations in abundance even in the absence of fishing, resulting in significant variability in annual recruitment strength. The fishery

therefore represents a **low risk**.

SOCIAL AND ECONOMIC OUTCOMES

Social

In 2015, 17 GDSMF vessels fished during the entire season, 10 of which fished for more than 10 days during the peak (pink snapper) season, typically with a crew of 2-3. Commercial fishing and associated fish processing are important sources of local employment in Denham and Carnarvon.

Shark Bay and Ningaloo are popular recreational fishing destinations especially during the winter months and school holidays. There was an estimated 53,832 (se 3,603) boat fishing days in Gascoyne Coast Bioregion in 2013/14 (Ryan *et al*. 2015).

The GDSR therefore provides a high social amenity with **moderate risk.**

Economic

The estimated GVP of GDSMF was in the range $1-5 million in 2015 t that represents a **moderate risk.** Product from this fishery entirely supplies domestic fish markets, mostly in Perth.

While a dollar value is difficult to assign to recreational and charter catches at this stage, the availability of demersal target species underpins the local recreational fishing-based tourism industry and generates significant income for the regional economy.

GOVERNANCE SYSTEM

Allowable Catch/Catch Rate Tolerance Levels

Commercial:

Pink snapper - The pink snapper Total Allowable Commercial Catch (TACC) has been set at 277 t since 2006/07. For a range of economic and operational reasons the entire TACC cannot realistically be caught in any season. Consequently, the landed pink snapper catch has mostly been ~230-240 t since 2006/07, a range considered to be the level where the TACC has effectively been reached. The catch of 196 t landed in 2014/15 was substantially lower than the 'annual tolerance' range.

The pink snapper catch rate has fallen below the threshold level of 500kg/standard boat day and is therefore **not acceptable**. While recent discussions with fishers suggest that a number of factors contributed to this, including loss of experienced skippers to the industry, low peak season prices and an increased level of interaction with sharks (depredation) which has resulted in recent changes in fishing operations such as gear used and locations and times fished. Updated stock assessment and review of catch and catch rate will be completed by March 2017.

Goldband snapper – Within the combined TACC for other mixed demersal species (see Harvest Strategy) there is a maximum limit of 100-120 t for goldband. The catch of 64 t landed in 2014/15 was **acceptable**.

Recreational:

Catch tolerance levels for recreational and charter pink snapper catch are under development.

Harvest Strategy

The current harvesting strategy for the GDSMF is based on a *constant catch approach* (where catch is kept constant) where a stock is in recovery, and a *constant exploitation approach* (where the catch varies in proportion to variations in stock abundance) where the stock is close to the target.

In line with this harvesting approach, the GDSMF is primarily managed using output controls via an ITQ system with a separate pink snapper TACC, and a combined TACC for other demersal scalefish species (since 2015/16 season only). The fishers also have to comply with gear restrictions, spatial closures and size limits that are in place for some species.

The recreational and charter fishery in the Gascoyne Coast Bioregion is also primarily managed using output controls, including size limits for some species, and daily bag and possession limits. Recreational fishers operating from a boat are required to hold a current Recreational Fishing from Boat Licence. Charter operators are also required to hold a Fishing Tour Operators Licence.

Compliance

The GDSMF is managed through a combination of area closures, gear restrictions and the use of input controls in the form of individual transferable quota allocations. Compliance with nomination requirements and area boundaries is effectively monitored through a satellite-based Vessel Monitoring System (VMS). The Department undertakes regular compliance inspections at sea and landing ports. Catch and Disposal Records must be lodged for pink snapper and other demersal scalefish separately at the designated landing ports (Coral Bay, Carnarvon and Denham only).

Consultation

The Department undertakes consultation directly with licensees on operational issues. Industry Annual General Meetings are convened by the Western Australian Fishing Industry Council (WAFIC), who are also responsible for statutory management plan consultation under a Service Level Agreement with the Department. The harvest strategy is being developed using an independent chair and working group.

Consultation processes with the recreational sector are facilitated by Recfishwest under a Service Level Agreement although the Department undertakes direct consultation with the community on specific issues.

Management Initiatives

With the annual catch rate performance level triggered, an updated stock assessment will be undertaken. The Department is also currently undertaking a review of the management settings for pink snapper within the GDSMF. A formal harvest strategy is being developed as part of the fishery undergoing full certification for MSC and to deal with inter-sectoral issues associated with proposals by the commercial sector to potentially return to the use of traps.

EXTERNAL DRIVERS

Under the Offshore Constitutional Settlement, commercial vessels licensed by the Commonwealth may operate in state waters off the Gascoyne coast, outside the 200 m isobath, as part of the Western Deepwater Trawl Fishery (WDWTF) (Chambers and Bath 2015). There was no fishing activity reported by WDWTF vessels in these waters in 2015 (AFMA unpublished data).

Climate change has the potential to impact fish stocks through increasing sea surface temperatures, changes in major ocean currents (e.g. Leeuwin Current), rising sea level and ocean acidification. An FRDC-funded project assessed the effects of climate change on key fisheries in Western Australia (Caputi *et al.* 2014). Pink snapper was a case study species within this project with potential impacts of climate change likely to include a southward shift in the centre of its geographic distribution; changes to spawning patterns; changes in individual growth and stock productivity, and through projected impacts on the Leeuwin Current, changes in egg and larval dispersal. These drivers represent a **moderate risk**.

REFERENCES

Chambers M, and Bath A. 2015. Western Deepwater Trawl Fishery in: Patterson H, Georgeson L, Stobutzki I and Curtotti R. (ed) 2015. Fishery status reports 2015. Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

Fowler A, Hamer P, Jackson G, Stewart J, and Wesche S. 2014. Snapper, *Chrysophrys auratus*, in: Flood M, Stobutzki I, Andrews J, Ashby C, Begg G, Fletcher R, Gardner C, Georgeson L, Hansen S, Hartman S, Hone P, Horvat P, Maloney L, MacDonald B, Moore A, Roelofs A, Sainsbury K, Stewardson C, Stewart J, Wise B. (eds) 2014. Status of key Australian fish stocks reports 2014. Fisheries Research and Development Corporation. Canberra, 486-498.

Marriott R, Jackson G, Lenanton R, Telfer C, Lai E, Stephenson P, Bruce C, Adams D, Norriss J, and Hall N. (2012). Biology and stock status of inshore demersal scalefish indicator species in the Gascoyne Coast Bioregion. *Fisheries Research Report*, No 228. Department of Fisheries, Western Australia. 210pp.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Taylor SM, Wise BS. 2015. State-wide survey of boat-based recreational fishing in Western Australia 2013/14. *Fisheries Research Report*, No. 268. Department of Fisheries, Western Australia. 208pp.

GASCOYNE INNER SHARK BAY SCALEFISH RESOURCE STATUS REPORT 2016

G. Jackson, H. Zilles, J. Brown and S. Turner

OVERVIEW

The Inner Shark Bay Scalefish Resource (ISBSR) comprises 20-30 species taken by commercial beach seine and recreational fishing in the waters of the Eastern Gulf, Denham Sound and Freycinet Estuary in inner Shark Bay. The commercial fishery targets four species/groups: whiting (*Sillago schomburgkii* and *S. analis*), sea mullet (*Mugil cephalus*), tailor (*Pomatomus saltatrix*) and western yellowfin bream (*Acanthopagrus morrisoni*). Most recreational fishing in Shark Bay is boat-based using hook and line to catch pink snapper (*Chrysophrys auratus*, three separate stocks), grass emperor (*Lethrinus laticaudis*), western butterfish (*Pentapodus vitta*), whiting (*Sillago spp.*), school mackerel (*Scomberomorus queenslandicus*), tailor, blackspot tuskfish (*Choerodon schoenleinii*) and goldspotted rockcod (*Epinephelus coioides*). A limited number of licensed charter vessels operate out of Denham and Monkey Mia.

SUMMARY FEATURES 2016

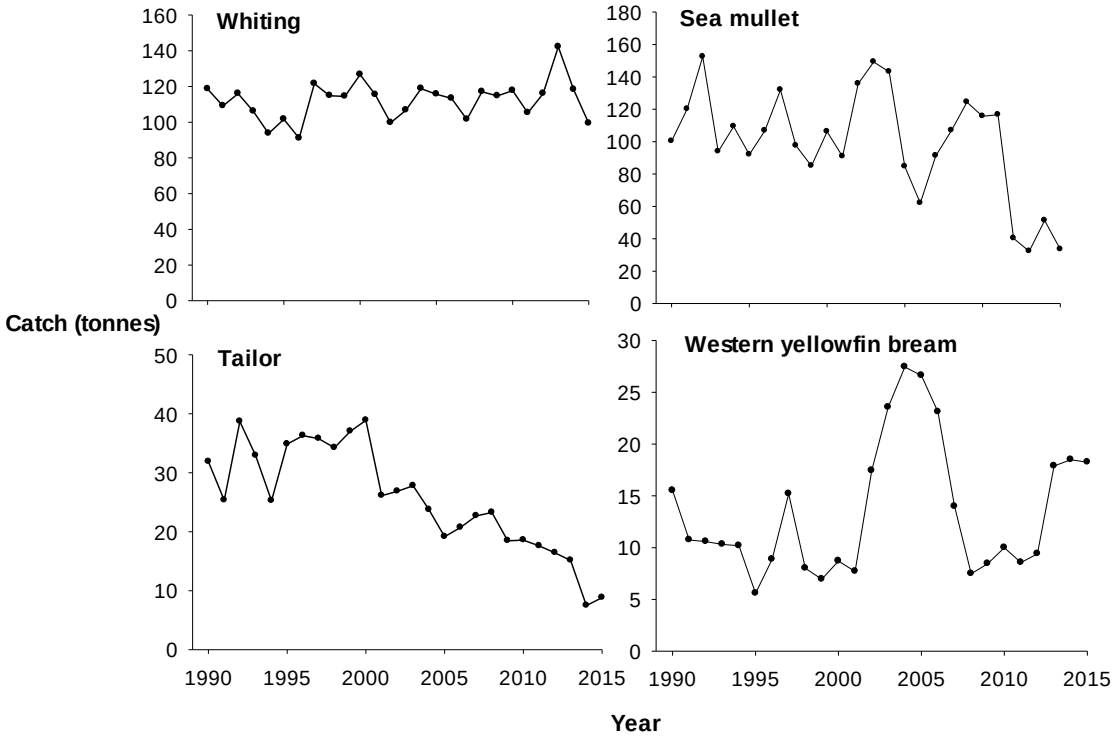
Fishery Performance	Commercial	Recreational
Total Catch 2015	164 t	~15-20 t (pink snapper only)*
Fishing Level	Acceptable	Acceptable
Stock/Resource Performance	**Stock Status**	**Assessment Indicators**
Demersal	Sustainable – Adequate	Annual: Catch, Catch rate; Periodic: Spawning biomass, Fishing mortality, SPR
Nearshore	Sustainable - Adequate	

EBFM Performance Asset	Level	Asset	Level
Bycatch	Low risk	**Listed Species**	Negligible Risk
Habitat	Negligible Risk	**Ecosystem**	Low Risk
Social	High Amenity Moderate Risk	**Economic**	GVP Level 2 ($1-5 million) Moderate Risk
Governance	Stable	**External Drivers**	Moderate Risk

** Based on estimates from on-site boat ramp surveys conducted in 2010, includes reported charter catches in 2015*

CATCH AND LANDINGS

In 2015, the total catch reported by the commercial fishery (Shark Bay Beach Seine and Mesh Net Managed Fishery [SBBSMNF]) was 164 t, comprising 99 t of whiting, 33 t of mullet, 18 t of western yellowfin bream, 9 t of tailor and 4 t of other mixed species including 1 t of pink snapper (Inner Shark Bay Figure 1). The charter catch of pink snapper reported in 2015 was 2.5 t (Eastern Gulf, Denham Sound and Freycinet Estuary combined). The estimated recreational catch of pink snapper for the three inner gulf areas in 2010 was ~15-20 t (all three areas combined) (Wise *et al*. 2012). More recent estimates from a boat ramp survey for the period March 2016-February 2017 will be available in mid-2017.



INNER SHARK BAY FIGURE 1. *Commercial catches of whiting, tailor, sea mullet and western yellowfin bream taken by SBBSMNF 1990-2015.*

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS (*Sustainable-Adequate*)

Pink snapper Inner Gulf Stocks

In Western Australia, pink snapper are divided into six management units, four of which are in the Gascoyne Coast Bioregion (Fowler *et al*. 2014). The three separate biological stocks found in inner Shark Bay (i.e. Eastern Gulf, Denham Sound, Freycinet Estuary) are nowadays predominantly fished by the recreational and charter sectors while the Gascoyne oceanic stock is mostly fished by the Gascoyne Demersal Scalefish Managed Fishery (see Gascoyne Demersal Scalefish Resource Status Report).

In the Gascoyne, pink snapper live to a maximum age of approximately 30 years, mature around 3-5 years of age and, in inner Shark Bay, form spawning aggregations between May-September (Jackson *et al*. 2010).

Commercial catches of pink snapper in the inner gulfs are relatively small (~1-2 t) and limited to bycatch taken by the SBBSMNF. Recreational fishing in inner Shark Bay steadily increased from the 1960s through to the 1990s with all three snapper stocks becoming over-exploited. Reductions in catch levels were generated by the additional management progressively introduced from 1998 onwards, this included notional Total Allowable Recreational Catches (TARCs) implemented in each area in 2003.

The most recent stock assessments that incorporated catch-at-age data up to 2013 indicated that the spawning biomass of all three stocks was estimated to be above the target (40% of the unfished level) in 2015. On the basis of the evidence available, these pink snapper stocks are **adequate.**

Yellowfin whiting

Yellowfin whiting in WA are found in nearshore and estuarine waters from Exmouth to Albany (Brown *et al*. 2013). Although stock structure has not been investigated, connectivity between yellowfin whiting in the 'northern' (Gascoyne Coast) and 'southern' (West and South Coast) regions is likely limited, and so are treated as separate stocks for assessment and management purposes. The northern stock is mainly fished in inner Shark Bay while the southern stock is fished along the lower west coast (see West Coast Nearshore and Estuarine Finfish Resource Status Report).

In 2015, the commercial catch of yellowfin whiting taken by the SBBSMNF was 99 t, which is within the target catch range (93-127 t), and the Catch Per Unit Effort (CPUE) at 166 kg/boat day was well above the threshold catch rate (75 kg/boat day). The commercial catch of yellowfin whiting in inner Shark Bay has been relatively stable at ~90-120 t since 1990. Whiting species (mostly yellowfin) are the third most retained species group taken by boat based recreational fishers in inner Shark Bay.

A stock assessment based on biological data collected in 2014 indicated that fishing mortality was above threshold level. Based on the evidence available, the yellowfin whiting stock in inner Shark Bay is classified as **adequate**.

Sea mullet

Sea mullet occurs throughout WA. Stock structure has not been investigated however it is possible that multiple cryptic species of sea mullet exist on the west coast as has been found on the east coast of Australia (Durand *et al.* 2012, Krück *et al.* 2013). Sea mullet within each WA bioregion are currently regarded as discrete breeding stocks.

In 2015, the commercial catch of sea mullet taken by the SBBSMNF was 34 t, which is ~50 t below the long-term average, and continues the declining trend with four consecutive years of sea mullet catch below the target catch range (77-144 t). The CPUE at 56 kg/boat day in 2015 is also just below the threshold catch rate (62 kg/boat day). These declines are partly explained by lower market demand with the SBBSMNF targeting the higher-value whiting species, but may also be attributable to a change in the distribution of sea mullet due to ocean warming (see West Coast Nearshore and Estuarine Finfish Resource Status Report).

Based on the evidence available, the sea mullet stock in inner Shark Bay is classified as **adequate**.

Tailor

Tailor in WA occurs from Onslow to Esperance and is believed to constitute a single stock over this range (Smith *et al.* 2013).

In 2015, the commercial catch of tailor taken by the SBBSMNF was 9 t, the second lowest catch on record after 2014 and continues the declining trend with catches since 2004 below the target catch range (25-40 t). The CPUE (15 kg/boat day) was below the threshold level (21 kg/boat day). The low landings of tailor that have become a feature of the fishery in recent years are mostly attributed to local processing restrictions.

The tailor catch in inner Shark Bay represents approximately half of the total commercial catch taken in WA with the remainder taken in the West Coast Bioregion (West Coast Nearshore and Estuary Scalefish Status Report).

Based on the evidence available, the tailor stock is classified as **adequate.**

Western yellowfin bream

Western yellowfin bream (*Acanthopagrus morrisoni*) are endemic to north-west WA from the Dampier Peninsula to south of Shark Bay (Iwatsuki 2013). Western yellowfin bream in inner Shark Bay are assessed and managed as a separate stock.

In 2015, the commercial catch of western yellowfin bream taken by the SBBSMNF (18 tonnes) and CPUE (30 kg/boat day) were above the target catch range (7-15 t) and the threshold catch rate (5 kg/boat day), as was the case in 2013 and 2014. These increases are likely attributable to another strong year class entering the fishery, as was previously observed in 2002-2007.

Based on the evidence available, the western yellowfin bream stock in inner Shark Bay is classified as **adequate.**

BYCATCH

Bycatch is minimal in the SBBSMNF because netting operations selectively target specific schools of fish and is therefore **low risk**.

PROTECTED SPECIES INTERACTIONS

As nets are actively set and hauled, if any listed species such as dugongs, dolphins or marine turtles are caught (rare events) they are immediately released and therefore such interactions are a **negligible risk**.

HABITAT

Seine netting over shallow sand banks and other naturally dynamic nearshore environments combined with the low frequency of fishing in any one location represents a **negligible risk.**

ECOSYSTEM INTERACTIONS

Catch levels in the fishery have been relatively stable over many decades, despite a long-term reduction in effort, suggesting that recruitment of the main

target species has not been significantly affected by fishing mortality and that interactions are **low risk**.

SOCIAL AND ECONOMIC OUTCOMES

Social

In 2015, 6 vessels operated in the SBBSMNF, employing around 16 fishers. Commercial fishing and associated fish processing are important sources of employment and income in Denham.

Shark Bay is a popular recreational fishing destination especially during the winter months and school holidays. There was an estimated 53,832 (se 3,603) boat fishing days in the Gascoyne Coast Bioregion in 2013/14 (Ryan *et al.* 2015).

The Inner Shark Bay Scalefish Resource therefore provides a high social amenity with **moderate risk.**

Economic

The estimated GVP of the SBBSMNF in 2015 was in the range $1-5 million that represents a **moderate risk**. Product from this fishery entirely supplies domestic fish markets (Perth and Sydney). While a dollar value is difficult to assign to recreational and charter catches, the availability of quality fish underpins the local recreational fishing-based tourism industry and generates significant income for the regional economy.

GOVERNANCE SYSTEM

Annual Catch/Catch Rate Tolerance Levels

Commercial:

Total fishing effort in the SBBSMNF was 599 boat days in 2015 which was the lowest level on record. While the total commercial catch in 2015 at 164 t was below the lower limit of the target catch range (235–335 tonnes), viewed against the historically low levels of current effort, the commercial catch level is considered **acceptable**.

Recreational:

Recreational (includes charter) catch tolerance levels are only currently in place for pink snapper. Recreational catches of pink snapper in 2015 are assumed to be similar to those estimated in 2010 (more recent data will be available in 2017) and therefore within the respective notional TARCs in each area, are therefore **acceptable**.

Harvest Strategy

Although a formal harvest strategy has not been developed for the Inner Shark Bay Scalefish Resource, the current harvesting strategy for the SBBSMNF is based on a *constant exploitation approach* (where the catch varies in proportion to variations in stock abundance).

The SBBSMNF is managed through input controls in the form of limited entry, gear restrictions (e.g. vessel size, net length and mesh size) and permanently closed waters.

The recreational and charter fishery in Shark Bay is managed using a combination of output controls including daily bag, possession, size and gear limits. Recreational fishers operating from a boat are required to hold a current Recreational Fishing from Boat Licence (RFBL) while net fishers require a Recreational Net Fishing Licence. Pink snapper stocks are tightly managed to notional TACs in the Eastern Gulf (11.25 t recreational; 3.75 t commercial), Denham Sound (11.25 t recreational; 3.75 t commercial) and Freycinet Estuary (3.75 t recreational; 1.25 t commercial).

Enforcement

The Department undertakes regular compliance at-sea and on-land inspections.

Consultation

The Department undertakes consultation directly with licensees on operational issues. Industry Management Meetings are convened by the Western Australian Fishing Industry Council (WAFIC), who are also responsible for statutory management plan consultation under a Service Level Agreement with the Department.

Consultation processes are facilitated by Recfishwest under a Service Level Agreement although the Department undertakes direct consultation with the community on specific issues.

Management Initiatives

A number of new management initiatives were introduced in 2016 following the latest stock assessment (2015) that indicated the spawning biomass of all three inner gulf pink snapper stocks was above the target (40% of the unfished level). These initiatives were designed to increase the amenity of the recreational fishing and included the removal of the 70 cm maximum size limit of inner gulf pink snapper. The Freycinet Estuary tag lottery system, which was introduced in 2003 as a key component of the recovery strategy, was also removed and replaced by an individual possession limit of 1 day's bag limit of whole fish or 5kg of fillets

within the Freycinet Estuary management area.

EXTERNAL DRIVERS

The Inner Shark Bay system has been considered relatively stable as a result of its typically low-rainfall and arid environment. However, recent extreme but occasional events including cyclone-related riverine floods (occurred in the Gascoyne and Wooramel Rivers in 2010-2011) and a marine heatwave (summer of 2010/11) had significant impacts on some marine habitats (e.g. temperate seagrasses) and important invertebrate species (e.g. blue crabs and scallops) (Pearce *et al*. 2011, Caputi *et al*. 2014). The impact of these events on key scalefish species in inner Shark Bay is unknown.

Climate change has the potential to impact fish stocks through increasing sea surface temperatures, changes in major ocean currents (e.g. Leeuwin Current), rising sea level and ocean acidification. An FRDC-funded project assessed the effects of climate change on key fisheries in Western Australia (Caputi *et al.* 2015). Pink snapper was a case study species within this project with potential impacts of climate change likely to include a southward shift in the centre of geographic distribution; changes to spawning patterns; changes in individual growth and stock productivity, and through projected impacts on the Leeuwin Current, changes in egg and larval dispersal.

These drivers represent a **moderate risk**.

REFERENCES

Brown J, Dowling C, Hesp A, Smith K, and Molony B. 2013. Status of nearshore finfish stocks in southwestern Western Australia. Part 3: Whiting (Sillaginidae). *Fisheries Research Report*, No. 248. Department of Fisheries, Western Australia. 128pp.

Caputi N, Jackson G, and Pearce A. 2014. The marine heatwave off Western Australia during the summer of 2010/11 – 2 years on. *Fisheries Research Report*, No 250. Department of Fisheries, Western Australia, Perth.

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2015. Management implications of climate change effect on fisheries in Western Australia Parts 1 & 2. FRDC Project 2010/535. *Fisheries Research Report*, No. 260. Department of Fisheries, Western Australia.

Durand JD, Shen KN, Chen WJ, Jamandre BW, Blel H, Diop K, Nirchio M, *et al.* 2012. Systematics of the grey mullets (Teleostei: Mugiliformes: Mugilidae): Molecular phylogenetic evidence challenges two centuries of morphology-based taxonomy. Molecular Phylogenetics and Evolution,64:73–92.

Fowler A, Hamer P, Jackson G, Stewart J, and Wesche S. 2014. Snapper, *Chrysophrys auratus*, in: Flood M, Stobutzki I, Andrews J, Ashby C, Begg G, Fletcher R, Gardner C, Georgeson L, Hansen S, Hartman S, Hone P, Horvat P, Maloney L, MacDonald B, Moore A, Roelofs A, Sainsbury K, Stewardson C, Stewart J, and Wise B. (eds). 2014. *Status of key Australian fish stocks reports 2014*, Fisheries Research and Development Corporation, Canberra, 486-498.

Iwatsuki Y. 2013. Review of the *Acanthopagrus latus* complex (Perciformes: Sparidae) with descriptions of three new species from the Indo-West Pacific . *Journal of Fish Biology*83(1): 64-95.

Jackson G, Norriss JV, Mackie MC, and Hall NG. 2010. Spatial variation in life history characteristics of snapper (*Pagrus auratus*) within Shark Bay, Western Australia. *New Zealand Journal of Marine and Freshwater Research* 44: 1-15.

Krück NC, Innes DI, and Ovenden JR. 2013. New SNPs for population genetic analysis reveal possible cryptic speciation of eastern Australian sea mullet (*Mugil cephalus*). *Molecular Ecology Resources*, 13(4), 715–725.

Pearce A, Lenanton R, Jackson G, Moore J, Feng M, and Gaughan D. 2011. The "marine heatwave" off Western Australia during the summer of 2010/11. *Fisheries Research Report*, No 222. Department of Fisheries, Western Australia, Perth.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Taylor SM, and Wise BS. 2015. State-wide survey of boat-based recreational fishing in Western Australia 2013/14. *Fisheries Research Report*, No. 268. Department of Fisheries, Western Australia. 208pp.

Smith K, Lewis P, Brown J, Dowling C, Howard A, Lenanton R, and Molony B. 2013. Status of nearshore finfish stocks in south-western Western Australia Part 2: Tailor. *Fisheries Research Report*, No. 247. Department of Fisheries, Western Australia. 112pp.

Wise B, Telfer CF, Lai KM, Hall N, and Jackson G. 2012. Long-term monitoring of boat-based recreational fishing in Shark Bay, Western Australia; providing advice for sustainable fisheries management in a World Heritage Area. *Marine and Freshwater Research,* **63:** 1129-1142.