NORTH COAST BIOREGION

ABOUT THE BIOREGION

The oceanography of the North Coast Bioregion (North Coast Overview Figure 1) includes waters of Pacific origin that enter through the Indonesian archipelago bringing warm, low salinity waters polewards via the Indonesian Throughflow and Holloway Currents which flow seasonally and interact with Indian Ocean waters. The Integrated Marine and Coastal Regionalisation for Australia (IMCRA V 4.0) scheme divides this Bioregion into 8 meso-scale regions: Pilbara inshore, Pilbara offshore, North West Shelf, Eighty Mile Beach, Canning, King Sound, Oceanic Shoals and Kimberley.

Ocean temperatures range between 22°C and 33°C, with localised higher temperatures in coastal waters, particularly along the Pilbara coastline. Fish stocks in the North Coast Bioregion are entirely tropical, with most having an Indo-Pacific distribution extending eastward through Indonesia to the Indian subcontinent and Arabian Gulf regions.

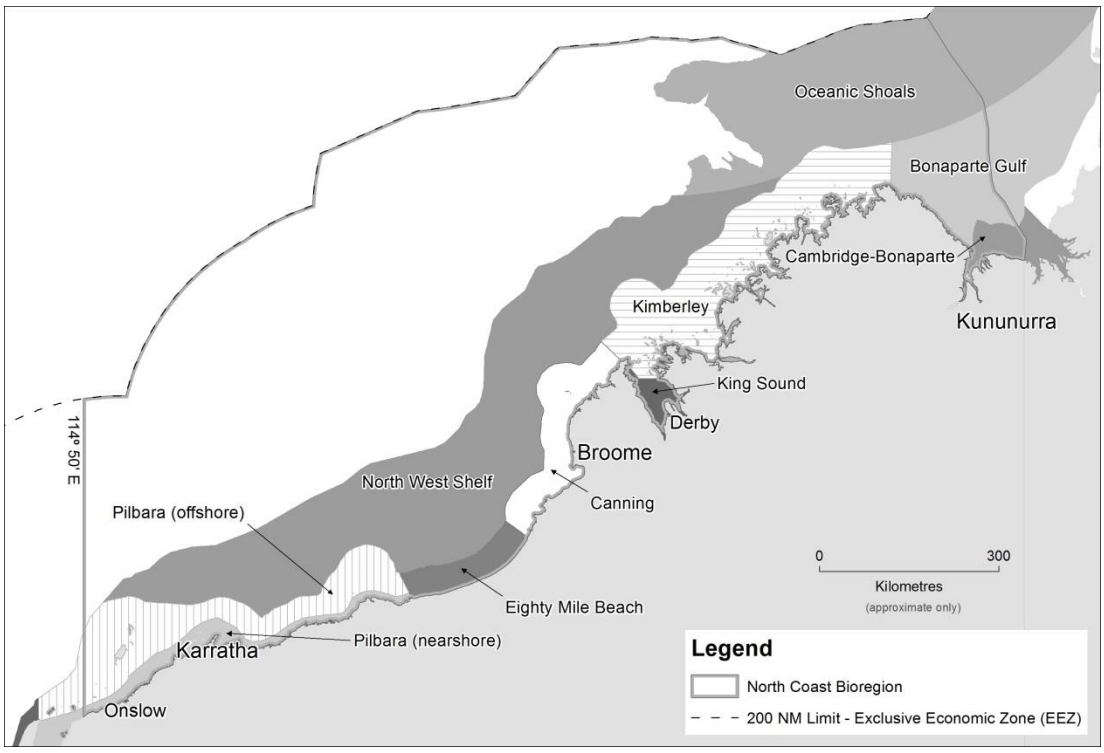
Coastal waters are generally low-energy in terms of wave action, but are seasonally influenced by infrequent but intense tropical cyclones, storm surges and associated rainfall run-off. These cyclone events generate the bulk of the rainfall, although the Kimberley section of the coastline does receive limited monsoonal thunderstorm rainfall over summer.

Significant river run-off and associated localised coastal productivity can be associated with cyclone events, with run-off ceasing during winter. Despite localised areas of high productivity the region is generally oligotrophic and larges areas of the coastline receive no riverine input. The entire North Coast region is subject to very high evaporation rates (3 metres per year), although the Pilbara coastline is more arid than the Kimberley, due to its lower cyclone frequency.

Other significant factors influencing coastal waters include the macro- tidal regime related to the wide continental shelf and the convergence of ocean currents,. Spring tides range from greater than 11 metres along the Kimberley section of the coast down to more than 2 metres in the West Pilbara.

As a result of these factors, the generally tropical low-nutrient offshore waters can, in the few small locations with rivers, be significantly influenced by rainfall run-off and tidal mixing to generate varying water quality in different sections of the North Coast Bioregion. Along the Kimberley coastline, waters are turbid and in areas locally productive, while the Pilbara Coast with its lower run-off and lesser tidal influence has the clear waters more typical of the tropics.

The coastal geography of the various sections of the coastline also differs. The Kimberley Coast is highly indented, with bays and estuaries backed by a hinterland of high relief. Broad tidal mudflats and soft sediments with fringing mangroves are typical of this area. The eastern Pilbara Coast is more exposed than the Kimberley, with few islands and extensive intertidal sand flats. Softer sediments and mangroves occur around the river entrances. The western Pilbara coastline is characterised by a series of significant but low-relief islands including the Dampier Archipelago, Barrow Island and the Montebello Islands. Nearshore coastal waters include rocky and coral reef systems, creating significant areas of protected waters. West Pilbara shorelines also include areas of soft sediment and mangrove communities.



NORTH COAST OVERVIEW FIGURE 1

Map showing the North Coast Bioregion and IMCRA (V 4.0) meso-scale regions: Pilbara inshore, Pilbara offshore, North West Shelf, Eighty Mile Beach, Canning, King Sound, Oceanic Shoals and Kimberley.

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;
- Increases 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 North Coast Bioregion is predicted to have relatively minor impacts from climate change, especially in the coming decade, compared to more southerly locations (Fletcher and Santoro 2012). 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. Changes in the distribution of key indicator species are being monitored in a national citizen-science program (www.redmap.org.au) that the Department is collaborating in.

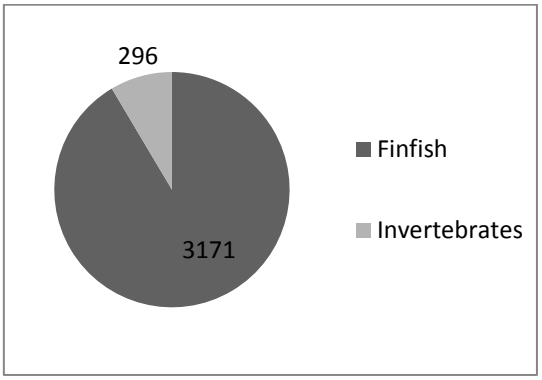
Commercial fishing

There are 15 different state-managed commercial fisheries that operate within the North Coast Bioregion. These fisheries target a variety of species including finfish, crustaceans, molluscs and echinoderms (North Coast Overview Figure 2). The principal commercial fisheries in the North Coast Bioregion focus on tropical finfish, particularly the high-value emperors, snappers and cods that are taken by the Pilbara Fish Trawl Fishery and the Pilbara and Northern Demersal trap fisheries. The typical catch is in the order of 3,000 t annually, making these fisheries, at an estimated annual value of at least $12 million, the most valuable finfish sector in the State. A number of other finfish fisheries operate in the BBioregion, including near-shore beach seining and gillnetting for barramundi and threadfin salmon (the Kimberley Gillnet and Barramundi Managed Fishery) and surface trolling for Spanish mackerel (the Mackerel Managed Fishery).

Another significant commercial fishery in this Bioregion is based on the collection of pearl oysters (*Pinctada maxima*) for use in the aquaculture production of pearls (see below). These are collected from the fishing grounds primarily off the Eighty Mile Beach, with smaller catches being taken around the Lacepede Islands (north of Broome).

The North Coast Bioregion also has a number of small, limited-entry trawl fisheries for prawns, producing about 700 t annually, valued at around $10 million. These fisheries include the Onslow, Nickol Bay, Broome and Kimberley Prawn Managed Fisheries (collectively referred to as the North Coast Prawn Managed Fisheries). Two small trap-based crab fisheries also exist in the Bioregion, targeting blue swimmer crabs in the Pilbara (the Pilbara Developing Crab Fishery) and mud crabs in the Kimberley (the Kimberley Developing Mud Crab Fishery). Sea cucumbers (also known and bêche-de-mer or trepang) are collected by hand by divers and waders throughout the Kimberley region as part of the Bêche-de-Mer Fishery. Catches are mainly comprised of two species, sandfish (*Holothuria scabra*) and redfish (*Actinopyga echinites*). The Trochus Fishery is a small fishery based on the collection of a single target species, *Tectus niloticus* from King Sound and the Buccaneer Archipelago. This fishery is operated by the Bardi Jawi and Mayala Aboriginal Communities, who have been collecting trochus in this area since the 1960s.

A traditional artisanal fishery also exists in an area around Roti Island, known as the MOU box.The MOU Box is an area within the Australian EEZ over which there is a bilateral agreement between Australia and Indonesia. The MOU allows Indonesian fishers to fish using traditional methods within Australian waters and has been operation al since 1974.



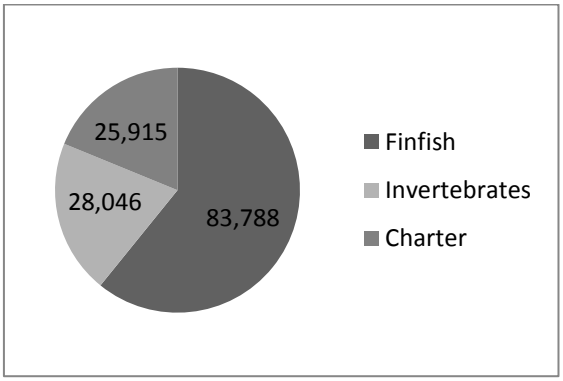
NORTH COAST OVERVIEW FIGURE 2

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

Recreational Fishing

Recreational fishing is experiencing significant growth in the North Coast Bioregion, with a distinct seasonal peak in winter when the local population is swollen by significant numbers of metropolitan and inter-state tourists travelling through the area and visiting, in particular, the Onslow,

Dampier Archipelago and Broome sections of the coastline. This may have been added to by the increased recreational fishing resulting from those involved in the construction or operation of major developments in this region. Owing to the high tidal range, much of the angling activity is boat-based, with beach fishing limited to periods of flood tides and high water. The numerous creek systems, mangroves and rivers, and ocean beaches provide shore and small boat fishing for a variety of finfish species including barramundi, tropical emperors, mangrove jack, trevallies, sooty grunter, threadfin, cods and catfish, and invertebrate species including blue swimmer crabs, mud crabs and squid (North Coast Overview Figure 3). Offshore islands, coral reef systems and continental shelf waters provide recreationally caught species including tropical snappers, cods, coral and coronation trout, sharks, trevally, tuskfish, tunas, mackerels and billfish.

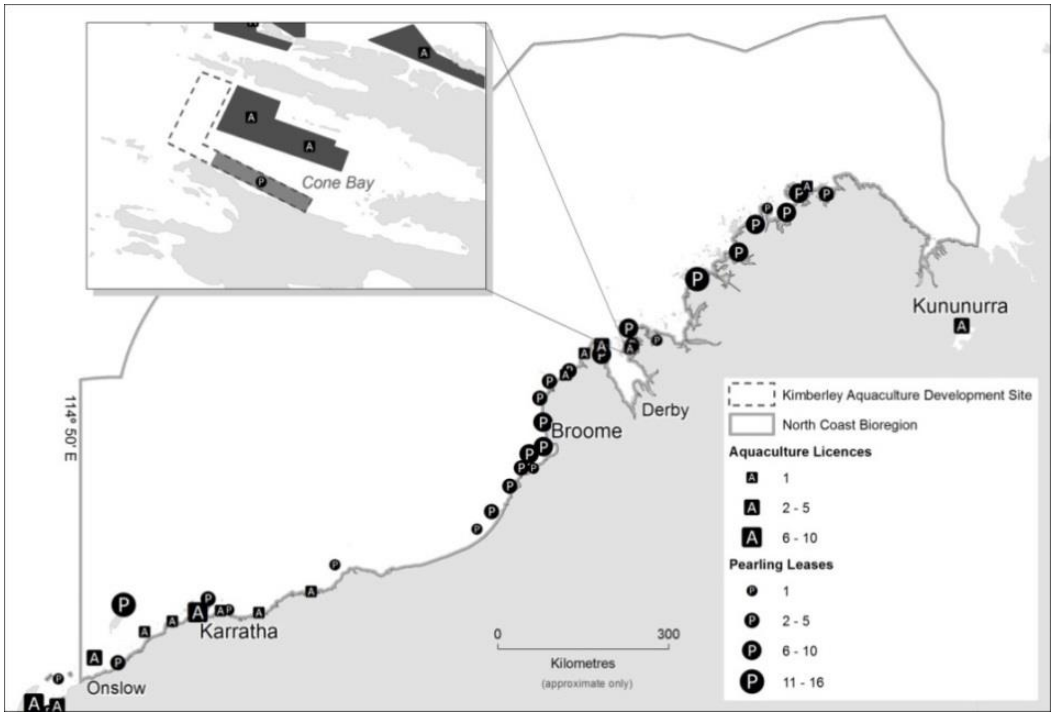


NORTH COAST OVERVIEW FIGURE 3

The North Coast Bioregion finfish and invertebrate catch numbers as assessed in the integrated survey of boat-based recreational fishing in WA 2011/12, and the charter boat catch numbers for the 2013 period.

Aquaculture

Aquaculture development in the North Coast Bioregion is dominated by the production of pearls from the species *Pinctada maxima*. An overview of aquaculture activities in the Bioregion is detailed in North Coast Overview Figure 4. A large number of pearl oysters for seeding is obtained from wild stocks and supplemented by hatchery-produced oysters, with major hatcheries operating at Broome and the Dampier Peninsular. Pearl farm sites are located mainly along the Kimberley coast, particularly in the Buccaneer Archipelago, in Roebuck Bay and at the Montebello Islands. Developing marine aquaculture initiatives in this region include growing trochus and barramundi. Marine production of barramundi is focussed in Cone Bay where an operator is currently licensed to produce 2,000 tonnes per annum. Establishment of an aquaculture zone (further described under the regional aquaculture research and development section in this chapter) has been funded in this area in which the Department of Fisheries will secure strategic environmental approvals, thereby streamlining the approvals processes for commercial projects and providing an "investment ready" platform for prospective investors. This is expected to lead to the development of further aquaculture operations in the region. A company developing a project culturing marine microalgae for the production of bio-fuels, omega-3 lipid and protein biomass previously established a demonstration facility near Karratha. The company is currently assessing alternative sites for the project. A focus of aquaculture development is provided by the Department of Fisheries' Broome Tropical Aquaculture Park, which houses a commercial pearl oyster hatchery and the Kimberley Training Institute aquaculture training facility. An indigenous project at One Arm Point operates a marine hatchery that focuses on a variety of ornamental and edible marine species.



NORTH COAST OVERVIEW FIGURE 4

Overview of aquaculture activity in the North Coast Bioregion, detailing locations of licensed finfish aquaculture facilities and pearling leases. Also indicated is the Kimberley Aquaculture Development Zone that is under development.

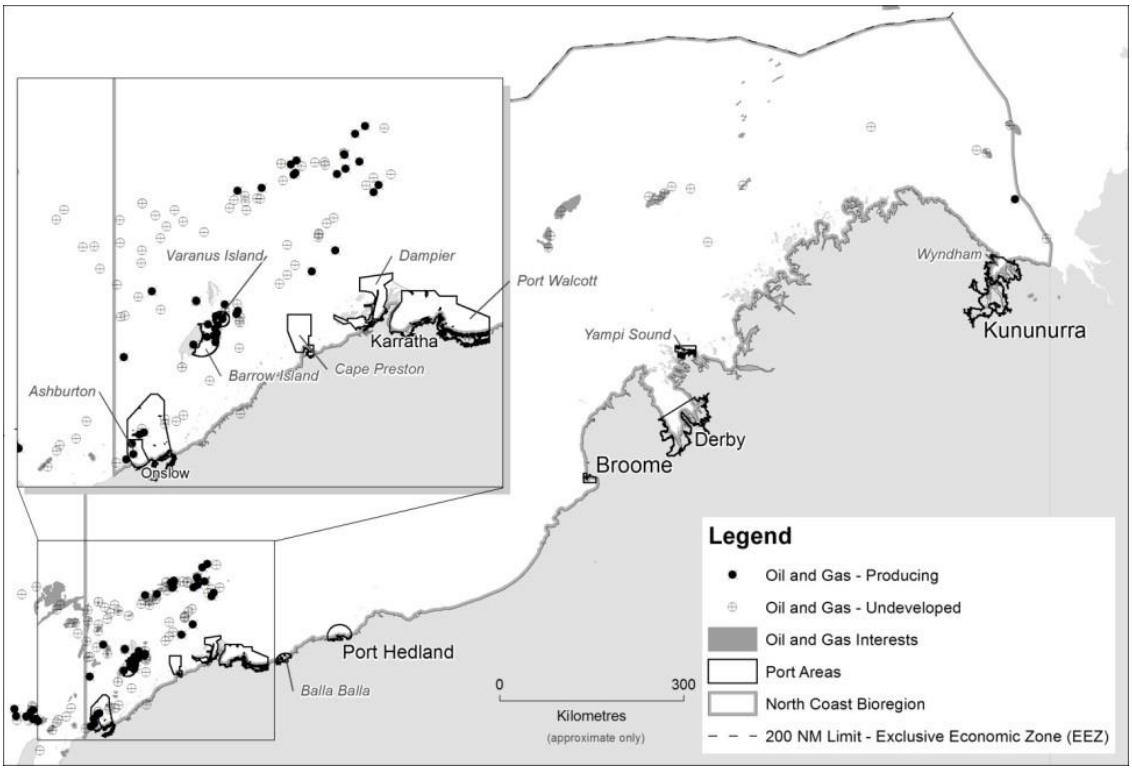
Tourism

The marine tourism industry has experienced significant growth within the North Coast Bioregion, particularly along the Kimberley coast. As coastal access is limited, tourists generally access the coast by boat from major population centres, such as Broome and Wyndam. Activities include charter fishing, diving, snorkeling, whale, turtle and dolphin watching, and sightseeing cruises.

Sites of greatest interests to tourists include places to fish, areas for sightseeing and secluded locations for general relaxation. Luxury cruises take tourists along the coastline and increasingly out to isolated coral atolls for fishing and diving. Primary dive locations include the Rowley Shoals, Scott Reef, Seringapatam Reef, Ashmore Reef and Cartier Island.

Oil and Gas Activity

Offshore oil and gas is a large and rapidly growing industry in the North Coast Bioregion. Within the Bioregion, the Northern Carnarvon, Browse and Bonaparte Basins hold large quantities of gas, and multiple projects are in various stages of development, production and exploration (North Coast Overview Figure 5). 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.



NORTH COAST OVERVIEW FIGURE 5

North Coast offshore oil and gas production sites and major ports.

Shipping and Maritime Activity

There are three major ports in the North Coast Bioregion: Broome, Dampier and Port Hedland (North Coast Overview Figure 5). The Port of Broome provides vital support for the Browse Basin offshore oil and gas industry. Other business includes livestock export, cruise liner servicing, coastal trading vessels, pearling, fishing and tourism charters. The Port of Dampier services both the land-based iron ore reserves and the offshore gas fields of the Carnarvon Basin. The Port of Port Hedland is the world's largest bulk exporter, with 99 % of the total cargo volume constituting exports. The port primarily exports iron ore, along with salt, livestock and petroleum products. There are eight other non-port authority ports in the North Coast Bioregion. In general, these ports and related export facilities are operated by resource companies. Most handle raw bulk commodity exports such as iron ore, crude oil and salt. An increase in shipping and port expansion associated with growth of the resources sector has potential implications for the marine environment. Potential threats include loss or contamination of marine habitats as a result of dredging and sea dumping, oil spills, interactions between vessels and listed species and the introduction of marine pests.

ECOSYSTEM MANAGEMENT

A variety of measures have been implemented to manage the potential impact of activities on the ecosystem within the North Coast Bioregion. These include:

Climate Change

Work is being finalized as part of a three-year FRDC-funded project (2010/535) that aimed to 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 WA marine environments using climate model projections. Lastly, existing management arrangements were 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 on fish stocks.

The Department of Fisheries' Research Division's Biodiversity and Biosecurity Branch also recently completed a pilot project aimed at establishing resource condition monitoring protocols for the Pilbara and Kimberley. The establishment of standardised long term resource monitoring programs is fundamental to understanding and thus mitigating the impacts of climate change on marine resources. The project focussed on an extensive survey of the research literature relating to the coastal and marine environments in the Pilbara and Kimberley. The review of the literature has highlighted those areas of research that are lacking from the region. The vast and remote coastline of the region dictates that remote sensing (satellite imagery and aerial photography) will be the primary tool for resource condition monitoring. The project concentrated on developing remote sensing as a monitoring tool, and developing a suite of resource condition indicators that accurately portray the health of the numerous marine and coastal environments, and set bench marks for which to assess environmental change, within the Pilbara and Kimberley. The Department is also a key collaborator in the National RedMap (Range Extension Database & Mapping project) project (www.redmap.org.au) which uses a citizen-science approach to document range extensions of a number of key identified climate-change affected species. Understanding shifts in populations is likely to be increasingly important to adaptive fisheries management.

Spatial Closures

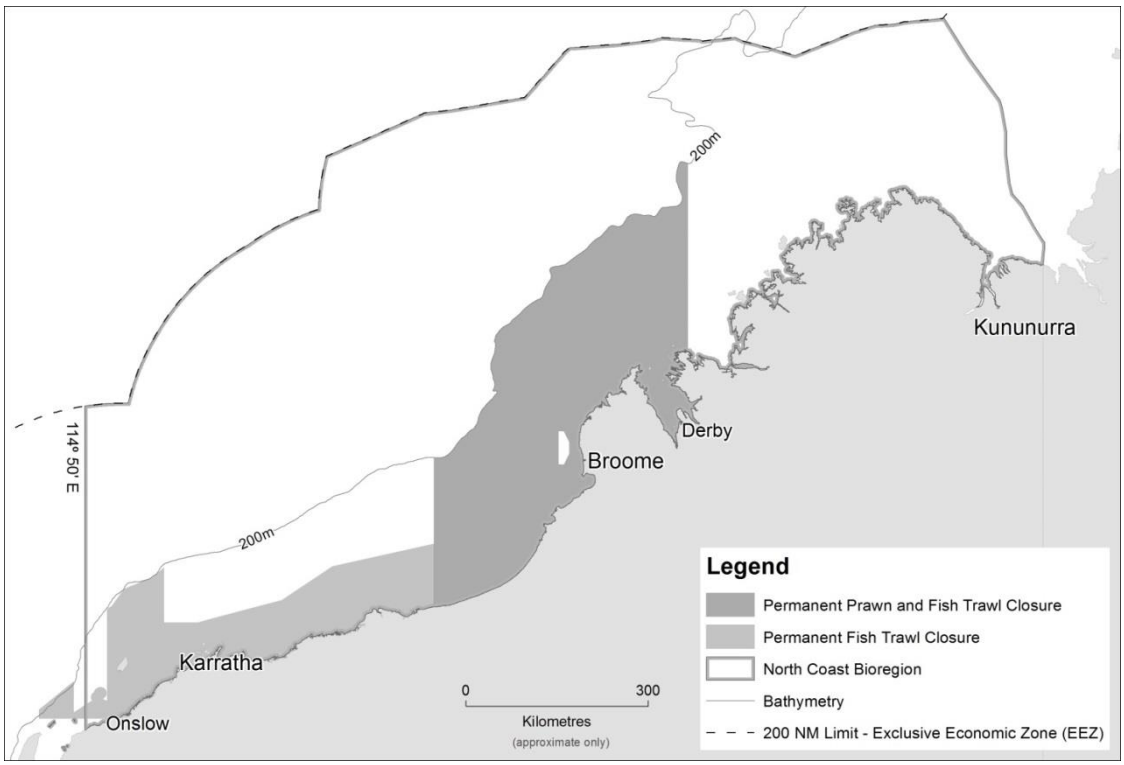
Extensive fisheries closures in coastal and most offshore waters have been introduced to manage finfish trawling by Australian vessels (North Coast Overview Figure 6). However, trawling is still permitted in a small number of limited locations, which in total represent less than 11% of the shelf waters (North Coast Ecosystem Management Table 1; see specific commercial trawl fishery reports elsewhere in this volume). This activity is carefully managed to ensure that impacts are acceptable. The trawling is subject to Ecologically Sustainable Development (ESD) requirements in accordance with the Commonwealth Government '*Guidelines for the Ecologically Sustainable Management of Fisheries*' under the Environment Protection and Biodiversity Conservation Act 1999. The extent of these areas means that 41% of the entire shelf region of the North Coast Bioregion could be classified as a marine protected area with an IUCN category of IV or higher (as per Dudley, 2008[1]; North Coast Ecosystem Management Table 1).

NORTH COAST ECOSYSTEM MANAGEMENT TABLE 1

The areas and proportions of the North Coast Bioregion making up State Waters and all continental shelf waters, out to 200 m depth, which meet the IUCN criteria for classification as marine protected areas.

IUCN category or equivalent	State Waters only (65,400 km2)				All Waters (837,500 km2 (including State waters))			
	Fisheries		Existing MPA		Fisheries		Existing MPA	
	km2	%	km2	%	km2	%	km2	%
I	0	0	0	0	0	0	1,300	< 1
II	0	0	1,900	3	0	0	1,900	< 1
III	0	0	0	0	0	0	0	0
IV	19,100	29	3,500	6	149,200	18	3,500	< 1
V	0	0	0	0	0	0	0	0
VI	36,800	56	4,100	6	677,500	81	4,100	< 1

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

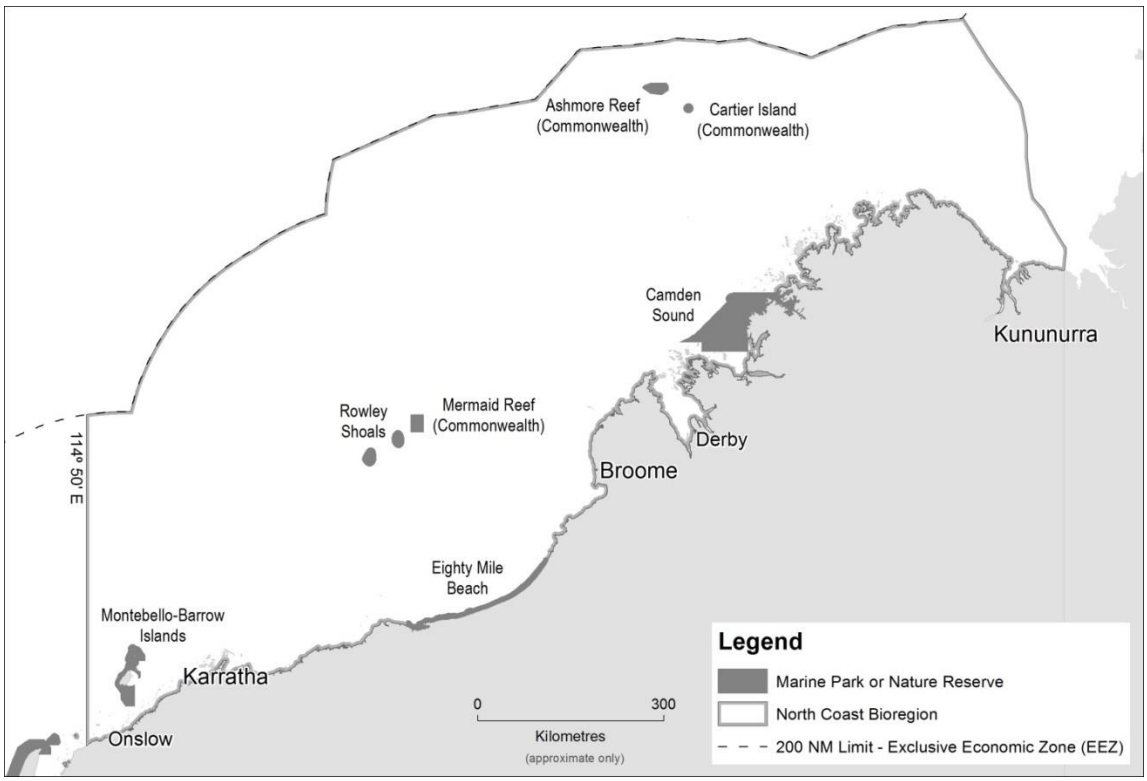


NORTH COAST OVERVIEW FIGURE 6

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

In addition to these habitat related marine protected area closures, the Bioregion has a number of other marine protected areas with various management objectives, summarised in North Coast Overview Figure 7. These include the Montebello and Barrow Islands and the Rowley Shoals proclaimed under the *Conservation and Land Management Act 1984* (see North Coast Ecosystem Management Figure 2), and closures to fishing under section 43 of the Fish Resources Management Act 1994 at Point Samson and the wreck of the Kunmunya Samson II (Delambre Reef). The Department of Fisheries has also participated in the marine conservation reserve planning process in this region. This has resulted in the recent establishment of the Lalang-garram Camden Sound Marine Park. The Department has recently received funding to establish baseline and ongoing monitoring and research to underpin ecosystem management of this area. There is considerable interest in developing further marine protected areas within the Kimberley region, and the State Government has announced funding of further marine protected areas at Eighty Mile Beach, Roebuck Bay and the Horizontal Falls. The proposed Dampier Archipelago marine conservation reserves are still under consideration by Government. The Department continues to work closely with relevant agencies and stakeholders to develop strategies to minimize environmental impacts in the marine environment. This includes participation in the Kimberley Science and Conservation Strategy developed with the Department of Parks and Wildlife (DPAW) and collaboration on relevant Western Australian Marine Science Institute (WAMSI) Kimberley Marine Research Program projects.

The Commonwealth Government has also undertaken a Marine Bioregional Planning process for Commonwealth waters between Shark Bay and the Northern Territory border. The federal minister for the environment had announced a final reserve network proposed for the North-West which spans the North Coast and Gascoyne Bioregions but this is under review by the current Government



NORTH COAST OVERVIEW FIGURE 7

Map showing the North Coast Bioregion and current and proposed state and commonwealth marine parks and reserves along the northern WA coast.

Management of Commercial Fisheries

There is a high degree of ecosystem management and protection for the ecological assets that are located within the North Coast Bioregion. Each of these fisheries operates under a specific management plan, the arrangements of which are implemented through the legislative framework provided by the *Fish Resources Management Act 1994* (FRMA). The FRMA and the management plan for each Fishery adhere to arrangements established under relevant Australian laws, with reference to international agreements that require conservation of all 'fish' and fisheries resources (which through the definition of fish includes nearly all aquatic organisms).

In WA, comprehensive controls on fishing were first introduced in the 1960s and now apply to all commercial fisheries. These controls are designed to ensure that all catches are kept at sustainable levels, which in turn requires that the annual catch is a relatively small proportion of the overall stock biomass. This approach maintains relatively high biomass levels for all harvested species compared to their unfished situation and therefore ensures that all trophic levels are being kept at relatively high levels of abundance. These management requirements have significantly reduced the risk of such trophic flow-on effects from occurring, and none are evident in the long-term trends in fish catches.

Strict limits on the use of fishing gear that can result in unwanted interactions with non-targeted species provide similar protection for bycatch and listed species and thus, biodiversity generally.

Examples of controls that operate in at least one fishery within the Bioregion include:

- Limited entry;
- Variable spawning/size season closures (areas closed or opened depending upon catch rates and sizes of invertebrates);
- Permanent and seasonal area closures to preserve sensitive habitats that are essential nursery areas;
- Temporal general closures;
- Primary and secondary bycatch reduction devices (BRDs) and excluder devices;
- Total Allowable Catch limits;
- Target catch ranges;
- Minimum commercial size limits;
- Protection of berried females (invertebrates); and
- Monitoring of fishing activities using the Vessel Monitoring System (VMS).

The State is currently employing a Bioregional approach to the pre-assessment of all its fisheries for potential third party certification according to the sustainability criteria developed by the Marine Stewardship Council (http://www.msc.org/). The progression of a number of fisheries to full certification is underway. This process will ensure independent assessment of the sustainability and effective management of assessed fisheries to an internationally recognised standard.

Management of Recreational fisheries

Recreational fishing in the North Coast Bioregion has been managed via a Bioregional-specific management strategy since 2003. This strategy consists of a set of bag, possession and size limits, permitted gear types and seasonal and area closures implemented under the Fish Resources Management Act 1994. All recreational fishing activities, including those of the charter sector, are subject to the closures associated with marine protected areas detailed above. In 2010, a statewide recreational 'fishing from boat' license was also introduced. A number of recreational fishing surveys have been undertaken, including a recent statewide recreational fishing from boat survey in 2011/12 (Ryan *et al.*, 2013)[1]. The results of such surveys are used to estimate recreational catch and effort of targeted finfish and crustaceans. The results of such surveys are used to maintain a sustainable Bioregional-specific management strategy. A second biennial survey is currently being completed.

Compliance and Community Education

Significant effort is put into ensuring adequate compliance with commercial and recreational fishing regulations. This includes at sea and aerial patrols to ensure closed seasons, closed areas, and operational rules are being adhered to. The use of VMS on commercial vessels also helps the Department monitor vessel location and speed, thus increasing compliance with closures while decreasing the need for untargeted patrol activities.

Biosecurity Risk Management

The Department is working closely with the Commonwealth Government and other jurisdictions to develop and implement the National System for the Prevention and Management of Marine Pest Incursions that will minimise the biosecurity risks associated with increased shipping in the Pilbara and Kimberley regions. Within WA, this is currently achieved through the Fish Resources Management Act 1994 and the Biosecurity and Agriculture Management Act 2007. The Department is the lead agency with responsibility for marine biosecurity in the State. The increase in international shipping movement and dredging activity associated with resource development in the Northern Bioregion is considered to present a high risk to the marine environment because of the potential for the introduction of non-indigenous marine organisms (including animals, plants, pathogens and diseases) into WA's coastal environment. Introduced marine pests can predate on native and farmed species, out-compete natives for space and food, alter nutrient cycle, lead to a loss of diversity in local species, cause human health impacts, negatively affect commercial fish and seafood species, negatively affect amenity and recreational activities and reduce the fuel efficiency for all vessel types. With increasing human population and associated travel, transport and trade, the risk of introducing new species is likely to grow.

Biosecurity risks associated with commercial vessel movements are managed through the routine monitoring of ports for marine pest species and management of risk associated with biofouling on commercial vessels utilizing state waters. Oil and gas related developments in the region have their own ministerial guidelines to ensure marine and coastal resources are protected. These developments undertake 'proof of freedom' pest monitoring to ascertain they have no pests present.

The Marine Biosecurity Research and Monitoring group have implemented a series of biosecurity related projects during 2013 – 2014. All projects aim to detect the presence of introduced marine pests (IMPs) using a suite of tools including ongoing background monitoring and large-scale port monitoring. Early detection of IMPs is vital if any attempt at eradication or other management strategies are to be successful. Two surveys have been implemented for the ports of Dampier and Port Hedland that have informed the Department of the status of IMPs in those ports. Background monitoring programs are also continuing within Dampier and Port Hedland Ports waters with assistance from the Dampier Port Authority and Port Hedland Port Authority. In addition the group has analysed the likelihood of IMPs being introduced into North Coast ports as a result of commercial vessel movements. Further detail may be found in the Introduced Pests Status Report at the end of this chapter. This work complements introduced aquatic organism incursion and fish kill incident response programs already in place in this Bioregion.

Management of Aquaculture

The main focus of the Department of Fisheries in the North Coast Bioregion continues to be on the regulation of the pearling industry based on the silver lip pearl oyster (*Pinctada maxima*) and the barramundi finfish aquaculture sector. The Department manages risks associated with aquaculture which include disease, the potential introduction of marine pest species and the impact of escapes. In recognition of the positive contribution aquaculture can have on wild stock sustainability, the economy and regional communities, the Department has recently engaged in a project to establish an aquaculture zone in the Kimberley with the aim of encouraging investment in sustainable finfish aquaculture through providing streamlined approval processes. The Department manages the impact of aquaculture via implementation of a comprehensive suite of conditions associated with aquaculture licences and through the legislative framework provided by the *Fish Resources Management Act 1994* (FRMA).

Management of Tourism

The Department has responsibility to manage the impacts of tourism where they may have a direct impact on fish resources. This is achieved through the measures detailed above aimed at managing recreational fishing. In addition to this regulation, formal management arrangements were also introduced for the charter sector in 2001 which include a 'cap' on the total number of operators statewide. Licensed operators that are engaged in extractive fishing are required

1 Ryan et al., 2013. An integrated system to survey boat-based recreational fishing in Western Australia 2011/12, December 2013. Fisheries Research Report 249.

to submit trip-by-trip catch and effort records. Otherwise, charter fishing is subject to the same regulation as private recreational fishers.

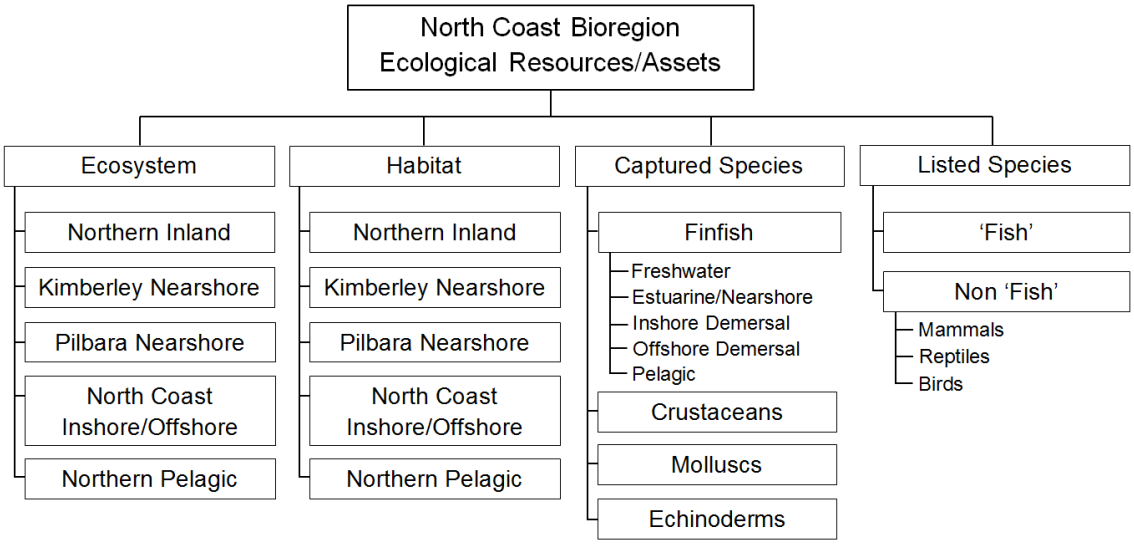
Management of Oil and Gas Impacts

Marine habitats within the North Coast Bioregion of Western Australia are experiencing increasing pressure through a range of activities but most notably as a result of increased resource development activity that is occurring in the area. The Department continues to engage with the Environmental Protection Authority through the environmental impact assessment process by providing advice on individual development proposals, which if implemented, have the potential to have an adverse impact on the marine environment. These include new (and upgraded) port developments in the Pilbara region, as well as offshore and nearshore oil and gas extraction projects in the Kimberley and Pilbara region. Major developments recently assessed for which the Department has played a key role include the Gorgon Gas Development at Barrow Island, and the proposed Kimberley LNG processing site. The Montara oil spill that occurred in this region highlights the potential risks to this area from oil and gas production.

ECOSYSTEM MONITORING AND STATUS

In order to assess the adequacy of management arrangements aimed at ensuring sustainability of the ecological assets within the North 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[1])(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 North Coast Bioregion are identified in Figure 8 and their current risk status reported on in the following sections.



NORTH COAST OVERVIEW FIGURE 8

Component tree showing the ecological assets identified and separately assessed for the North Coast Bioregion. Under the integrated marine and coastal regionalisation for Australia scheme, the Bioregion has been divided into 6 meso-scale regions (See Introduction Fig. 1): Kimberly Nearshore, Kimberley Inshore, Pilbara Nearshore, Pilbara Inshore, Offshore Oceanic Shoals and Northern Pelagic (imcra, v 4.0, 2006) which have been adopted for sub-regional management within an EBFM framework.

1 Fletcher, W.J., Shaw, J., Metcalf, S.J. & D.J. Gaughan (2010) An Ecosystem Based Fisheries Management framework: the efficient, regional-level planning tool for management agencies. Marine Policy 34 (2010) 1226–1238

External Drivers

External factors include factors 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 North Coast Bioregion include climate, introduced pests and diseases and oil and gas development activities.

Climate

External Driver	Current Risk Status
Climate	LOW

The North Coast Bioregion is predicted to have relatively minor impacts from climate change, especially in the coming decade, compared to more southerly locations. Cheung *et al.* (2012)[1] examined the effects of climate change on the distribution of 30 species of marine fish and invertebrates along the Western Australian coast. Important North Coast Bioregion species included western king prawns (*Penaeus latisulcatus*), blue swimmer crabs (*Portunus armatus*), redthroat emperor (*Lethrinus miniatus*), Spangled emperor (*Lethrinus nebulosus*), common coral trout (*Plectropomus leopardus*), rosy snapper (*Prestipomoides filamentosus*), goldband snapper (*Pristipomoides multidens*) and scaly mackerel (*Sardinella lemuru*). Changes in distribution were simulated using outputs from both a Regional Oceanographic Model and a Global Circulation Model. Results indicated a median shift of around 19 km per decade towards higher latitudes and 9 m deeper per decade by 2055 relative to 2005. As a result of these shifts, the temperate coast of Western Australia is expected to experience a 'tropicalisation' of the marine community, with an increased dominance of warmer-water species, resulting in shifted fishing grounds and unexpected trophic effects (Cheung *et al*. 2012).

Introduced Pests and Diseases

External Driver	Current Risk Status
Introduced Pests and Diseases	HIGH

The increase in international shipping movement and dredging activity associated with resource development in the North Coast Bioregion is considered to present a high risk to the marine environment because of the potential for the introduction of non-indigenous marine organisms, including animals, plants, pathogens and diseases. In 2012/13 the Department responded to a number of detections of potentially invasive marine pests species in the Bioregion. The Department recently completed a likelihood analysis which evaluated the relative risk to each port based on a number of parameters including vessel visitation (volumes, types, volume, origin and last port of call), pest species likely to be introduced and their likelihood of establishment (based on biological compatibility with the receiving environment). The report identified ports in the Bioregion to be at greatest inoculation risk (described as the vessel origin that poses the greatest risk) from vessels that travelled within state waters (intrastate), whereas for the other Bioregions the greatest risk was from international vessels. There was a very high compatibility between the potential incoming marine pests and the environments of the North Coast with the greatest infection and establishment risk to the North Coast coming from China (Bridgwood & McDonald 2014)[2]. The Department implements a range of monitoring and research activities in the Bioregion, focussed on early detection of potential marine pests at key high risk ports. Further detail may be found in the Appendix section entitled "Activities of the Marine Biosecurity Research Unit during 2013/14".

Oil and Gas Development Activity

External Driver	Current Risk Status
Oil and Gas Development	LOW

While there are a number of specific oil and gas related offshore developments that are proposed in this region, at the overall ecosystem level there is only a low risk that the ecosystem will be altered measurably. Some of the risks identified (e.g. increased turbidity) are being examined under WAMSI 2 projects. In addition, State and Commonwealth marine parks, including totally protected zones, are currently planned or in place.

Ecosystems and Habitats

Coastal geography is extremely variable within the North Coast Bioregion and its identified meso-scale ecosystems include a range of key habitats 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) which include:

- *Mangroves*: Mangroves occur throughout the Bioregion, and within the Kimberley, are considered to be very well developed and relatively pristine. The mangrove communities of Roebuck Bay and Eighty Mile Beach have been listed as Ramsar Wetlands of International Significance mainly due to the numbers of migratory wading birds they support.
- *Seagrasses:* Seagrasses are mainly tropical species. Twelve species have been identified throughout the North Coast Bioregion, including one endemic species (*Cymodocea angustata*). Within the Bioregion, seagrasses are generally found in shallow water environments near the mainland coast and offshore reefs and shoals.
- *Algae:* Algal growth is restricted by the limited presence of hard substrates on the North West Shelf. Throughout

1 Cheung, W., Meeuwig, J., Feng, M., Harvey, E., Lam, V., Langlois, T., Slawinski, D., Sun, C., and Pauly, D. (2012). Climate-change induced tropicalisation of marine communities in Western Australia. *Marine and Freshwater Research* 63: 415-427.

2 Bridgwood, S. and McDonald, J. A likelihood analysis of the introduction of marine pests to Western Australian ports via commercial vessels. Fisheries Research Report No. 259. Department of Fisheries, Western Australia. 212pp.

the Kimberley, the effects of strong tidal currents and high turbidity result in low macroalgal diversity. Surveys in the Kimberley have identified 72 species of macroalgae in the southern Kimberley and 90 species (not including coralline algae) in the northern Kimberley, most of which are widespread tropical taxa.

- *Sponges and Filter-Feeding Communities:* Sponges are found from tidal areas to the deep waters of the Abyssal Plain and generally occur as part of a mixed filter-feeding community. Species richness varies considerably throughout the Bioregion, with both relatively low-diversity communities (< 25 species, e.g. Rowley Shoals) and exceptionally rich communities (> 250 species, e.g. Dampier-Port Hedland regions). Sponge communities throughout the Bioregion are also broadly different. For example, a study by the Western Australian Museum found more than half the sponges identified at Mermaid, Scott and Seringapatam Reefs were unique to a single reef (WAM, 2006).
- *Coral Reefs:* Coral reefs in the Bioregion fall into two general groups: the fringing reefs around coastal islands and the mainland shore and large platform reefs, banks and shelf-edge atolls on the mid and outer shelf. North of Cape Leveque, the Kimberley supports extensive nearshore reef systems . Areas of fringing reef development include islands in the Buccaneer Archipelago, the Heyward island group, islands of the Bonaparte Archipelago and off mainland shores of Cape Voltaire and Cape Bougainville. Coral diversity is typically high, with surveys of the Buccaneer Archipelago) having recorded 280 species of coral from at least 55 genera. Coral reefs are also well developed around offshore island such as Ashmore, Cartier, Hibernia, Seringapatam and Scott Reefs, Browse Island and the Rowley Shoals.
- *Sand/Mud:* Embayments along the Kimberley are known to have extensive muddy tidal flats and the majority of the offshore area is dominated by soft sediment seabeds, which are mainly sand/mud with occasional patches of coarser sediments.

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.

A high level of protection of the ecosystems and habitats within the North Coast Bioregion is ensured based on the limited area of the Bioregion that is available to commercial trawl fishing activity (North Coast Bioregion Overview Figures 6 and 7) . The Department manages commercial, charter, recreational and indigenous fishing in State coastal waters (generally to 3 nm). By way of the *Offshore Constitutional Settlement 1995* (OCS) agreement between the State and Commonwealth Governments, control is also given to WA for most fisheries which operate out to 200 nm from the coast (except for trawling where WA's jurisdiction is limited to the 200 m isobath). If the areas that are not trawled is taken into account, 89 % of statewide benthic habitats out to the 200 m isobath are, in practical terms, fully protected and may never have been trawled (North Coast Ecosystem Management Table 1). In addition to fisheries-related closures, the North Coast Bioregion has a number of marine protected areas described under the preceeding "spatial closures" section.

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.

Kimberley Nearshore

Ecosystem/habitat	Aquatic zone/category	Current Risk Status
Kimberley nearshore ecosystem	Estuarine	LOW (non-fishing)
Kimberley nearshore ecosystem	Marine	LOW
Kimberley nearshore habitat	Estuarine Sand/Mud Mangroves	LOW (non-fishing)
Kimberley nearshore habitat	Marine Sand/Mud Sponge Reef Mangroves	LOW

The Kimberley Nearshore Ecosystem (KNE) includes coastal waters to 20 m depth from Cape Missiessy at the northern end of Eighty Mile Beach (19° 03' S; 121° 31' E) to the Northern Territory border. This ecosystem includes the nearshore sections of five of the IMCRA-identified Bioregions: Canning, King Sound, Kimberley, Cambridge-Bonaparte and Bonaparte Gulf.

Ecosystem

Estuarine (non-fishing)

With the onshore developments that are proposed in this area, while some specific areas may be locally impacted, these still only pose a low risk to the overall nearshore/estuarine ecosystem of this Bioregion.

Marine

The main fisheries in the region are selective and based on trap (Kimberley Demersal Mud Crab Fishery; KDMCF), gillnet (Kimberley Barramundi Gillnet Fishery; KBGF) and hand collection (Kimberley Beche-de-Mer Fishery; KBMF).The current level of fishing by all methods in the Kimberley Nearshore Ecosystem does not appear to have noticeably affected the trophic systems and/or community structure of the ecosystem. The majority of catch from each fishery is comprised of the main target species, and catches of these species have remained relatively stable throughout the history of each fishery, excepting where effort has dropped due to market demands (i.e. the Trochus Fishery). The target species for each fishery have wide distributions beyond the fishing areas, and their removal at current rates is unlikely to seriously or irreversibly alter community structure.

Habitat

Estuarine (non-fishing)
The main risks to nearshore habitats come from oil and gas resource development and the expansion of port facilities, plus periodic cyclones.

Marine
The main fisheries in the region are selective and based on trap (Kimberley Demersal Mud Crab Fishery; KDMCF), gillnet (Kimberley Barramundi Gillnet Fishery; KBGF) and hand collection (Kimberley Beche-de-Mer Fishery; KBMF) and thus constitute a minimal disturbance to benthic habitats. The majority of these fishing activities occur in mud/sand habitats in estuaries, tidal creeks and embayments. In general, mud/sand areas are less affected by disturbances than sensitive habitats, i.e. corals and seagrasses. In the case of the KDMCF, fishing with traps results in limited habitat disturbance, and the large mesh size used prevents the capture of benthic organisms. The sheltered, shallow mangrove environment is protected from wind and waves, and there is minimal dragging of traps on the sea bottom during retrieval. Fishing activities associated with the KBGF mainly take place over sandy habitats in nearshore, shallow waters, which are subject to extreme tidal currents and associated effects. Gillnets have a relatively low seafloor impact, and the Fishery is considered to be a low risk to benthic habitats. Fishers in the BDMF catch bêche-de-mer by diving or wading, with collection by hand only. Divers collect bêche-de-mer as they drift over the bottom and are careful not to contact the seabed during fishing activities. The spatial distribution of all fishing activities are also managed through the use of seasonal and area closures to protect sensitive habitats.

Pilbara Nearshore

Ecosystem/habitat	Aquatic zone/category	Current Risk Status
Pilbara nearshore ecosystem	Estuarine	LOW (non-fishing)
Pilbara nearshore ecosystem	Marine	LOW
Pilbara nearshore habitat	Estuarine Sand/Mud Mangroves	LOW (non-fishing)
Pilbara nearshore habitat	Marine Sand/Mud Sponge Reef	LOW

The Pilbara Nearshore Ecosystem (PNE) is defined as coastal waters to 20 m depth from Cape Missiessy at the northeastern end of Eighty Mile Beach (19° 03' S; 121° 31' E) to the North Coast Bioregion boundary just south of Onslow (114° 50' E). This region includes the nearshore sections from three IMCRA-identified Bioregions: Pilbara Inshore, Pilbara Offshore and Eighty Mile Beach.

Ecosystem

Estuarine (non-fishing)
With the onshore developments that are proposed in this area, while some specific areas may be locally impacted, these still only pose a low risk to the overall nearshore/estuarine ecosystem of this Bioregion.

Marine
The current level of removal of all retained species is considered to have only minor impacts on the trophic structure of the Pilbara nearshore ecosystem. The current level of fishing by all methods in the Pilbara nearshore ecosystem does not appear to have noticeably affected the trophic systems and/or community structure of the ecosystem. The majority of catch from each fishery is comprised of the main target species, and catches of these species have remained stable throughout the history of each fishery. The majority of the retained catch for both the Onslow Prawn Managed Fishery (OPMF) and the Nikol Bay Prawn Managed Fishery (NBPMF) is comprised of various prawn species, with target prawn species comprising on average 80 % of the total catch in the OPMF and 74 % in the NBPMF for the past 10 years. None of the main target species are known to be involved in any strong ecological interactions and their removal at current rates is unlikely to seriously or irreversibly alter community structure. Prawns have a very high natural mortality and turnover rate, such that a large percentage of the yearly recruits are naturally removed from the system (either by death or predation) by the end of the fishing season regardless of fishing activities. As a result of this naturally high variation, the effect of removing prawns at current levels through fishing would be minimal. Additionally, the management of spatial and seasonal closures ensures that an adequate spawning stock of all species of prawns survive to reproduce recruits for the subsequent season.

Habitat

Estuarine (non-fishing)
The main risks to nearshore habitats come from oil and gas resource development and the expansion of port facilities, plus periodic cyclones.

Marine
The majority of fishing activities take place over mud and sand habitats. Trawl activities are considered to have the highest relative impact of the methods used within the Pilbara nearshore ecosystem which also includes low impact activities of trap (eg Pilbara Developing Crab Fishery) and hand collection (eg Pearl Oyster Managed Fishery) based fisheries. However, the spatial extent of trawling activities is small, and there are a variety of measures in place to manage any impacts. Both the Onslow Prawn Managed Fishery (OPMF) and the Nikol Bay Managed Prawn Fishery (NBMPF) fisheries use otter trawl systems, which have been demonstrated to have the least impact of all forms of trawling Within Onslow Area 1, a study of biodiversity found no significant differences in the fish and invertebrate abundance, species richness, evenness or diversity between trawled and untrawled areas (Kangas *et al*. 2007)[1]. These findings indicate that trawling does not have a significant impact on the faunal community, which also suggests that trawling has not significantly impacted on the benthic habitats where

1 Kangas et al., 2007. Development of biodiversity and habitat monitoring systems for key trawl fisheries in Western Australia, December 2007. Fisheries Research Report No 160.

trawling occurs. The trawl grounds of the OPMF and the NBPMF are largely separated, on a geographical and depth basis, from other sensitive habitats, such as coral and sponge communities. Trawlers focus their activities in areas of high western king, brown tiger and/or banana prawn abundance, which is typically mud and sand areas outside of dense soft coral/sponge habitats.

Kimberley Inshore (Shelf)

Ecosystem/habitat	Aquatic zone/category	Current Risk Status
Kimberley inshore ecosystem	Marine	LOW
Kimberley inshore habitat	Marine Sand/Mud Sponge Reef	LOW

The Kimberley Inshore Ecosystem comprises the broad North West Shelf area off the Kimberley coast and includes all waters seaward of the 20 m depth contour to depths of 250 m and includes a number of mid-shelf islands. The Kimberley Inshore Ecosystem includes sections of five IMCRA Bioregions: Canning, Kimberley, Cambridge-Bonaparte, Bonaparte Gulf and the northern section of the North West Shelf.

Ecosystem

While there are a number of specific oil and gas related offshore developments that are proposed in this region, at the overall ecosystem level there is only a minor risk that the ecosystem will be altered measurably. Assessments of the community structure and trophic level of all commercially caught fish species in the Pilbara and Kimberley regions over the past 30 years found no evidence that there have been any systematic changes. Therefore, there is no indication that the fish faunas have been impacted by the development of the scalefish fisheries to the extent that ecosystem function in the Kimberley Inshore Ecosystem has been affected (Hall and Wise 2011).The majority of catch from each fishery is comprised of the main target species, and catches of these species have relatively remained stable throughout the history of each fishery, excepting where effort has dropped due to economic factors (i.e. the Broome Prawn Managed Fishery). None of the main target species are known to be involved in any strong ecological interactions, and their removal at current rates is unlikely to seriously or irreversibly alter community structure.

Habitat

Trawl activities are considered to have the relatively highest habitat impacts of the methods used within the Kimberley Inshore Ecosystem; however, the majority of trawling takes place of sand/mud bottom habitats, and only occurs over a small area of the ecosystem with most of this region being closed to trawling. Additionally, the spatial extent and intensity of fishing activities in both the trawl and trap (e.g. the Northern Demersal Scalefish Managed Fishery) fisheries are monitored annually using daily logbooks and VMS.

Prawn trawling by the Broome Prawn Managed Fishery and the Kimberley Prawn Managed Fishery occurs predominantly over mud and sand habitats and both fisheries use otter trawl systems, which have been demonstrated to have the least impact of all forms of trawling. The spatial distribution of fishing activities in these fisheries is monitored using VMS, to ensure fishing activities remain outside sensitive habitats, as well as monitor the intensity of fishing activities in any one location.

Pilbara Inshore (Shelf)

Ecosystem/habitat	Aquatic zone/category	Current Risk Status
Pilbara inshore ecosystem	Marine	LOW
Pilbara Inshore habitat	Marine Sand/Mud Sponge Seagrass Reef	MODERATE (fishing) LOW (non-fishing)

The Pilbara Inshore Ecosystem comprises the broad North West Shelf area off the Pilbara coast and includes all waters seaward of the 20 m depth contour to depths of 250 m and includes a number of mid-shelf islands. The Pilbara Inshore Ecosystem includes sections of three IMCRA Bioregions: Pilbarra Offshore, Eighty Mile beach and the southern part of the North West Shelf.

Ecosystem

Given the large areas closed to both trawling and to all commercial fishing, there is only a low risk that the level of fishing in this region is changing the regional-level community structure to an unacceptable level. Assessments of the community structure and trophic level of all commercially caught fish species in the region over the past 30 years found no evidence that there have been any systematic changes. Therefore, there is no indication that the fish faunas have been impacted by the development of the scalefish fisheries to the extent that ecosystem function in the Pilbara Inshore Ecosystem has been affected (Hall and Wise 2011).The majority of catch from each fishery is comprised of the main target species, and catches of these species have remained stable throughout the history of each fishery. None of the main target species are known to be involved in any strong ecological interactions and their removal at current rates is unlikely to seriously or irreversibly alter community structure. The total catch of the largest demersal scalefish fishery, the Pilbara Fish Trawl Fishery Interim Managed Fishery has declined from annual average catch levels of close to 2500 t during 1995 – 2004, to an average of 1200 t per annum since 2008. This is considered to be due to effort restrictions that were imposed by the trawl industry in 2008 and the Department in 2009. It is unlikely that total removals would significantly disrupt the trophic dynamics of the region, as most species in the catch are generalist carnivores that consume a wide range of fish and invertebrates from demersal habitats. Additionally, there are other species of medium-sized carnivores in the Pilbara Inshore Ecosystem that are not caught in significant quantities by the Fishery and

contribute to the total biomass of carnivores in the region. These non-target species play a similar trophic role to targeted species and are likely to compensate for the effect of removals by the fishery.

Habitat

Although fish trawling occurs in these areas, trawl activities are tightly constrained. The large area permanently closed to trawling and the relatively small area where trawling actually occurs indicates that the habitat in this region is appropriately managed. Trawl activities are considered to have the highest habitat impacts of the methods used within the region; however, the majority of trawling takes place of sand/mud bottom habitats, and there are a variety of measures in place to manage any impacts. A number of measures are in place to manage the impact of the Pilbara Fish Trawl Fishery Interim Managed Fishery on benthic habitats including gear restrictions, effort restrictions and spatial closures. All trawl nets are required to have rubber discs (max. diameter of 350 mm) attached to the ground rope which allow the net to fish slightly off the bottom and ride over obstructions, such as sponges. The maximum diameter of the rubber discs is aimed at restricting the movement of trawlers to areas of soft/flat seabed. There are also spatial constraints throughout the Fishery, including depth restrictions and closed areas. Trawling is only permitted in waters deeper than 50 m, which provides an inshore refuge area for attached benthos from which recruitment onto the trawl area is possible. Large areas over the 0 – 200 m depth range within the fishing boundaries are also closed to trawling. The location of fishing activities are reported in daily logbooks and monitored with VMS. Fishing levels are such that the fished area of the Pilbara Demersal Scalefish Fishery (PDSF; trawl, trap and line sectors) between depths of 30 and 120 m should remain at or below 60 % of the total fishing area. With the current spatial restrictions on fishing activities (see above), only 46 % of the PDSF area and less than 5 % of the NorthWest Shelf is accessible to trawl vessels. Plots of trawl activity from VMS data indicate that the actual area trawled is significantly less than this. The most likely potential impacts to the habitat in this area are from oil and gas infrastructure development and operation.

Offshore Oceanic Shoals

Ecosystem/habitat	Aquatic zone/category	Current Risk Status
Offshore Oceanic Shoals Ecosystem	Marine	LOW (non-fishing)
Offshore Oceanic Shoals Habitat	Marine Sand/Mud Reef	LOW (non-fishing)

The Offshore Oceanic Shoals Ecosystem (OSE) includes the waters beyond the shelf break, with depths greater than 250 m. This ecosystem includes one IMCRA v.4 Bioregion, the Offshore Oceanic Shoals.

Ecosystem

There are a number of specific oil and gas related offshore developments that are proposed in this region, particularly around Scott Reef. At the overall ecosystem level, however, there is only a low risk that the ecosystem will be altered measurably. The majority of fishing activities is focused around islands, reefs and shoals, which are known to be areas of localised productivity. The area around Ashmore Reef, Cartier Island and Scott and Seringapatam Reefs is an important area for traditional fishers from Indonesia and can be accessed by the fishers through a Memorandum of Understanding (MoU), which was agreed between the Australian and Indonesian Governments in 1974. In 1983, Ashmore Reef and Cartier Island were declared nature reserves, and by 1989, the collection of trepang was prohibited following overfishing from Indonesian fishers. Currently, traditional fishing activities are spatially restricted and fishers are permitted to obtain a maximum finfish catch for immediate consumption and one days sailing only. The Northern Demersal Scalefish Fishery and the Mackerel Managed Fishery also operate in the area around these reefs and islands, including at Woodbine and Johnson Banks. The cumulative ecological impacts from these fishing activities are minimal, as there is no significant commercial effort in the Offshore Oceanic Shoals Ecosystem.

Habitats

The main threat to benthic habitats in this ecosystem is from oil and gas development at Scott Reef. A small amount of line fishing occurs around these offshore shoals and reefs but is likely to have a negligible impact on the benthic habitat.

Northern Pelagic

Ecosystem/habitat	Aquatic zone/category	Current Risk Status
Northern Pelagic Ecosystem	Marine	LOW

The Northern Pelagic Ecosystem includes the pelagic waters and suite of species found within the North Coast Bioregion ‘above’ the inshore demersal and offshore demersal suites.

Ecosystem

Historical fisheries in the region include the Northern Shark Fishery (NSF) and Mackerel Managed Fishery (MMF) which operate in the pelagic component of the North Coast Bioregion and are based on based on gillnet/ longline and trolling gear types respectively. The NSF has, however, not operated since 2009. The main species targeted and caught by the MMF are fast swimming, pelagic carnivores. In 2012, 332 t of mackerel and other pelagic species were retained by the fishery with Spanish mackerel comprising over 99 % of the total catch. Spanish mackerel are generalist carnivores and consume a wide range of fish and invertebrate species from both pelagic and demersal habitats. Therefore, the impact of any reduction in abundance of mackerel species would be spread across many prey species. Additionally, mackerel are just one of many medium-sized carnivore species in the northern waters of WA, and any reduction in mackerel abundance would have little impact on the total biomass of carnivores in each region.

Habitats

The fishing gear used in the Northern Pelagic Ecosystem does not contact the sea bed during fishing operations. Within the Mackerel Managed Fishery (MMF), fishing trips may last for several days, during which time the vessels anchor overnight in sheltered locations. The main impact on the benthic habitat in the fishery is likely to be from this anchoring activity, however, anchors are typically set over naturally dynamic sandy habitats and any impacts from anchoring are wide spread throughout the fishing area.

Captured Species

Finfish

The principal fisheries in the North Coast Bioregion focus on tropical finfish, particularly the high-value emperors, snappers and cods. These species are taken by the Pilbara Demersal Scalefish Fishery (trawl, trap and line sectors) and the Northern Demersal Scalefish Fishery. The typical catch is in the order of 3000 t annually at an estimated annual value of around $ 12 million, making these fisheries the most valuable finfish sector in the state. A number of other finfish fisheries operate in the Bioregion, including near-shore beach seining and gillnetting for barramundi and threadfin salmon (the Kimberley Gillnet and Barramundi Managed Fishery) and surface trolling for Spanish mackerel (the Mackerel Managed Fishery). The Department manages commercial, charter, recreational and indigenous fishing in the State coastal waters (generally 3 nm). By way of the *Offshore Constitutional Settlement 1995* (OCS) agreement between the State and Commonwealth Governments, control is also given to WA for most fisheries which operate out to 200 nm from the coast (except for trawling where WA's jurisdiction is limited to the 200 m isobath). Indicator species which reflect the characteristics of the broader exploited stocks are monitored in order to assess ecological risk to the ranges of species targeted.

Estuarine/ Nearshore (0-20m depth)

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

The Kimberley Gillnet and Barramundi Managed Fishery (KGBF) is the only commercial fishery operating in the nearshore and estuarine zones of the North Coast Bioregion. It encompasses the taking of any fish by means of gillnet in inshore waters and the taking of barramundi *(Lates calcarifer)* by any means. The primary target species are barramundi and threadfin salmon. The KGBF is managed through input controls in the form of: limited entry; seasonal closures; area closures; and gear restrictions (e.g. net length and mesh size). Access to the Fishery is limited to five licence holders since two in Roebuck Bay bought out. There is no indication that the fish faunas have been impacted by the development of the scalefish fisheries to the extent that ecosystem function in the ecosystem has been affected (Hall and Wise 2011). Stocks of barramundi and threadfin salmon are considered to be at acceptable levels.

Inshore (shelf) Demersal (20-250 m depth)

Captured Species	Aquatic zone	Ecological Risk
Finfish	Inshore (shelf) demersal (20-250m depth)	MODERATE

There are four State-managed commercial fisheries in the Inshore Demersal region, which use multiple methods to target demersal fish stocks. These fisheries include: The Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF); The Pilbara Trap Managed Fishery (PTMF); The Pilbara Line Fishery (PLF); and The Northern Demersal Scalefish Managed Fishery (NDSF).

These fisheries all target the tropical demersal scalefish suite in the Pilbara and Kimberley Inshore Ecosystem and are collectively referred to as the Pilbara Demersal Scalefish Fisheries (PDSF) and Kimberley Demersal Saclefish Fisheries (KDSF). The trawl fisheries land the largest component of the catch, comprising more than 50 scalefish species. The current status of demersal finfish stocks captured by the Pilbara trawl fishery requires a review. A research survey is underway to assist in determining if the recent low catch rates are due to changes to trawl gear or to localized depletion.

Pelagic

Captured Species	Aquatic zone	Ecological Risk
Finfish	Pelagic	MODERATE

The Spanish Mackerel stock in this region targeted by the Mackerel Managed Fishery is at acceptable levels, and there are few other pelagic fish that are impacted.

Invertebrates

A significant commercial invertebrate fishery in this Bioregion, is the Pearl Oyster Managed Fishery, which is based on the collection of pearl oysters (*Pinctada maxima*) for use in the aquaculture production of pearls. These are collected from the fishing grounds primarily off Eighty Mile Beach, with smaller catches being taken around the Lacepede Islands (north of Broome).

The North Coast Bioregion also has a number of small, limited-entry trawl fisheries for prawns, producing around 700 t annually and valued at around $10 million. These fisheries include the Onslow, Nikol Bay, Broome and Kimberley Prawn Managed Fisheries (collectively referred to as the North Coast Prawn Managed Fisheries).Two small trap-based crab fisheries also exist in the Bioregion, targeting blue swimmer crabs in the Pilbara (the Pilbara Developing Crab Fishery) and mud crabs in the Kimberley (the Kimberley Developing Mud Crab Fishery). Sea cucumbers (also known and bêche-de-mer or trepang) are collected by hand by divers and waders throughout the Kimberley region as part of the Bêche-de-Mer Fishery. Catches are mainly comprised of two species, sandfish (*Holothuria scabra*) and redfish (*Actinopyga echinites*). The Trochus Fishery is a small fishery based on the collection of a single target

species, *Tectus niloticus* from King Sound and the Buccaneer Archipelago. This fishery is operated by the Bardi Jawi and Mayala Aboriginal Communities, who have been collecting trochus in this area since the 1960s.

Estuarine/Nearshore

Captured Species	Aquatic zone	Ecological Risk
Crabs	Estuarine/ Nearshore (0-20 m depth)	LOW
Trochus	Nearshore	LOW
Pearl Oyster	Nearshore	LOW
Bêche-de Mer	Nearshore	LOW

There is a small amount of fishing for mud crabs and blue swimmer crabs in some estuarine and inshore areas and its ecological risk is considered to be low.

The North Coast Trochus Fishery in King Sound is an indigenous fishery targeting the commercially important gastropod shell *Tectus niloticus*, commonly known as trochus. It is a hand collection fishery open to nominated fishers from the community. No fishing took place in 2012.

The pearl oyster fishery only targets a very small section of the pearl oyster stock both spatially and within the available size range. Recent catches have been well below the quota levels due to low market demand but are beginning to increase again.

Bêche-de-mer, also known as 'sea cucumbers' or trepang, are commercially harvested echinoderms (sea slugs) processed and sold for medicinal purposes in Asia. The majority of the effort has been expended in the Kimberly region, although there have been several years with substantial effort directed into the Pilbara region.

Inshore (shelf)

Captured Species	Aquatic zone	Ecological Risk
Prawns	Inshore (shelf)	MODERATE

There are a number of separate prawn stocks and fisheries within this Bioregion and each has limited entry, seasonal and area closures. Annual recruitment to these stocks is variable, which combined with the higher costs of operating in this region, has resulted in fishing effort being much lower in recent years.

Listed species

A number of endangered, threatened and protected[1] (ETP) species can be found within the North Coast Bioregion, including cetaceans, dugongs, marine turtles, sea snakes, elasmobranchs, seahorses and pipefish, crocodiles and seabirds and migratory shorebirds. These species are protected by various international agreements and national and state legislation. International agreements include:

- Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention);
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES);
- The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974 (JAMBA)[2];
- The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986 (CAMBA)[2];
- The Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007 (ROKAMBA)[2]; and
- Any other international agreement, or instrument made under other international agreements approved by the environment minister including the EBPC Act 1999.

Primary pieces of national and Western Australian legislation include the Commonwealth Environment Protection and Biodiversity Act 1999 (EPBC Act), the Western Australian Wildlife Conservation Act 1950 (WC Act), and the Fish Resources Management Act 1994 (FRMA).

The only fisheries in the region that have reported any interactions with ETP species are the two trawl fisheries, the Onslow Prawn Managed Fishery (OPMF) and the Nikol Bay Prawn Managed Fishery (NBPMF) and the Kimberley Gillnet Barramundi Fishery (KGBF). ETP interactions with the trawl fisheries are few, due to fishing arrangements, such as the use of bycatch reduction devices and the separation of trawling activities from most ETP species' primary habitat. Similarly, Fishers in the KGBF actively avoid capturing ETP species; however, a small amount of interactions have been reported with saltwater crocodiles and sawfish.

Fish

Listed species	Risk
Elasmobranch	MODERATE
Syngnathids and Solenotomids	LOW
Other Fish	LOW

The sawfish (Pristidae), speartooth shark (*Glyphis glyphis*) or the northern river shark (*Glyphis garricki*) are captured in small numbers by net fishing and trawlers in some areas of the Kimberley region. The area of these fisheries in which sawfish are vulnerable to capture is small relative to the total range of each species, suggesting limited impacts on each population. However, elasmobranchs grow and reproduce slowly, and even low levels of fishing mortality may be unsustainable.

Sea horses and pipefish are occasionally captured in trawl nets and fish/crab traps. The areas of each fishery in which syngnathids and solenostomids are vulnerable to capture is

1 Note that being on a listed species list does not automatically indicate that a species is either threatened or endangered.

2 Further information on the CMS, JAMBA, CAMBA and ROKAMBA is provided at www.environment.gov.au/biodiversity/migratory/index.html

small relative to the total distribution of the species, which includes waters inshore of the fishery and fishery closed areas, as well as structured habitats where trawling does not occur.

Recent video observations indicate that the potato cod is present in high numbers at discrete locations within the Kimberley region where the NDSF operates. Potato cod (*Epinephelus tukula*), a totally protected species, rarely enter fish traps due to their large size and girth limiting their capacity to pass through the entrance funnel into fish traps.

Non-Fish

Listed species	Ecological Risk
Turtles/Seasnakes	LOW
Crocodiles	LOW
Dolphins	MODERATE
Sea/Shore Birds	LOW

Sea snakes and occasionally turtles are encountered in trawl catches. Both of these species are typically returned to the sea alive. Grids are now compulsory on trawl nets, which has largely eliminated the capture of any turtle or other large animal.

Crocodiles are occasionally captured in nearshore/ freshwater fisheries' nets and most often are released alive.

Dolphins are captured by the Pilbara trawl fishery, but dolphin excluder devices have reduced this incidence to acceptable levels, with further refinements in net design currently being trialled. The Pilbara fish trawl fishery recently secured a three year WTO with further conditions around dolphin and sawfish interactions and monitoring.

Anecdotal information from Lake Argyle fishers suggests that interactions with birds and crocodiles are very low. Additionally, the fishery is closed from 1 November to 31 December each year, during a high-use period for protected migratory birds.

Introduced Pests Status Report

Regional Monitoring and Research Update

The introduction and spread of marine pests in WA waters poses a serious threat to native biodiversity and can have widespread effects on both our economy and health. There are two key vectors for marine pest translocation: ballast water and hull fouling. The Marine Biosecurity Research and Monitoring group continue to implement a series of biosecurity related projects in the North Coast Bioregion with two aims. The first is to examine the likelihood of inoculation; infection and establishment of compatible marine pests in the North Coast Bioregion from commercial vessel movements (see Bridgwood & McDonald 2014). The second aim is for early detection of the presence of introduced marine pests (IMPs) using a suite of tools.

From a biosecurity perspective the introduction of a marine pest to any region is based on multiple factors that can be grouped into two themes; the likelihood of inoculation and the likelihood of infection and establishment. Inoculation likelihood assumes that the greater the number of vessel visits from a source with IMPs the greater the risk of IMPs being brought into the recipient port i.e. a positive linear relationship. Based on commercial vessel data from 2011, there were 8195 commercial visits to the North Coast Bioregion and the greatest inoculation risk was from intrastate vessel movements. The infection and establishment likelihood takes into account the sources of IMPs (based on a vessels last port of call (LPOC)), the frequency of visits from those sources and the compatibility between the IMPs salinity and temperature tolerances and North Coast Bioregion's marine environment. There was a 90% compatibility rating of potential inbound IMPs with the environment of the North Coast Bioregion from 23 international last ports (Introduced Pests Figure 1). When the cumulative effect of the number of vessel visits from a LPOC and number of IMPs present at that LPOC is considered, the greatest infection and establishment risk to the North Coast Bioregion was from China (Introduced Pests Figure 2).

Early detection of IMPs is vital if any attempt at eradication or other management strategies is to be successful. Thus the Marine Biosecurity Research and Monitoring group undertake marine pest monitoring at the ports of Dampier and Port Hedland. In recognition of the risks IMPs pose to WA ports the Marine Biosecurity Research and Monitoring group have developed complementary monitoring to occur every alternate year to national monitoring. Whereas the national monitoring adheres to the Australian Marine Pest Monitoring

1 Bridgwood, S and McDonald, J. 2014. A likelihood analysis of the introduction of marine pests to Western Australian ports via commercial vessels. Fisheries Research Report No. 259. Department of Fisheries, Western Australia. 212pp.

Guidelines and is endorsed by the Commonwealth, the complementary monitoring is a smaller more focussed version designed to target select high risk sites in each port. The complementary monitoring of Dampier and Port Hedland ports was completed in early 2014. The next round of national monitoring for these ports is scheduled for early 2015.

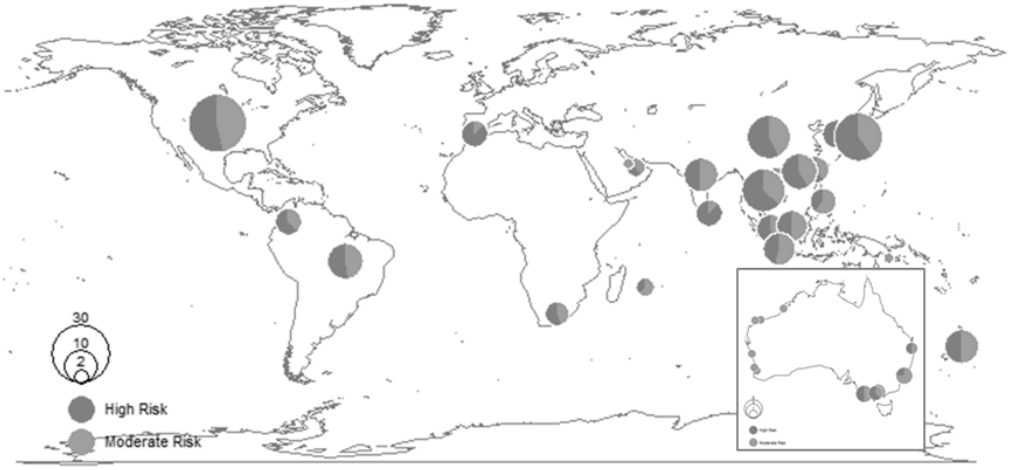
In addition the Marine Biosecurity Research and Monitoring group, with financial and *in-kind* assistance from Dampier and Port Hedland Port Authorities and stakeholders, is running an Early Warning System program using *in-situ* sampling arrays to aid in the early detection of marine pests in both ports.

Through this combined surveillance the species that have been detected in this region are reported in Introduced Pests Table 1.

INTRODUCED PESTS TABLE 1

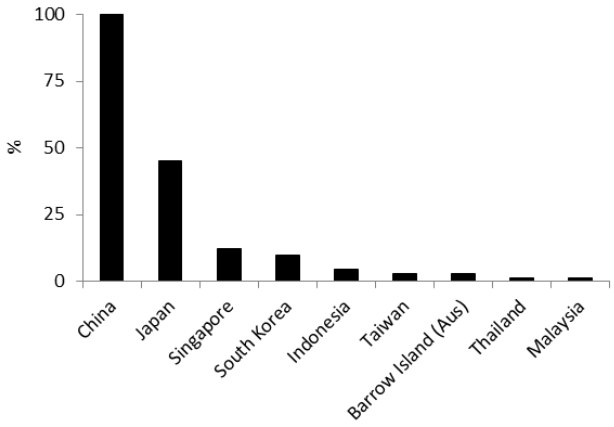
Introduced marine species detected in this bioregion.

Common name	Scientific name	Type of organism	IMS/IMP listing
	Theora fragilis	Mollusc	Introduced species
	Didemnum perlucidum	Ascidian	Introduced species – likely pest



INTRODUCED PESTS FIGURE 1

The last port of call locations of compatible IMPs for the North Coast Bioregion



INTRODUCED PESTS FIGURE 2

Ranking of the infection and establishment risk posed to the North Coast Bioregion by international and domestic last ports of call. Each last port of call value is expressed as a relative percentage of the largest last port of call value (i.e. China 100%

FISHERIES
North Coast Prawn Managed Fisheries Status Report

E. Sporer, M. Kangas, M. Shanks and N. Blay

Main Features

Status		Current Landings	
Stock level	Adequate	Onslow:	<1 t
Fishing level	Acceptable	Nickol Bay:	106 t
		Broome:	2 t
		Kimberley:	154 t

Fishery Description

The four prawn fisheries that operate in the North Coast Bioregion include the Onslow (OPMF), Nickol Bay (NBPMF), Broome (BPMF) and Kimberley (KPMF) Prawn Managed Fisheries. These are all otter trawl fisheries and extend from the north eastern boundary of the Exmouth Gulf Prawn Fishery to 126° 58' east longitude (Cape Londonderry – boundary of the Northern Prawn Fishery).

The OPMF and NBPMF operate along the western part of the North-West Shelf. The OPMF targets western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus* spp.) whereas the NBPMF primarily targets banana prawns (*Penaeus merguiensis*).

The BPMF operates in a designated trawl zone off Broome and targets western king prawns (*Penaeus latisulcatus*) and coral prawns (a combined category of small penaeid species).

The KPMF operates off the north of the state between Koolan Island and Cape Londonderry. It predominantly targets banana prawns (*Penaeus merguiensis*) but also catches tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus endeavouri*) and western king prawns (*Penaeus latisulcatus*).

Governing legislation/fishing authority

Onslow Prawn Fishery Management Plan 1991

Onslow Prawn Managed Fishery Licence

Nickol Bay Prawn Fishery Management Plan 1991

Nickol Bay Prawn Managed Fishery Licence

Broome Prawn Managed Fishery Management Plan 1999

Broome Prawn Managed Fishery Licence

Kimberley Prawn Fishery Management Plan 1993

Kimberley Prawn Managed Fishery Licence

Commonwealth Government *Environment Protection and Biodiversity Conservation Act 1999* (Export Exemption)

Consultation process

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

Boundaries

The boundaries of the OPMF are 'all the Western Australian waters between the Exmouth Prawn Fishery and the Nickol Bay prawn fishery east of 114º39.9' on the landward side of the 200 m depth isobath'. The fishery is divided into three parts with associated size management fish grounds (SMFGs) and nursery areas as follows: Area 1, incorporating the Ashburton SMFG; Area 2, incorporating the Mangrove Island and Weld Island SMFGs and Coolgra Point Nursery; and Area 3, incorporating the Fortescue SMFG (Northern Prawn Figure 1).

The boundaries of the NBPMF are 'all the waters of the Indian Ocean and Nickol Bay between 116°45' east longitude and 120° east longitude on the landward side of the 200 m isobath'. The NBPMF incorporates the Nickol Bay, Extended Nickol Bay, Depuch and De Grey SMFGs. (Northern Prawn Figure 2).

The boundaries of the BPMF are 'all Western Australian waters of the Indian Ocean lying east of 120° east longitude and west of 123°45' east longitude on the landward side of the 200 m isobath'. The actual trawl area is contained within a delineated small area north west of Broome as shown in Northern Prawn Figure 3.

The boundaries of the KPMF are 'all Western Australian waters of the Indian Ocean lying east of 123°45´ east longitude and west of 126°58´ east longitude'. It abuts the western boundary of the Commonwealth Northern Prawn Fishery (NPF). The KPF has four inshore closures and two SMFGs in place (Northern Prawn Figure 4).

Management arrangements

Management of all the north coast prawn fisheries is based on input controls including limited entry, seasonal and area closures, and gear controls including bycatch reduction devices. Fish Escape Devices are mandatory in all trawl nets. The Department's Vessel Monitoring System (VMS) monitors the activities of all boats.

OPMF: The management arrangements in the OPMF involve using a standardised net headrope allocation whereby each Managed Fishery Licence (MFL) has an equal allocation of net headrope length in each Area. However, there are different net sizes permitted between Areas. Area 1 boats are authorised to use two trawl nets each having a maximum headrope length of 10.98 metres (6 fathoms). These boats operate under an exemption to fish with larger size nets. In Areas 2 and 3 a maximum headrope length of 29.27 metres (16 fathoms) is permitted in either twin or quad gear configuration. Trawl net headrope amalgamation between MFLs has been permitted in the OPMF consistent with other trawl fisheries. The fleet is composed of trawlers up to 23 metres in length. Additionally, the fishery is exempt from the 375 boat unit rule.

Different licence classes apply to the OPMF, allowing boats to trawl in specific zones. These classes are listed below, with figures in brackets indicating number of licensed boats:

Class A	Areas 1, 2 and 3 (four MFLs)
Class B	Areas 2 and 3 (three MFLs)
Class C	Area 2 (11MFLs, that are also Exmouth Gulf Prawn MFLs)
Class D	Area 3 (12 MFLs that are also Nickol Bay prawn MFLs)

The 2013 season officially opened on 8 April and closed on 19 October with subsidiary openings and closings of SMFG's. The specific SMFG openings were as follows:

Areas 1, 2, 3	08 April – 19 October
Fortescue SMFG	01 June – 30 September
Ashburton SMFG	02 May – 30 June
Weld Island SFMG	02 May– 31 August
Mangrove Island SFMG	02 May –19 October

NBPMF: The management arrangements in the NBPMF provide for authorised boats to tow any combination of standard otter trawl nets provided that the total headrope length does not exceed 29.27 metres (16 fathoms). Each licence has an equal allocation of headrope length and the maximum total headrope length for the entire fleet is 409.78 metres (224 fathoms). The 2013 season opened on 18 March and closed on 19 October with subsidiary openings and closings of SMFG's. The specific SMFG openings were as follows:

Nickol Bay	26 May – 30 September
(Day fishing only 26 May – 9 June)	
Extended Nickol Bay SMFG	26 May –19 October
Depuch SMFG	26 May – 30 September
De Grey SMFG	26 May – 19 October

BPMF: The BPMF management arrangements provide for the use of standard otter trawl nets not exceeding 73.16 metres (40 fathoms) in either twin or quad gear configuration. Each of the five licences in this fishery has an equal allocation and the maximum total headrope length for the entire fleet is 365.8 metres (200 fathoms). The Fishery opened on 1 June and officially closed on 12 October, providing for 133 fishing nights.

KPMF: The KPMF Management Plan permits the use of two otter trawl nets where the total headrope length does not exceed 58.5metres (32 fathoms). There are 124 boats licenced to fish in the KPMF, 45 of these also held an NPF licence.

Seasonal dates for the KPMF are generally aligned with those of the adjacent NPF. This strategy aims to prevent large shifts of fishing effort into the KPMF. There are permanent inshore closures and a total allowable effort cap system is in place that restricts the number of fishing days to a total of 1500 days, with 600 and 900 boat days allocated to the first and second part of the season respectively. The 2013 season opened on 1 April with a mid-season closure commencing on 27 May. The fishery re-opened on 1 August, with a final season closure on 30 November.

A comprehensive Ecologically Sustainable Development (ESD) assessment of these fisheries has been undertaken to identify any potential sustainability risks requiring direct management action. The only issue identified through this process related to the breeding stock levels of target species (e.g. banana, tiger and king prawns). Boxed text in this status report provides the annual assessment of performance for this issue. The Department of the Environment (DotE) completed the reassessment of the NBPMF, OPMF, KPFM and BPMF trawl fisheries and export approval has been granted until 20 August 2015 for all fisheries under the one approval.

Research summary

Research programs are focused to underpin the sustainable management of these small fisheries involving stock monitoring and assessment utilising information from daily logbooks and processor unloads.

In the OPMF a field-based consultative process is normally undertaken whereby industry and the Department's Research Division decide on the extent of an area to be fished within the areas that are officially opened, and to limit the fishing of small size prawns. For 2013 limited commercial fishing was undertaken. The installation of the pipeline into the hinterland from platforms at sea and the construction of wharf facilities increased uncertainty of fishing viability in Area 1 the most productive area in this fishery. Area 3 was fished by three boats from the NBPMF, which has access to that part of the Onslow fishery.

For the NBPMF and KPMF rainfall records are also used to update the rainfall-catch relationship for banana prawns. For the BPMF a depletion analysis is undertaken when sufficient fishing activity occurs which assists in the assessment of the king prawn stocks within the permitted fishing area. Insufficient effort has occurred in this fishery since 2008 precluding the use of this analysis.

A preliminary harvest strategy with control rules has been developed for these fisheries.

Retained Species

Commercial production (season 2013):

Onslow:	**0.5 tonnes**
Nickol Bay:	**106 tonnes**
Broome:	**2 tonnes**
Kimberley:	**154 tonnes**

Landings

OPMF: The total recorded landings that occurred in the OPMF were <1 t comprising of tiger prawns, banana prawns and king prawns (Northern Prawn Figure 5).

NBPMF: The total recorded landings of major penaeids for the 2013 season were 106 t, comprising: 106 t of banana prawns (96 t from the Nickol Bay fishery, and 10 t from Onslow, Area 3), < 1 tonne combined recorded landings of king prawns, endeavour prawns and tiger prawns. The landings of banana prawns was lower than the predicted catch of 150 t and catch range (120 to 180 t) (Northern Prawn Figure 6). Less than 1 t of all byproduct was landed which included bugs, blue swimmer crab and mixed finfish.

BPMF: Recorded landings for target species were very low at 2 t for king prawns and less than 1 t of coral prawns (Northern Prawn Figure 7). There were also very low landings of byproduct species (<1 tonne) including cuttlefish and bugs.

KPMF: The total recorded landings in the KPMF were 154 t, comprising 144 t of banana prawns, 6 t of tiger prawns, 4 t of endeavour prawns and < 1 t of king prawns (Northern Prawn Figure 8). Banana prawn landings were below their target catch range (200-450 t) and below the projected catch range (230 to 350 t) calculated using the relationship between summer rainfall and annual landings. Both tiger and endeavour prawns were below their target catch ranges. Fishing occurred in both fishing periods for 2013 but effort was low, possibly reducing total catches for these species. Negligible quantities of by-product were reported.

Recreational component: **Nil**

Fishing effort/access level

OPMF: One boat fished during the 2013 season.

NBPMF: Six boats fished during the 2013 season for an aggregated total of 178 boat days (Northern Prawn Figure 6). This is a relatively low total effort and within the expected effort levels reflecting the moderate banana prawn abundance this season.

BPMF: A total of 11 nights of fishing effort was expended by one boat in 2013 (Northern Prawn Figure 7). The low effort (and number of boats operating) in the fishery has been due to uncertainty of the prawn abundance available at the start of the season and economics of fishing (high fuel costs and crew wages). Generally one boat 'trials' fishing during the early part of the season to determine if catch rates are viable and other licensees make an economic decision based on these catch rates before sending boats to this fishery.

KPMF: Twelve boats fished during 2013 for an aggregated total of 314 boat days (Northern Prawn Figure 8). This low effort reflects the economic conditions and targeting banana prawns at high catch rates. Boats left the fishery when banana prawn catch rates declined hence the low catches of other prawn species. The total days was well below the 1500 aggregated days allocated to fish and similar to 2008 to 2012.

Stock Assessment

Assessment complete:	**Yes**
Assessment level and method:	**Level 1 - Catch**

(Rainfall-catch relationship for NBPMF and KPMF for banana prawns, depletion analysis for BPMF - when appropriate)

Breeding stock levels:	**Adequate**

Projected catch next season (2014):

NBPMF:	**145 t banana prawns**
KPMF:	**290 t banana prawns**

For the prawn stocks in the North coast region their short life cycle, high fecundity and dispersed nature prevent fishing from depleting breeding biomass to unacceptable levels. Historical catch levels from periods where it is known that recruitment was not affected by fishing effort have been used as the basis for calculating target catch ranges. These catch ranges are used as an indicator of breeding stock adequacy.

The recent series of low annual landings of prawns is still a feature in many of these northern fisheries and are in part due to low effort caused by the current economic conditions including, high fuel and equipment prices and low market prices and variable market conditions. Catches of banana prawns are highly variable and related to the amount of rainfall recorded in the region with consecutive high rainfall years providing the optimal conditions for banana prawn recruitment.

OPMF: There was limited commercial fishing undertaken in 2013. The total landings of prawns were extremely low. There has been disruption and disturbance to the most productive Area 1fishing grounds. This has included construction of facilities on the hinterland for the delivery of gas via a pipeline from the offshore gas platforms, wharf construction and general boat movement in the area making fishing operations difficult. Since there was little catch and also effectively no effort on the tiger prawn stock in this part of the fishery, adequate breeding stock would remain. This also applies for the king prawn stock. The dredging for the wharf facility and inshore disturbance for the construction of the pipeline facility is likely to cause short-term loss of some nursery habitat and may change the hydrology for prawn movement in the immediate area. This disturbance may cause some loss of seagrass/algal habitats and may impact juvenile tiger prawns in the short term.

NBPMF: In 2013, the annual catch was within the target catch range, despite low effort, indicating adequate overall stock (and breeding stock) abundance. King and tiger prawn landings were extremely low and below the target catch ranges. Whether these low catches are due to low stock levels, very limited targeting on these species or due to environmental factors is not known at this stage. The catch projection for banana prawns in Nickol Bay is based on the summer rainfall level between December and March

(Northern Prawn Figure 9). The total rainfall between December 2013 and March 2014 (at Roebourne) was 222.5 mm and the predicted catch for 2014 is around 145 t with a range of 115 –170 t of banana prawns.

BPMF: The very low fishing effort that occurred was reflected in the low king prawn landings of 2 t. While no stock assessment was completed in 2013, the average king prawn catch rate of 14.7 kg/hr is at the lower end of the acceptable catch range for viable commercial fishing and reflect the very low catch and effort levels under the current economic conditions. Because of the low effort only part of the fishery was exploited to its potential total catch.

KPMF: The total landings of banana prawns were below the target catch range, 200 to 450 t and the projected range (230 – 350 t). Both tiger and endeavour prawn landings were very low and below their target range, which is likely to be effort related.

Throughout the history of the fishery, the stock of banana prawns in the Kimberley has been assessed using the annual catch (tonnes) and effort (boat fishing days). This is consistent with a DoF Level 1 assessment. The catch is compared against specified reference levels for catch, i.e. a target catch range (200 – 450 t) and we now also propose a catch limit reference point of 100 tonnes, provided the effort also remains within the historical range. The target historical catch range spans the observed catches in most years, apart from four years where the catch was below the target range. The 2013 landings are the lowest recorded since 1980. Effort is also low but not as low as recorded in 2011 when 145 t of banana prawns were caught.

The relationship between the early season rainfall and catches of banana prawns (the dominant species taken in this area) is based on the rainfall in Kalumburu and Derby in January and February (which was 597 mm in 2014). The predicted catch of banana prawns in 2014 is 290 t, with a range of 230 to 350 t.

The main performance measures for the OPMF, NBPMF and KPMF relate to maintenance of breeding stocks for each of the major target prawn species.

In 2013 the breeding stock indicators in the OPMF (catches within specified ranges, as set out in the 'Fishery Governance' section) were not able to be measured because extremely low fishing effort was applied resulting in very low total prawn landings in this fishery.

The breeding stock indicator for banana prawns in the NBPMF was met because the landings were within the target catch range. There were no recorded king or endeavour prawn landings, therefore, they were below the target ranges. The tiger prawns landings were negligible and below the target range. This is likely to be a result of limited targeting of these species.

An assessment of breeding stock could not be made for the BPMF due to very low fishing effort.

The breeding stock indicators in KPMF (catches within specified ranges) for banana prawns were not met as the landings were below the target range and the projected range. Tiger and endeavour prawns were below the target range. This likely to be due to low levels of effort expended on these species as their behaviour is quite different to that of the aggregating behaviour of the banana prawns and generally are taken in the latter part of the season thus more effort could result in fishing for a longer time at low catch rates.

Non-Retained Species

Bycatch species impact: **Low**

Bycatch from the northern prawn fisheries is typical of tropical trawl fisheries (i.e. from 2:1 up to about 5:1 relative to the target species), but the effort levels and spatial coverage are too low to impact bycatch species' populations. The introduction of fish escapement devices (FEDs) within all the nets towed by each vessel has reduced this risk even further. The NBPMF and KPMF fishery operates predominantly by specifically targeting schools of banana prawns. This targeting of schools of banana prawns results in relatively low effort and minimal bycatch compared with other trawl fisheries. The impact on bycatch in the OPMF and the BPMF was negligible due to very low effort. All trawl nets have grids to exclude large fish and listed species.

Listed species interaction:

OPMF, BPMF: **Nil**

NBPMF, KPMF: **Negligible**

The northern prawn fisheries have previously caught the occasional turtle and sea snakes and the overall low effort level and targeted coverage suggest that such interactions would not have been significant. Bycatch reduction devices ('grids') and FEDs are now fully implemented minimising the capture of large animals including turtles.

NBMF: In 2013 no turtles were recorded as captured. Two sea snakes were reported as caught and released alive, one seahorse/pipefish, 10 sawfish (status unknown) were reported as landed.

KPMF: 124 sea snakes were reported as captured and all but two were returned to the sea alive. Two sawfish were reported as captured, and returned to the sea alive.

Ecosystem Effects

Food chain effects: **Low**

For all the northern prawn fisheries and in particular the OPMF with no fishing and BPMF the limited spatial coverage of the fisheries and low levels of effort and catch, it is unlikely to have any significant ecological consequences. In addition for the NBPMF and the KPMF, the highly variable nature of banana prawn recruitment, positively related to cyclonic rainfall, any food chain impacts from fishing are likely to be minimal.

Habitat effects:

OPMF, BPMF: **Negligible**

NBPMF, KPMF: **Low**

In 2013 the area fished in the three northern fisheries where fishing took place ranged from 1.4% in the Kimberley fishery

to <1% in the Nickol Bay, Broome and Onslow fisheries, within the overall area of these fisheries (Northern Prawn Figures 1-4). The fisheries are generally restricted to clean sand and mud bottoms, where trawling has minimal long-term physical impact. Because there was limited fishing activity in the OPMF the habitat effects was changed from low to negligible.

Social Effects

Estimated employment in these fisheries for 2013 was 40 to 60 including skippers and other crew with additional people involved in local processing.

Economic Effects

Estimated annual value (to fishers) for 2013:

OPMF/NBPF/BPMF/KPMF:

Level 2 - $1 - 5 million ($2.5 million)

Fishery Governance

OPMF Target catch range: 60 – 180 tonnes

Current fishing level: Negligible

Under normal effort levels and previous environmental conditions, the target ranges of prawn catches, based on the catches of the 1990s, are as follows:

King prawns	10 – 55 t
Tiger prawns	10 – 120 t
Endeavour prawns	5 – 20 t
Banana prawns	2 – 90 t

NBPMF Target catch range: 90 – 300 tonnes

Current fishing level: Acceptable

Banana prawns	40 – 220 t
King prawns	20 – 70 t
Tiger prawns	2 – 40 t

BPMF Target catch range: 55 – 260 tonnes

Current fishing level: Acceptable

Under current effort levels and previous environmental conditions, the target ranges of prawn catches are as follows:

King prawns	35 – 170 t
Coral prawns	20 – 90 t

For king prawns the target range is based on the catches of the 1990s, while for coral prawns it is based on the seven-year range (1996 – 2002) since catches were first recorded.

KPMF Target catch range: 240 – 500 tonnes

Current fishing level: Acceptable

Under current effort levels and previous environmental conditions, the target ranges of prawn catches, based on the catches of the 1990s, are as follows:

Banana prawns	200 – 450 t
Tiger prawns	15 – 60 t
Endeavour prawns	7 – 80 t

The overall target range for all species combined is different from the aggregate of the individual species ranges shown above. This is because the environmental circumstances that benefit banana prawns generally result in decreased catches of the other species. Effort is now a considered a factor when reviewing target catch ranges in these northern fisheries.

New management initiatives (2014): None

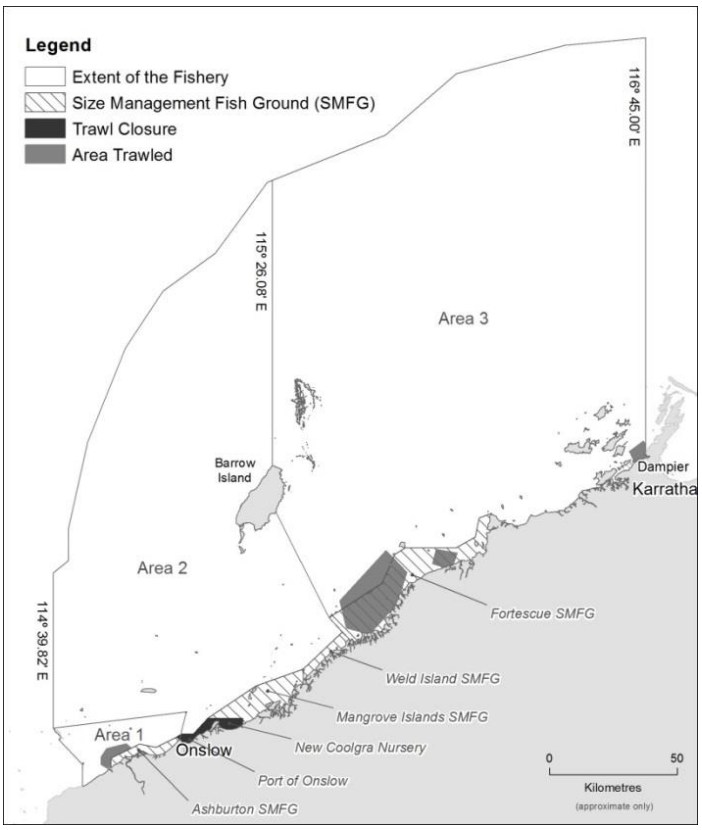
External Factors

The resource industry developments in the OPMF during 2013 have created uncertainty about the access to prawn abundance in traditionally high catching fish grounds and overall viability of operations.

Banana prawns are rainfall dependent and can be highly variable annually in the KPMF, NBPMF and for the OPMF where banana prawns may be in some years be taken predominantly off the mouth of the Ashburton River. Due to high costs of fishing and low prawn prices, some boats in these fisheries are choosing not to fish in years of relatively low banana prawn catches. There is also competition for boat crew with the oil and gas resource sector.

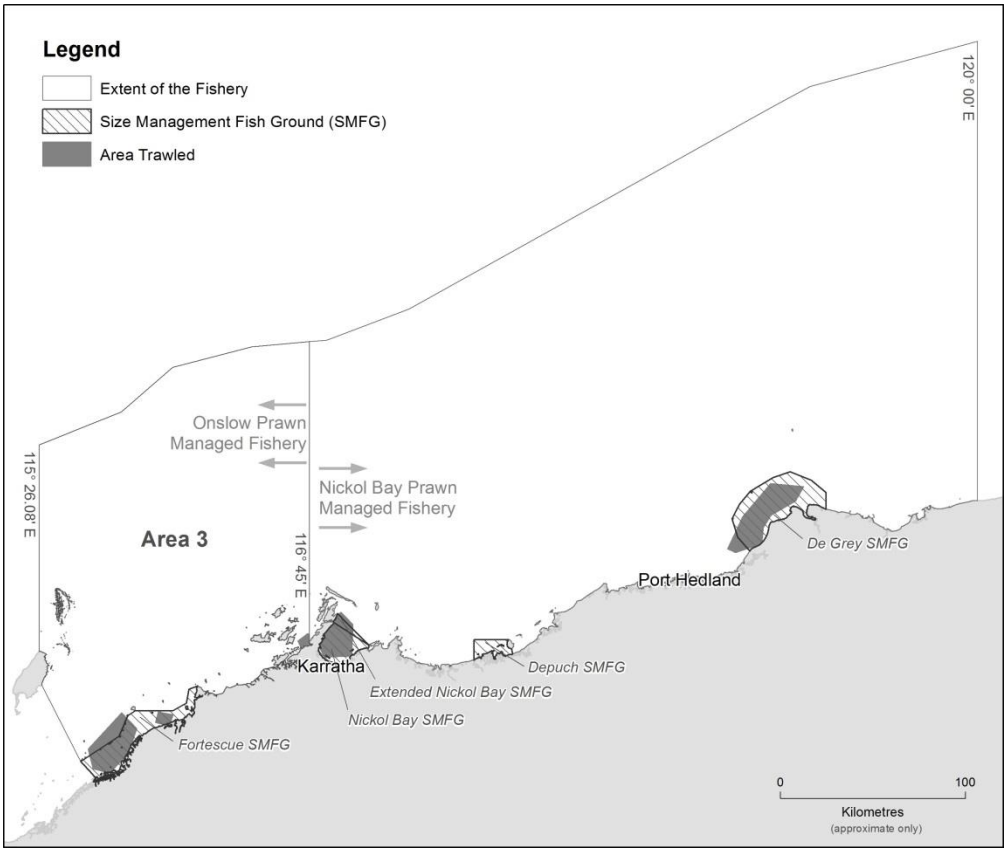
In the BPMF one factor influencing catches is the timing of the season which is set by the mid-season closure for the Northern Prawn Fishery, and, since the permitted fishing area is small, in some years the timing of prawn recruitment and the prawn migration patterns may not result in significant abundances in the permitted fishing area. The success of this fishery also depends on how the limited fishing season coincides with the king prawn recruitment and catchability, which is strongly influenced by the lunar period.

The marine heatwave event in 2010/11 and continued higher than average water temperatures in northern WA waters may be having a negative effect of abundance of king prawns which could also be contributing to the very low landings of this species in all of these northern fisheries.



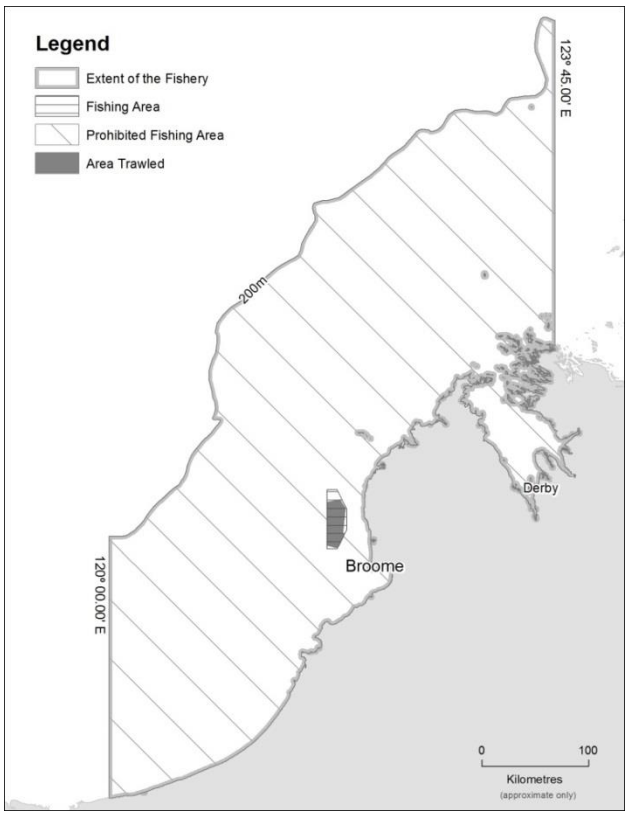
NORTHERN PRAWN FIGURE 1

Boundaries of the Onslow Prawn Managed Fishery indicating trawl closures and size management fish grounds area trawled in 2013.



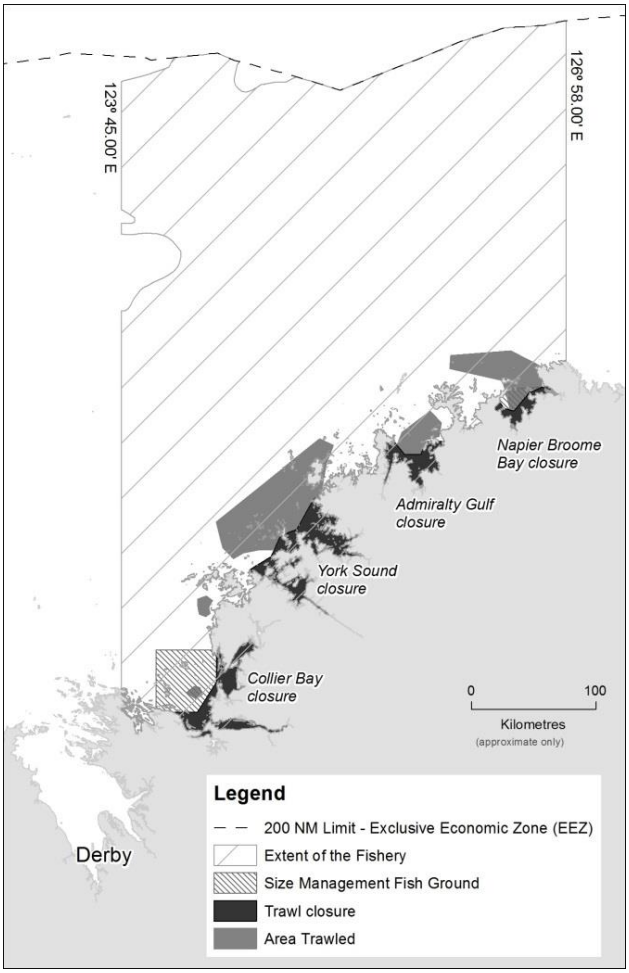
NORTHERN PRAWN FIGURE 2

Boundaries of the Nickol Bay Prawn Managed Fishery indicating nursery areas and size management fish grounds and areas trawled in 2013.



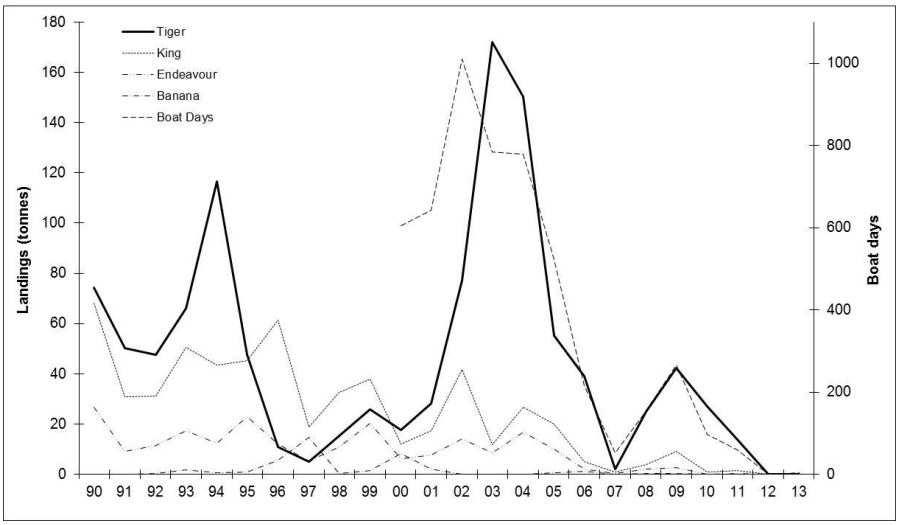
NORTHERN PRAWN FIGURE 3

Boundaries of the Broome Prawn Managed Fishery indicating area trawled in 2013.



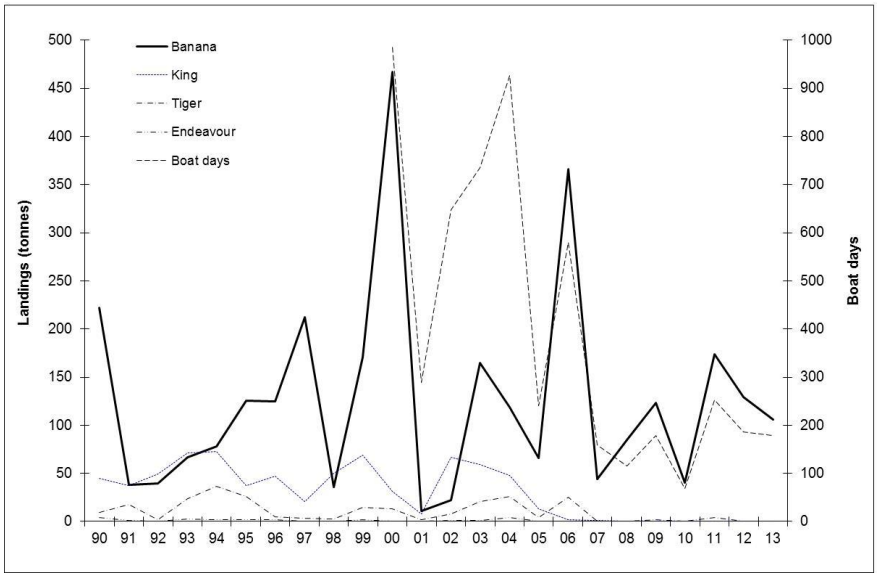
NORTHERN PRAWN FIGURE 4

Areas fished in the Kimberley Prawn Managed Fishery in 2013, Size Management Fish Grounds and the inshore trawl closures.



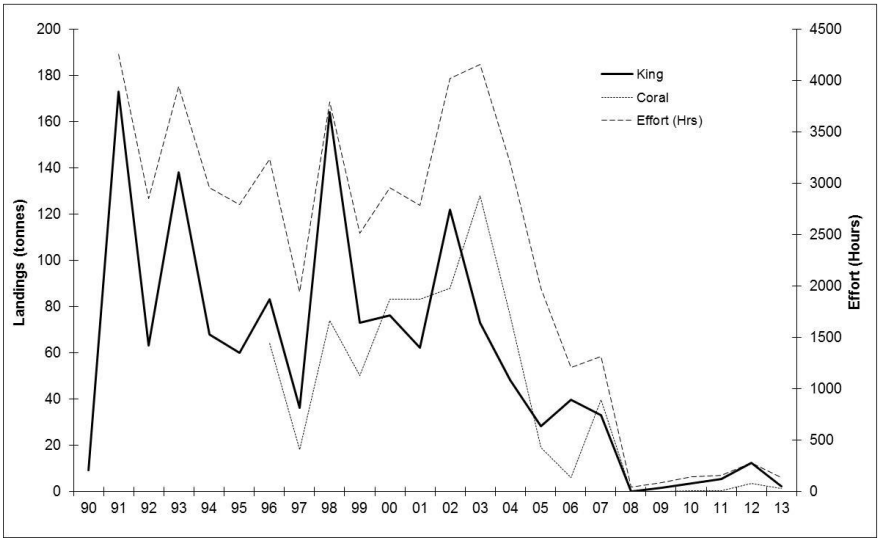
NORTHERN PRAWN FIGURE 5

Annual landings and number of boat days (from 2000) for the Onslow Prawn Managed Fishery, 1990 – 2013.



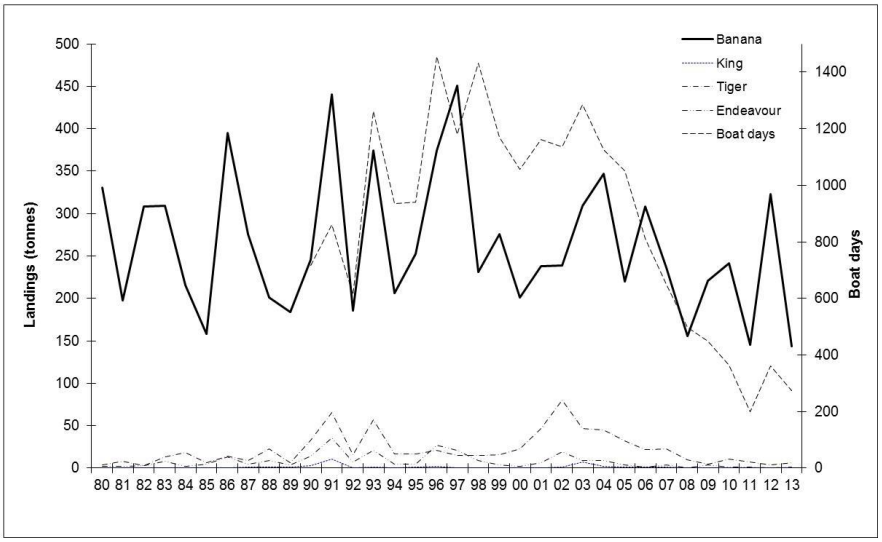
NORTHERN PRAWN FIGURE 6

Annual landings and boat days (from 2000) for the Nickol Bay Prawn Managed Fishery, 1978 – 2013.



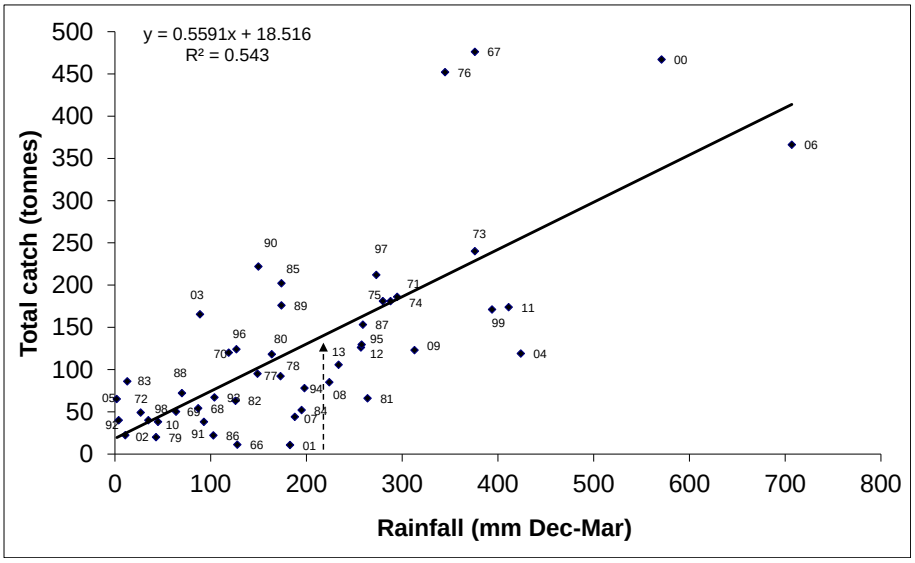
NORTHERN PRAWN FIGURE 7

Annual landings and fishing effort for the Broome Prawn Managed Fishery, 1991 – 2013.



NORTHERN PRAWN FIGURE 8

Annual landings and number of boat days (from 1990) for the Kimberley Prawn Managed Fishery, 1980 – 2013.



NORTHERN PRAWN FIGURE 9

Relationship between banana prawn landings in Nickol Bay and rainfall between December and March for 1966 – 2013 with rainfall level for 2014 indicated by the arrow.

North Coast Nearshore and Estuarine Fishery Status Report

S.J. Newman, G. Mitsopoulos, C. Skepper, A. Thomson, R. Marriott and D. Wallis

Main Features

Status		Current Landings	
Stock levels	Acceptable	Total	124.6 t
Fishing Levels	Acceptable	Barramundi	52.1 t
		Threadfin	57.3t
		Recreational	20% of total (last estimate 2012)
		Charter	< 7 t (barramundi and threadfin)

Fishery Description

Commercial

The Kimberley Gillnet and Barramundi Managed Fishery (KGBF) operates in the nearshore and estuarine zones of the North Coast Bioregion from the WA/NT border (129ºE) to the top end of Eighty Mile Beach, south of Broome (19ºS). It encompasses the taking of any fish by means of gillnet in inshore waters and the taking of barramundi *(Lates calcarifer)* by any means.

The other species taken by the fishery are predominantly king threadfin *(Polydactylus macrochir)* and blue threadfin *(Eleutheronema tetradactylum)*. The main areas of operation for the fishery are the river systems and tidal creek systems of the Cambridge Gulf, the Ria coast of the northern Kimberley, King Sound, Roebuck Bay and the northern end of Eighty Mile Beach to 19ºS (Kimberley Gillnet Figure 1).

Recreational

Recreational fishing activities are concentrated around key population centres, with a seasonal peak in activity during the dry season (winter months).

Governing legislation/fishing authority

Commercial

Kimberley Gillnet and Barramundi Managed Fishery Management Plan 1989

Kimberley Gillnet and Barramundi Managed Fishery Licence.

Recreational

Fish Resources Management Act 1994; Fish Resources Management Regulations 1995 and other subsidiary legislation.

Consultation processes

Commercial

The Department undertakes consultation directly with licensees on operational issues. Industry Annual General Meetings are now 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.

Recreational

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

Boundaries

Commercial

The waters of the KGBF are defined as ‘all Western Australian waters north of 19° south latitude and west of 129° east longitude and within three nautical miles of the high water mark of the mainland of Western Australia and the waters of King Sound south of 16°21.47′ south latitude’ (Kimberley Gillnet Figure 1).

Recreational

The North Coast Bioregion, which encompasses the Pilbara and Kimberley regions, extends from the Ashburton River south of Onslow to the WA/NT border (all land and water north of 21º46’S latitude and east of 114º50’E longitude).

Management arrangements

Commercial

The KGBF is managed primarily through input controls in the form of limited entry, seasonal and spatial area closures and gear restrictions. Access to the KGBF is limited to five licences, following the buyout of the two licences from the Broome coast (Roebuck Bay) in 2013.

There is a closed season in which fishing is prohibited in the KGBF. In the southern KGBF (west of Cunningham Point, 123º08.23′ E longitude) the closure extends from 1 December to 31 January the following year, while in the northern section of the KGBF (east of Cunningham Point) the closure extends from 1 November to 31 January the following year (see Kimberley Gillnet Figure 1). There are also limits on the length of net and mesh sizes to be used in the fishery.

There are now only three principal fishing areas within the KGBF: Cambridge Gulf (including Ord River), Kimberley coast (six small river systems) and King Sound. Following the buyout of the two licences from the Broome coast (Roebuck Bay), this area is now closed to commercial fishing.

There are commercial fishing area closures around major town sites and recreationally important fishing locations, namely Broome Jetty to Crab Creek, Roebuck Bay, Jacks Creek, Yardogarra Creek, Thangoo Creek, Cape Bossut to False Cape Bossut, Derby Jetty, the Fitzroy River and all its creeks and tributaries south of 17º27′ S, Whistle Creek and Admiral Bay, and the lower Ord River upstream of Adolphus Island.

Recreational

Fish species in the North Coast Bioregion are assigned bag and size limits according to their ecological suite and risk to sustainability. The bag and size limits are species-specific (e.g. Barramundi) or species group specific (e.g. mullet) to ensure that stock levels are maintained. These bag and size limits have been revised and new simpler rules that apply across most Bioregions were introduced in 2013. These new rules include the following: barramundi (individual daily bag limit and possession limit of 2 fish, minimum legal length (MLL) of 550 mm and a maximum size limit of 800 mm); black jewfish (individual daily bag limit of 2 fish, MLL 700 mm); king threadfin (individual daily bag limit of 2 fish, MLL 450 mm); other threadfin species (individual daily bag limit of 4 fish) and tripletail (individual daily bag limit of 2 fish, MLL 300 mm).

Recreational set and haul netting is prohibited in all waters of the North Coast Bioregion with the exception of haul netting in the waters of the Dampier Archipelago (between Cape Preston and Cape Lambert) with the following restrictions: haul nets must not exceed 30 metres in length; mullet are the only species to be retained and all other species must be returned to the water.

Research summary

Monthly catch and effort data from the commercial fishery are used to assess the status of barramundi and threadfin populations targeted by this fishery. This status report is compiled annually and provided to industry and fisheries' management officers.

The biological characteristics required for fisheries management for both threadfin species have been completed (Pember *et al*. 2005)[1]. These data may be used to provide a stock assessment of threadfin in the KGBF and Pilbara in the future. The stock structure of both threadfin species was defined by Welch *et al*. (2010)[2] and will be considered in future monitoring and assessment programs. The bycatch of elasmobranchs in the KGBF and the previous Pilbara Coast fishing area was examined during 2002 and 2003 (McAuley *et al*. 2005)[3]. Estimates of recreational boat and shore based catches were assessed in 1999/2000 (Williamson *et al*. 2006)[4] and an integrated survey of boat-based recreational fishing in WA was conducted during 2011/12 (Ryan *et al*. 2013)[5].

Retained Species

Commercial landings (season 2013):

All species	**124.6 tonnes**
Barramundi	**52.1 tonnes**
Threadfin	**57.3 tonnes**

The principal species landed are barramundi and two species of threadfin (king threadfin and blue threadfin). Small quantities of elasmobranchs (sharks and rays), black jewfish *(Protonibea diacanthus)* and tripletail *(Lobotes surinamensis)* are also landed. The composition of the elasmobranch catch varies considerably between fishing areas but it mainly consists of whaler shark species (Family Carcharhinidae), including pigeye sharks *(Carcharhinus amboinensis)*, blacktip whalers (mainly *C. tilstoni*) and various species of rays. Sawfish (Family Pristidae) are totally protected under the *Fish Resources Management Regulations 1995* and may not be retained by this fishery, and are released alive wherever possible.

The total reported catch of all species in the KGBF in 2013 was 124.6 t (Kimberley Gillnet Figure 2). The total landings of barramundi from the KGBF were 52.1 t for 2013 (Kimberley Gillnet Table 1, Kimberley Gillnet Figure 3), an increase on the reported catch of 39.7 t in 2012. The 2013 landings of threadfin from the KGBF were 57.3 t (Kimberley Gillnet Table 1, Kimberley Gillnet Figure 4), higher than that reported in 2012 (46.2 t). The composition of the KGBF catch in 2013 is summarised in Kimberley Gillnet Table 2.

Recreational catch estimate (last estimate 2011/12): 20% of total catch

The recreational catches from boat-based fishers in 2011/12 were estimated to be approximately 8.4 t of barramundi and approximately 7.0 t of threadfin.

The estimate that the recreational catch in 2011/12 was 20% of the total catch. This estimate is not directly comparable to the 1999/2000 survey results (Williamson *et al*. 2006).

Estimates of the recreational catch by boat-based fishers for barramundi will be underestimated as shore-based fishers and boat-based fishers that fished only in freshwater were out of scope of the 2011/12 survey.

The reported charter vessel catches for the North Coast Bioregion in 2013 were estimated to be approximately 4.1 t of barramundi and approximately 2.2 t of threadfin.

As such, there is an estimated annual harvest of 12.5 t of barramundi (recreational + charter) reported in the North Coast Bioregion. In addition, there is an estimated annual harvest of 9.2 t of all threadfin (recreational + charter) reported in the North Coast Bioregion.

Even though these data underestimate the recreational catch, the recreational catch (i.e. recreational + charter) is estimated at around 20% of the total (commercial and recreational) barramundi and threadfin catch in these areas in 2012. Separately, the recreational catch of barramundi can be estimated at around 25% of the total (commercial and recreational) catch in these areas in 2012. The recreational catch of threadfin can be estimated at around 15% of the total (commercial and recreational) catch in these areas in 2012.

Fishing effort/access level

Commercial

The effort reported in the fishery this year is block days. The effort used in the fishery is currently being reviewed. Fishing practices vary across the industry and are not uniform. For example, some fishers actively fish their nets for a few hours while others leave their nets in the water for up to 24 hours. Furthermore, reporting practices are inconsistent across time. It is anticipated that effective effort in the fishery, once validated, will reflect the total length of net set and the time that net is set in the water. During 2013, the total effort across the fishery was 630 block days, an increase on the 2012 effort figure of 511 block days and considerably below the effort reported from 2008 to 2010 (a range of 800-935 block days). This decrease in effort is linked to one vessel not operating in 2012, thus reducing the overall effort in the fishery and in particular the effort expended in Roebuck Bay. There is considerable latent effort in the KGBF.

1 Pember, M.B., Newman, S.J., Hesp, S.A., Young, G.C., Skepper, C.L., Hall, N.G. and Potter, I.C. (2005). Biological parameters for managing the fisheries for Blue and King Threadfins, Estuary Rockcod, Malabar Grouper and Mangrove Jack in north-western Australia. Final Report to the Fisheries Research and Development Corporation (FRDC) on Project No. 2002/003. Centre for Fish and Fisheries Research, Murdoch University, Murdoch, Western Australia, Australia. 172 pp.

2 Welch, D.J., Ballagh, A.C., Newman, S.J., Lester, R.J.G., Moore, B.R., van Herwerden, L., Horne, J.B., Allsop, Q., Saunders, T., Stapley J.M. and Gribble, N.A. (2010). Defining the stock structure of northern Australia's threadfin salmon species. Final Report to the Fisheries Research and Development Corporation, Project 2007/032. *Fishing and Fisheries Research Centre Technical Report No. 10*, Fishing & Fisheries Research Centre, James Cook University, Townsville, Australia. 180 pp.

3 McAuley, R., Lenanton, R., Chidlow, J., Allison, R. and Heist, E. (2005). Biology and stock assessment of the thickskin (sandbar) shark, *Carcharhinus plumbeus*, in Western Australia and further refinement of the dusky shark, *Carcharhinus obscurus*, stock assessment, Final FRDC Report – Project 2000/134, Fisheries Research Report No. 151, Department of Fisheries, Western Australia. 132 pp.

4 Williamson, P.C., Sumner, N.R. and Malseed, B.E. (2006). A 12-month survey of recreational fishing in the Pilbara region of Western Australia during 1999-2000, Fisheries Research Report No. 153, Department of Fisheries, Western Australia, 61 pp.

5 Ryan K.L., Wise, B.S., Hall, N.G., Pollock, K.H., Sulin, E.H. and Gaughan, D.J. (2013). An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Fisheries Research Report No. 249, Department of Fisheries, Western Australia 162 pp.

Recreational

A summary of the key findings of the integrated survey of boat-based recreational fishing in regards to Barramundi, Blue and King threadfin by Ryan *et al*. (2013) are provided below.

- Recreational catches of Barramundi by RFBL holders occurred in the North Coast Bioregion. The majority of the boat-based recreational catch of barramundi was released or discarded (72%). The majority of the catch was taken in estuary habitats (64%), but also in freshwater (21%) and nearshore areas (16%). Barramundi were harvested throughout the year, with higher catches observed in winter (38%), spring (29%) and autumn (20%). All the barramundi catch was taken by line-fishing.
- All recreational catches of Blue and King threadfin by RFBL holders aged five years or older occurred in the North Coast Bioregion. Similar proportions of the boat-based recreational catch of Blue threadfin were retained (54%) and released (46%). Catches were taken predominantly from nearshore habitat (86%), but also estuarine habitats (14%). Blue threadfin were harvested throughout the year, with higher catches observed in winter (71%) compared with spring (6%), summer (3%) and autumn (20%). All catches were taken by line fishing.
- The majority of the boat-based recreational catch of King threadfin was retained (66%). Catches were taken from estuary (51%) and nearshore (49%) habitats. King threadfin were harvested throughout the year, with higher catches observed in autumn (45%) and spring (42%) compared with winter (4%) and summer (9%). All catches were taken by line fishing.

Stock Assessment

Assessment complete:

Barramundi **Yes**

Threadfin **Yes**

Assessment level and method:

Level 2 - Catch Rate

Breeding stock levels:

Barramundi **Adequate**

Threadfin **Adequate**

The level of catch of barramundi increased in 2013 due to an increase in effort levels along the Kimberley Coast and Broome Coast areas. The level of catch of threadfin was higher than that reported in 2012, with the catch increasing in the Kimberley coast area in 2013.

The commercial catch rates for barramundi in the KGBF increased in 2013 (82.7 kg/block day) to the highest level reported since 1990 (Kimberley Gillnet Figure 3). The catch rate for threadfin in 2013 (90.88 kg/block day) across the fishery was much lower than that reported in 2012 (178.1 kg/block day; Kimberley Gillnet Figure 4) and 2011 (184.7 kg/block day).

There is a need to update the stock assessment for barramundi and also a need to re-evaluate the effort measure used in the fishery (planned for 2015/16). There is the potential for localised depletion risks to threadfin populations given their fine scale spatial stock structure.

Non-Retained Species

Bycatch species impact: **Low**

The fishery operates at a relatively low intensity over a wide area of the Kimberley region, specifically targeting barramundi and threadfin. The fishing gear uses large mesh sizes, and hence does not generate a significant bycatch of species important to other sectors, but does take some sharks and rays. Where practicable, sharks and rays are released alive. However, there is some mortality of sharks and rays associated with gillnet capture. Because of the low spatial density of fishing effort relative to the widespread distribution of these species and the size-selectivity of the permitted mesh sizes, these impacts are unlikely to be significant to the stocks involved.

Listed species interaction: **Low**

The fishing gear used for this fishery (gillnets) is known to result in the bycatch of protected crocodiles *(Crocodylus porosus)* and sawfish (Family Pristidae). These species are generally released alive or avoided as far as is practicable. Because of the low effort levels and the low spatial intensity of fishing effort, these impacts are unlikely to pose a significant threat to the sustainability of the stocks of these species. In 2012, listed species interactions were reported for both crocodiles and sawfish.

Catches of the speartooth shark *(Glyphis glyphis)* or the northern river shark *(Glyphis garricki)*, which are listed under the *Environment Protection and Biodiversity Conservation Act 1999* as critically endangered and endangered, respectively, are rare in the KGBF. However, as these species look similar to other whaler shark species, they may be captured but misidentified. Given the fishery's overall low effort levels, particularly inside the freshwater drainages in which these species are most likely to occur, the fishing operations of the KGBF are unlikely to pose a significant threat to the sustainability of the stocks of these species. Any increase in effort levels inside freshwater drainages will need to be monitored.

Ecosystem Effects

Food chain effects: **Low**

This fishery poses a minimal risk on the nearshore and estuarine ecosystem of the Kimberley region.

Habitat effects: **Low**

The fishing gear has minimal impact on the habitat. The area and habitat fished is subject to extreme tidal currents and associated effects and is typically mud flat areas.

Social Effects

Commercial

During 2013, six vessels fished in the KGBF with an average crew level of approximately 2.7 people, with an estimate of at least 16 people directly employed in the fishery. There was additional employment through local processors and distribution networks. The fishery provides fresh fish for the local communities and the tourism industry throughout the Kimberley region.

Recreational

A significant number of recreational and charter anglers also fished across the region.

Economic Effects

Estimated annual value (to fishers) for 2013:

Level 2 - $1-5 Million

The value of the North Coast Nearshore and Estuarine Fishery was reported using the 6 categories defined in Fletcher *et al.* (2010[1]) that are used to assess the relative economic (based on gross value product, GVP) and social amenity value associated with each ecological asset. These values are based on GVP figures derived from the 2012-2013 financial year.

The KGBF historically principally targeted the high-value species, barramundi and threadfin. With the closure of Roebuck Bay, the future catches from the KGBF will primarily consist of barramundi as the majority of the threadfin catches were derived from Roebuck Bay. The fishery's score value in 2013 was estimated to be 2 (i.e. Risk level – Low; Economic value – $1-5 million). However, the social amenity definition for the KGBF is Important (this fishery is an important asset locally and/or the use or existence of the asset is important to the broader community).

Fishery Governance

Target commercial catch range:

Barramundi **33-44 tonnes**

Current Fishing (or Effort) Level: **Acceptable**

The target commercial catch range is calculated based on catch information from 1989 – 1999, a period during which the fishery was stable and levels of exploitation were considered to have been sustainable. Note that the target catch range for barramundi has recently been revised to be consistent with the reference points and control rules adopted for other fisheries. The current approach specifies this range as the values within the minimum and maximum catches observed during the reference period. The revised target commercial catch range (33 – 44 t) is similar to that previously used (32 – 45 t). As such, the threshold values for the target commercial catch range have been calculated as being within the range of 33 – 44 t, with a limit reference range of 23-54 t.

For most years, the level of barramundi catch was within the target catch range. The barramundi catch in 2001, 2003 and from 2008-2010 was above the target range, as a result of increased effort levels in different areas of the fishery. In only 2 years (2007 and 2011) was the barramundi catch below the target catch range. This reduced catch was associated with reduced effort levels in the fishery. The barramundi catch in 2013 was 52.1 t, above the target catch range but below the limit range. The increase in catch was due to a marked decrease in fishing effort in the Kimberley Coast and Broome sectors of the fishery. This increased catch was obtained with high catch rates and may suggest increasing stock biomass for barramundi. Furthermore, in 2013, 2 licenses were removed from the Broome sector of the fishery (Roebuck Bay closure). This sector of the fishery is now recreational and indigenous only fishing. This effort removal is likely to produce reduced levels of catch in future years. The current fishing level is therefore considered to be acceptable.

A review of the fishery is planned for 2015/16 and will include reviews and updates of the status of the barramundi stock, the current fishing and effort levels and the target catch range for barramundi.

New management initiatives (2014/15)

The KGBF management plan was amended in June 2012 to modernise the fishery management arrangements. The next management review of the fishery is due after the 2015 /16 financial year.

External Factors

The barramundi stocks utilising the Kimberley river systems as nursery areas are expected to be reasonably resilient to fishing pressure. However, the impact of increasing exploitation from the charter and tourism sectors, as well as population growth associated with the gas and mining development sectors on barramundi stocks needs to be monitored.

Furthermore, the smaller, isolated stocks along the arid Pilbara coastline are likely to experience highly variable recruitment due to environmental fluctuations (e.g. the amount of rainfall). These stocks will be subject to increased exploitation pressure from recreational fishers (driven by regional population growth resulting from gas and mining developments), and specific management arrangements may be needed in the future.

In addition, the introduction of new marine parks (State and Federal) across the Kimberley region has the potential to concentrate fishing effort from multiple sectors into those areas that are easily accessible, further increasing risks of local depletion of barramundi and threadfin stocks.

The KGBF underwent MSC pre-assessment in late 2013. Outcomes are expected in late 2014.

1 W.J. Fletcher, J. Shaw, S.J. Metcalf & D.J. Gaughan (2010) An Ecosystem Based Fisheries Management framework: the efficient, regional-level planning tool for management agencies. Marine Policy 34 (2010) 1226–1238

KIMBERLEY GILLNET TABLE 1

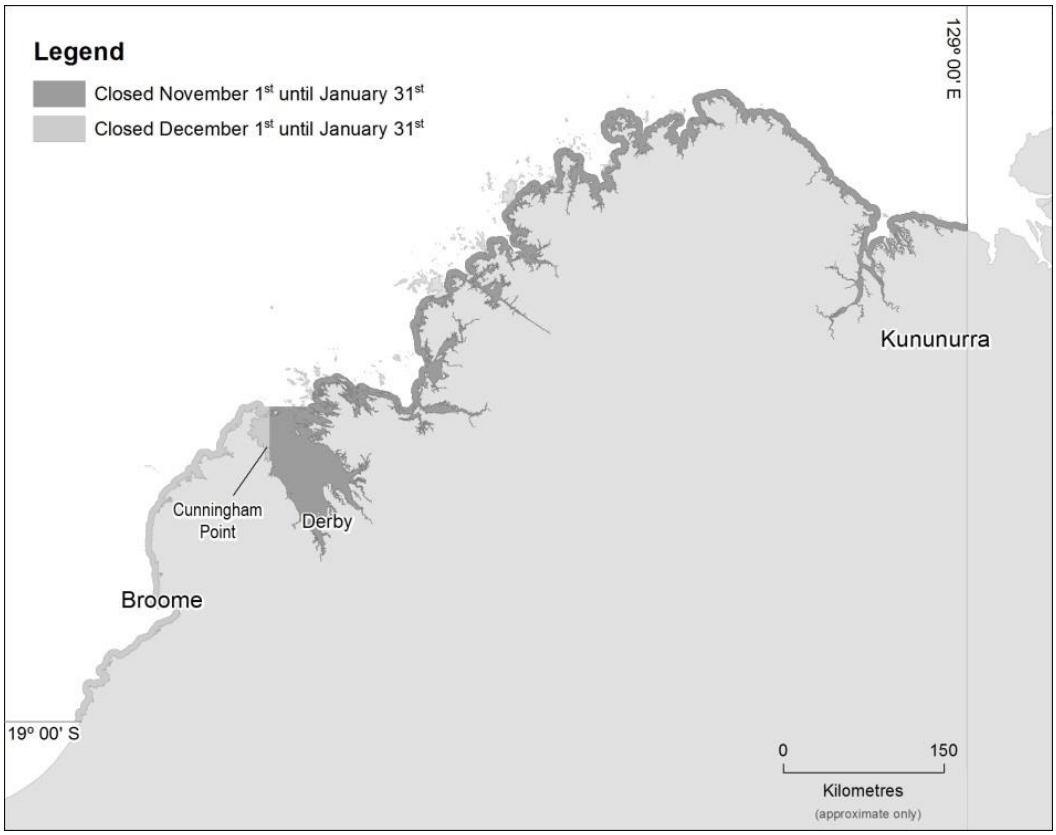
Annual catches of the major target species by the KGBF from 2003-2013.

Species	Kimberley Gillnet Annual Catch (tonnes)										
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Barramundi	45.0	53.5	35.6	36.3	27.2	54.8	59.6	57.1	28.5	39.7	52.1
Threadfin	94.1	75.8	70.6	67.7	78.5	101.2	89.9	83.3	74.2	46.2	57.3
Total	148.0	136.1	117.8	109.9	111.4	165.6	167.3	150.9	110.5	91.0	124.6

KIMBERLEY GILLNET TABLE 2

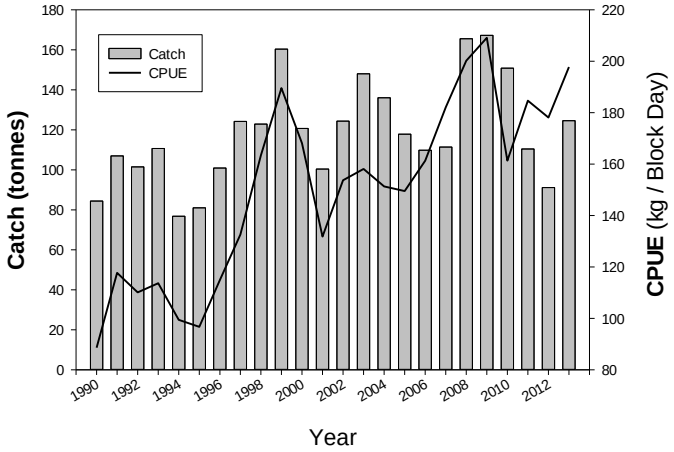
Summary of the reported catch (t) in the KGBF in 2013 and the percentage composition of each of the major species retained.

Species	Catch (tonnes)	Composition %
Threadfin	57.2	46.0
Barramundi	52.1	41.8
Tripletail	0.8	0.6
Black jewfish	2.1	1.7
Sharks	10.6	8.5
Other fish	1.8	1.4
Total	124.6	100



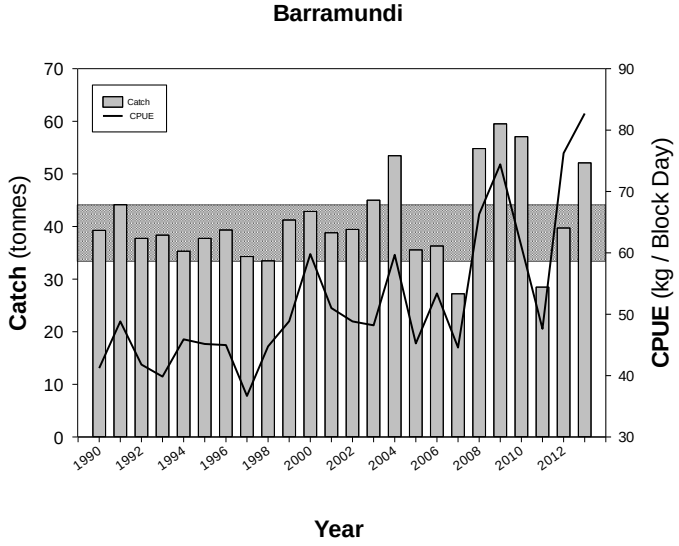
KIMBERLEY GILLNET FIGURE 1

Location and extent of the KGBF within the Kimberley region of Western Australia. Note: this map is indicative only.



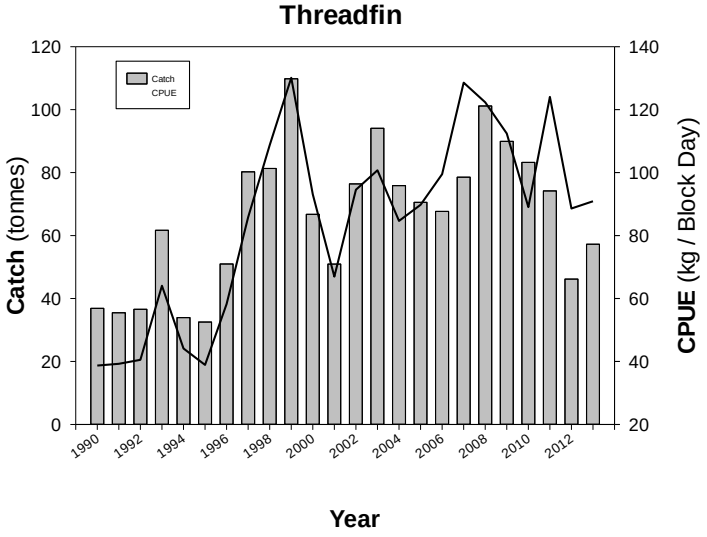
KIMBERLEY GILLNET FIGURE 2

The annual total catch and catch per unit effort (CPUE, kg block day^{-1}), from all areas of the KGBF Including sharks and rays over the period 1990 to 2013.



KIMBERLEY GILLNET FIGURE 3

The annual catch and catch per unit effort (CPUE, kg block day^{-1}) for barramundi from the KGBF over the period 1990 to 2013. The upper and lower bounds of the target commercial catch range for barramundi are shown by the shaded catch area between 33 and 44 tonnes.



KIMBERLEY GILLNET FIGURE 4

The annual catch and catch per unit effort (CPUE, kg block day^{-1}) for threadfin from the KGBF over the period 1990 to 2013.

North Coast Demersal Fisheries Status Report

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Main Features

Status		Current Landings	
Pilbara:		Total North Coast Demersal landings	2,727 t
Stock level	Adequate	Recreational (top 10 demersal)	77 t (~3% of total)
Fishing Level		Pilbara:	
Trawl Fishery	Acceptable	Total	1,499 t
Trap Fishery	Acceptable	Red emperor	104 t
Line Fishery	Acceptable	Rankin cod	56 t
Kimberley:		Bluespotted emperor	139 t
Stock level	Adequate	Pilbara Fish Trawl Fishery	1,074 t
Fishing Level	Acceptable	Pilbara Fish Trap	339 t
		Pilbara Line	85 t
		Charter	~26.7 t (1.8.% of total)
		Kimberley (NDSF):	
		Total	1,228 t
		Red emperor	131 t
		Goldband snapper	493 t
		Charter	~11.2 t (0.9% of total)

Fishery Description

There are a number of commercial and recreational fisheries that operate in the northern bioregion which target, to varying degrees, the following tropical, demersal fish species (in order of gross tonnage); goldband snapper (*Pristipomoides multidens*), crimson snapper (*Lutjanus erythropterus*), red emperor (*Lutjanus sebae*), bluespotted emperor (*Lethrinus punctulatus*), saddletail snapper (*Lutjanus malabaricus*), Rankin cod (*Epinephelus multinotatus*), brownstripe snapper (*Lutjanus vitta*), rosy threadfin bream (*Nemipterus furcosus*), spangled emperor (*Lethrinus nebulosus*) and moses snapper (*Lutjanus russelli*). Each of these fisheries is outlined below.

Commercial

Pilbara

The Pilbara Demersal Scalefish Fisheries include the Pilbara Fish Trawl (Interim) Managed Fishery, the Pilbara Trap Managed Fishery and the Pilbara Line Fishery, which collectively use a combination of vessels, effort allocations (time), gear limits, plus spatial zones (including extensive trawl closures) as management measures. The Trawl Fishery lands the largest component of the catch of demersal finfish in the Pilbara (and North Coast Bioregion) comprising more than 50 scalefish species. In comparison, the trap fishery retains a subset of about 45 to 50 scalefish species, and while the Line Fishery catch comprises a similar number it also includes some deeper offshore species, e.g. ruby snapper (*Etelis carbunculus*) and eightbar grouper (*Hyporthodus octofasciatus*).

Kimberley

The Northern Demersal Scalefish Managed Fishery (NDSF) operates off the northwest coast of Western Australia in the waters east of 120° E longitude. The permitted means of operation within the fishery include handline, dropline and fish traps, but since 2002 it has essentially been a trap based fishery which uses gear time access and spatial zones as the primary management measures. The main species landed by this fishery are red emperor and goldband snapper.

Recreational

Recreational fishing activities on these species are mostly line based fishing from boats which are concentrated in inshore areas around key population centres, with a peak in activity during the dry season (winter months, April/May to September/October).

Governing legislation/fishing authority

Commercial

Pilbara

Pilbara Trap Managed Fishery Management Plan 1992

Pilbara Trap Managed Fishery Licence

Pilbara Fish Trawl Fishery (Interim) Management Plan 1997

Pilbara Fish Trawl Interim Managed Fishery Permit

Prohibition on Commercial Fishing for Demersal Scalefish (Pilbara Area) Order 1997

Prohibition on Fishing by Line from Fishing Boats (Pilbara Waters) Order 2006

Commonwealth Government *Environment Protection and Biodiversity Conservation Act 1999* (Wildlife Trade Order – Pilbara Fish Trawl)

Kimberley

Northern Demersal Scalefish Managed Fishery Management Plan 2000

Northern Demersal Scalefish Managed Fishery Licence

Commonwealth Government *Environment Protection and Biodiversity Conservation Act 1999* (Export Exemption).

Recreational

Fish Resources Management Act 1994; Fish Resources Management Regulations 1995 and other subsidiary legislation.

Consultation processes

Commercial

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

Recreational

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

Boundaries

Commercial

Pilbara

The Pilbara Fish Trawl Interim Managed Fishery is situated in the Pilbara region in the north west of Australia. It occupies the waters north of latitude 21°35'S and between longitudes 114°9'36"E and 120°E. The Fishery is seaward of the 50 m isobath and landward of the 200 m isobath (North Coast Figure 1).

The Fishery consists of two zones; Zone 1 in the south west of the Fishery (which is closed to trawling) and Zone 2 in the North, which consists of six management areas. Areas 1 to 6 each cover 1,300; 1,800; 880; 1,500; 2,300 and 7,200 square nautical miles, respectively. The total area available for trawling in Zone 2 is 14,980 square nautical miles; however, only 6,900 square nautical miles are currently open (i.e. ~46% of Zone 2 is currently open to trawling). This represents less than 5% of the total shelf area available in the North Coast Bioregion. The exact latitudes and longitudes delineating the areas are listed in the *Pilbara Fish Trawl Fishery (Interim) Management Plan 1997*.

The Pilbara Trap Managed Fishery (North Coast Figure 1) lies north of latitude 21°44'S and between longitudes 114°9.6'E and 120°00'E on the landward side of a boundary approximating the 200 m isobath and seaward of a line generally following the 30 m isobath. The exact latitudes and longitudes delineating the fishery are listed in the *Pilbara Trap Management Plan 1992*.

The Pilbara Line fishing boat licensees are permitted to operate anywhere within "Pilbara waters". This means all waters bounded by a line commencing at the intersection of 21°56'S latitude and the high water mark on the western side of the North West Cape on the mainland of Western Australia; thence west along the parallel to the intersection of 21°56'S latitude and the boundary of the Australian Fishing Zone and north to longitude 120°E. The exact latitudes and longitudes delineating the Fishery are listed in the *Prohibition on Fishing by Line from Fishing Boats (Pilbara Waters) Order 2006*.

Kimberley

The waters of the Northern Demersal Scalefish Fishery are defined as all Western Australian waters off the north coast of Western Australia east of longitude 120°E. These waters extend out to the edge of the Australian Fishing Zone (200 nautical miles) (North Coast Figure 1). The fishery is further divided into two fishing areas; an inshore sector (Area 1) and an offshore sector (Area 2; see North Coast Figure 1). The *Northern Demersal Scalefish Managed Fishery Management Plan 2000* was amended in 2013 to formalise the previous voluntary industry agreement which further divides the offshore sector (Area 2) into 3 zones; A, B and C. Zone B comprises the area with most of the historical fishing activity. Zone A is an inshore developmental area and Zone C is an offshore deep slope developmental area representing waters deeper than 200 m. The inshore waters in the vicinity of Broome are closed to commercial fishing. This closure was put in place to reduce the potential for conflict between commercial fishers and recreational, charter and customary fishers (North Coast Figure 1).

Recreational

Recreational fishing in the North Coast Bioregion encompasses all waters in both the Pilbara and Kimberley regions, extending from the Ashburton River south of Onslow to the WA/NT border with the exception of some areas within Marine Parks.

Management arrangements

Commercial

Pilbara

The Pilbara Fish Trawl Interim Managed Fishery is managed through a combination of area closures, gear restrictions, and the use of input controls in the form of individual transferable effort allocations monitored by a satellite-based vessel monitoring system (VMS). This Interim Management Plan was implemented in 1998, with effort levels determined to achieve the best yield from the Fishery while keeping exploitation rates of the indicator species at sustainable levels. Currently, the Interim Management Plan has a cessation date of 30 June 2016.

A large amount of the area within the boundaries of the Trawl Fishery is closed to trawling. Much of this has been closed since the implementation of the Interim Management Plan (1998) including Zone 1 of the Fishery and Area 3 of Zone 2 of the Trawl Fishery. In addition, Area 6 of Zone 2 has been closed since the commencement of the Interim Management

Plan except for two periods of research trawling in 1998 and 1999. The area inshore of the 50 m depth isobath is also closed to trawling. Areas 1, 2, 4 and 5 are open to trawl fishing all year round, with separate effort allocations (in hours) in each of the Areas, as outlined in the Interim Management Plan. The open areas of the Trawl Fishery are trawled with varying intensity due to differing effort allocation, substrate composition and economic considerations (e.g. distance from ports).

There are 11 permits for the Fishery, with the combined effort allocations being consolidated over time onto 3 full time vessels.

The Trap Fishery is also managed primarily by the use of input controls in the form of individual transferable effort allocations monitored with a satellite-based VMS. There has also been a closure to trapping in Area 3 since 1998.

The authority to fish in the Trap Fishery is limited by reference to a specified number of trap days expressed in terms of units of entitlement. The capacity is currently limited to 5,456 trap days. However, the Management Plan allows the Director General to alter the value of these units. There are 6 licences in the Fishery, with the allocation consolidated onto 3 vessels.

The Line Fishery is managed under the *Prohibition on Fishing by Line from Fishing Boats (Pilbara Waters) Order 2006*. Nine Fishing Boat Licences are exempted from this prohibition for any nominated 5-month block period within the year. There has also been a closure to line fishing for demersal scalefish in Area 3 since 1998.

Comprehensive Ecological Sustainable Development (ESD) assessments were submitted to the Commonwealth Government's Department of the Environment (DotE), in 2004 for both the Pilbara Trap and Trawl Fisheries to allow product to be exported. These ESD assessments determined that performance should be assessed annually for breeding stock levels, listed species interactions and habitat effects. As a result, the Pilbara Trap Fishery was declared an approved Wildlife Trade Operation in November 2004 for a period of three years. This was not renewed after December 2007 as the fishery was not exporting. The Pilbara Fish Trawl Interim Managed Fishery has been recently re-accredited as an approved Wildlife Trade Operation until May 2017.

Kimberley

The Northern Demersal Scalefish Fishery is managed primarily through input controls in the form of an annual fishing effort capacity, with supplementary gear controls and area closures. The annual fishing effort capacity limits the amount of effort available in the fishery to achieve the notional target total allowable catch. The annual effort capacity is set by the Director General based on the available research advice in consultation with licensees. This effort capacity is then allocated among license holders through units of entitlement on Managed Fishery Licences, for use in Zones A, B and C in Area 2 of the Fishery. In 2014, the annual effort capacity was 616 fishing days for Zone A, 985.6 fishing days in Zone B and 1,100 fishing days for Zone C.

The notional target TAC for Zone B is a recommended level of catch for the entire demersal species suite and is derived from the estimated sustainable catch of the key target species (determined through stock assessments) and their historical proportions in the catch.

The areas that encompass Zone A and Zone C are likely to have a lower sustainable catch compared with Zone B, and thus exploratory TACs are set for Zone A and Zone C. These will need to be revised as effort and catches in these zones increase.

Access to the offshore sector (Area 2) of the NDSF is limited to 11 licences under an individually transferable effort (ITE) system. This allows the effort quota to be operated by a lesser number of vessels. For example, during 2013, 8 vessels (trap fishing in zones A and B and one line trip in Zone C) collectively held and operated the effort individually assigned to the 11 licences. Each trap must have an internal volume equal to or less than 2.25 m^3. While there is no restriction on the number of traps that can be fished per vessel, each licensee is allocated an annual effort quota in 'standard fishing days' based on the use of 20 traps (or 5 lines) per day. The number of allowable fishing days declines, if the number of traps (or lines) being fished increases beyond this level. The number of days and traps fished, as recorded by the vessel monitoring system, is converted to standard fishing days. A comprehensive environmental risk assessment of this fishery has determined that performance should be reported against measures relating to breeding stocks of the two indicator species, red emperor and goldband snapper, and the cod/grouper complex (a suite of more than 10 species), as reflected by their catch levels.

Recreational

The recreational fishery for demersal fish in the North Coast Bioregion is managed in a similar manner to other Bioregions across the State through the use of input controls (e.g. size limits) and output controls (e.g. limits on the numbers of fish that can be taken by individuals and boats – these are assigned based on a number of risk categories).

Since 2 March 2010, all persons fishing from a powered boat anywhere in the state have been required to hold a Recreational Fishing from Boat Licence or fish in the company of a licence holder. The Recreational Fishing from Boat Licence provides a statewide database of recreational boat fishers that can be utilised for survey purposes.

Demersal fish, particularly the iconic species such as coral trout and red emperor, are considered prime recreational target species. As such, resource-sharing issues will be a consideration in future management arrangements across this Bioregion.

Research summary

Pilbara

Monitoring and assessment of the Pilbara Trawl, Trap and Line Fisheries includes the collection of spatial data on effort and catch of 11 major target species from statutory logbooks, VMS data, and weighed catches from unload data. Assessment of the status of the suite of retained demersal scalefish is based on the performance of indicator species (red emperor, Rankin cod, bluespotted emperor, brownstripe snapper, goldband snapper and ruby snapper) using various assessment methods constituting a weight-of-evidence approach. These methods include trend analysis of trawl catch rates using two measures of effort (time spent trawling

as reported in statutory logbooks and time spent in each management area derived from VMS pollings) for five indicator species and the total catch in each of the trawl-managed areas. In addition, ages are determined from otolith sections for selected indicator species in each trawl-managed area and the Trap Fishery, and for ruby snapper from the Line Fishery.

Estimates of fishing mortality are derived from age structures and compared to internationally recognised biological reference points (see Stock Assessment section). Approximately every 4-5 years the spawning biomass of two indicator species, red emperor and Rankin cod, are assessed using the age-composition and catch rate data synthesised into an integrated age-structured model.

In 2010, a fishery independent research survey was conducted which involved an ecological assessment of the demersal fish assemblages and habitat characteristics across trap, trawl and closed (Area 3) management areas. The results of that survey are currently being collated.

An intense six month independent observer program designed to monitor bycatch and interactions with endangered, threatened and protected species was completed in December 2012 in order to meet a specific set of conditions from DotE within the current WTO for the Fishery. The outcomes of the observer program are reported in Fisheries Research Report 244.

Kimberley

Assessment of the status of the demersal fish stocks in Zone B of the NDSF is determined annually using catch and catch rates of the major species or species groups, and every ca. 5 years using an age-based stock assessment model where applicable to assess the status of two indicator species, red emperor and goldband snapper, based on age-composition data collected in previous years. The next assessment (scheduled for 2014) will incorporate age composition data collected during 2012 from two surveys conducted on board industry vessels. Age composition data were collected from both fixed and random sites within the fished areas of Zone B of Area 2 of the NDSF. Ongoing monitoring of this fishery is being undertaken using both catch and effort logbook and VMS data.

The catch from the NDSF also includes components from Zone A of the fishery. The level of catch from Zone A will be monitored closely in the future as this area of the fishery has been receiving more effort in recent years.

The catch from the NDSF also includes at times some species from the waters of Zone C in depths greater than 200 m. The resources of this Zone are unlikely to be substantial, and given the lower productivity of these longer-lived, deeper-slope reef fish, the sustainable catch from this zone is likely to be significantly lower than for Zone B.

Retained Species

Commercial landings (season 2013):

Pilbara Fish Trawl	**1,074 tonnes**
Pilbara Fish Trap	**339 tonnes**
Pilbara Line	**85 tonnes**
Kimberley (NDSF)	**1,228 tonnes**

The commercial catches of key species and species groups from across the North Coast Bioregion and their relative contribution to catches within the Pilbara and Kimberley sectors in 2013 are summarised in North Coast Table 9. The relative contribution of the Kimberley sector has been increasing as the catch from the Pilbara sector has been stable.

Pilbara

The total catch of demersal scalefish taken by the trawl fishery has declined from an annual average catch of close to 2,500 t during the period 1995 – 2004 to an average of 1,166 t per annum since 2008 (North Coast Tables 1 and 2). These total annual catches have been below the target catch range (2,000 to 2,800 t) for seven consecutive years, with 1,074 t landed in 2013 (North Coast Table 2). These lower annual catches are considered to be a response to the effort reductions imposed on the trawl fishery since 2008.

The catches of the major target species landed by the trawl fishery were generally lower or similar in 2013 than the previous year due to less effort, i.e. crimson snapper 132 t (182 t in 2012), bluespotted emperor 98 t (151 t in 2012), rosy threadfin bream 76 t (102 t in 2012), brownstripe snapper 66 t (90 t in 2012), goldband snapper 80 t (75 t in 2012), red emperor 54 t (62 t in 2012), saddletail snapper 53 t (52 t in 2012), spangled emperor 11 t (15 t in 2012) and Rankin cod 11 t (16 t in 2012). The total retained byproduct was 9 t (17 t in 2012) and included bugs, cuttlefish, and squid (North Coast Table 2).

The total annual catch taken by the Pilbara trap fishery has remained relatively consistent since 2004 averaging 438 t per year (North Coast Tables 1 and 2). In 2013, the total catch of 339 t was below the target catch range of 400-500 t, but was associated with reduced effort in the fishery (North Coast Table 2 and 3). The major species taken by the trap fishery in 2013 were goldband snapper 61 t (56 t in 2012), red emperor 49 t (60 t in 2012), Rankin cod 43 t (64 t in 2012), bluespotted emperor 41 t (59 t in 2012), and crimson snapper 32 t (39 t in 2012).

The total annual catch of scalefish taken by the line fishery is historically much lower than that taken annually by the trawl and trap fisheries (North Coast Tables 1 and 2). In 2013, the total annual catch for the line fishery was 85 t, which was slightly lower (~5 t) than that taken in 2012 but within the target catch range of 50-115 t (North Coast Table 2). In recent years (since ~2006), the line fishery catches have been dominated by ruby snapper and goldband snapper, typically accounting for more than 40% of the total annual catch. In 2013, the ruby snapper catch was 12 t (26 t in 2012) and the goldband snapper catch was 31 t (9 t in 2012) (North Coast Table 1). This fishery and the Commonwealth's North West Slope Trawl Fishery are likely to be targeting the same stock (management unit) of ruby snapper, so catches from both commercial fisheries need to be considered in any future assessment or development of a harvest strategy.

Kimberley

The NDSF catches over the past six years have all been in excess of 1,000 t, and represent the highest recorded catches since the inception of the fishery in 1998. The total catch of 1,228 t in 2013 is the highest catch recorded during this period, although the Zone B component (913 t) was slightly lower than the peak catch recorded from this sector of the fishery in 2012. The catch in Zone A of the fishery increased

significantly to 291 t in 2013, which exceeded the previous highest recorded catch from this sector of 201 t in 2010 (North Coast Tables 6 and 7).

The NDSF principally targets red emperor and goldband snapper, with a number of species of snappers (Lutjanidae), cods (Epinephelidae) and emperors (Lethrinidae) comprising the majority of the remainder of the catch (North Coast Table 6). The species composition of the landed catch in 2013 is similar to that reported in 2012, with goldband snapper dominating the landed catch. The landed catch of goldband snapper in 2013 (493 t) was similar to that reported in 2012 (487 t). Catch levels of goldband snapper have remained high since the peak catch of 523 t reported in 2010. The last five years represent the highest reported landings of this species, continuing an overall trend of increasing catches since 2005. The total catch of red emperor in 2013 was 131 t, which is similar to the red emperor catch levels reported over the past three years (2010-2012). The cods/groupers catch in 2013(195 t) was higher than that reported in 2012 (170 t), and represents the highest level of catch reported for this species complex. It continues a trend of increasing catches for the cods/groupers since 2002. Rankin cod dominates the composition of the cod/grouper catch complex. The catch of Rankin cod increased from 52 t in 2012 to 62 t in 2013 (North Coast Table 7). The catches reported above represent those derived from all zones of the NDSF. It is noteworthy that the increased catches of cods/groupers in Zone A have largely driven the overall higher catches of this complex since 2010. The catches from Zone A also consist of a large number of species which are not well represented in the Zone B catch; these include bluespot emperor (*Lethrinus punctulatus*) and crimson snapper (*Lutjanus erythropterus*). In 2010, this mix of Zone A species ('other fish') constituted 149 t (51%) of the overall catch from Zone A.

The catch rate of red emperor in Zone B in 2013 decreased slightly, remaining at a level consistent with those recorded during the period 2009-12. However, recent catch rates are lower than those reported for this species from 2005-08 (North Coast Figure 4). Total landings were also significantly higher during this period. The catch rates for goldband snapper in Zone B decreased slightly, but remained within the higher range reported since 2008. These high levels of catch rate (2008–2011) have followed the sharp increase in catch rates for goldband snapper from 2006 (North Coast Figure 5). The catch rate for the cod/grouper complex in Zone B in 2013 decreased slightly, noting that catch rates in 2012 were the highest recorded for this species complex. This continues a period of generally increasing catch rates for this species complex since 2005, with particularly high levels of catch rate since 2010 (North Coast Figure 6).

The 2013 catch of red emperor and goldband snapper were within acceptable levels as defined in the Export exemption for this fishery (see 'Fishery Governance' section), with neither species exceeding the threshold level (20% increase in average catch of the previous 4 years). However, the cod/grouper complex did exceed the threshold, with a 25.7% increase in the average catch over the last four years, derived primarily from Zone A.

Recreational catch estimate (season 2013):

Pilbara	**~3%**
Kimberley	**~3%**

North Coast Bioregion

A statewide integrated survey of boat-based recreational fishing in WA was conducted during 2011/12 (Ryan *et al*. 2013[1]). Estimates from this survey are not directly comparable to the survey conducted in 1999/2000 (Williamson *et al*. 2006[2]).

A total of 153 finfish species were taken in the North Coast Bioregion (both Pilbara and Kimberley; Ryan *et al*. 2013). The most common were: stripey snapper (14%), grass emperor (12%), spangled emperor (9%), barcheek coral trout (4%), and barramundi, blackspot tuskfish, blackspotted rockcod, blue tuskfish, golden trevally and Spanish mackerel (3% each). These 10 species accounted for 57% of the total catch (by numbers). There is little overlap with the main species landed by recreational fishers and those landed by the commercial fisheries covered in this report.

An estimated annual harvest of 76.9 t was reported for the top 10 demersal species in the North Coast Bioregion (Ryan *et al*. 2013). In terms of estimated harvest, the dominant demersal species were grass emperor (16.1 t), spangled emperor (14.8 t), barcheek coral trout (11.2 t) and red emperor (9.3 t). Even though the catch estimate of the top 10 demersal species is an underestimate of the total recreational catch, the total demersal recreational catch can be estimated to be at least ~3% of the combined (commercial and recreational) demersal scalefish catch in the North Coast Bioregion in 2013. In addition, the red emperor recreational catch can be estimated to be ~4% of the combined (commercial and recreational) red emperor catch in the North Coast Bioregion in 2013.

Pilbara

While there is a major recreational fishery in the Pilbara and the charter sector is an increasing user of the resource, the inshore closures to the commercial sector provide a high degree of spatial separation between the user groups. The recreational and charter sectors do not catch significant quantities of most species targeted by the commercial Pilbara demersal scalefish fisheries. The reported charter vessel catch of demersal scalefish in the offshore waters of the Pilbara (depth > 30 m) in 2011 was estimated to be ~1.2% (~20 t) of the commercial catch. However, due to the increasing population in the Pilbara from mining developments, catches are likely to increase in the future.

The reported charter vessel catch of demersal scalefish in the waters of the Pilbara demersal fisheries in 2013 was estimated to be 26.7 t (red emperor – 3.4 t; Rankin cod – 8.4 t; spangled emperor – 2.7 t; goldband snapper – 2.1 t; ruby snapper – 0.4 t). The Pilbara charter vessel catch is estimated to be ca. 1.8% of the Pilbara commercial catch of demersal fish.

Kimberley

Historically, there has been little recreational or charter boat fishing effort directed towards the demersal fishes in Area 2 of the NDSF, the species that are targeted by commercial fishers. However, this is now changing with charter vessels moving into the inshore demersal waters of the NDSF.

1 Ryan K.L., Wise, B.S., Hall, N.G., Pollock, K.H., Sulin, E.H. and Gaughan, D.J. 2013. An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Fisheries Research Report No. 249, Department of Fisheries, Western Australia 162 pp.

2 Williamson, P.C., Sumner, N.R. and Malseed, B.E. 2006. A 12-month survey of recreational fishing in the Pilbara region of Western Australia during 1999-2000, Fisheries Research Report No. 153, Department of Fisheries, Western Australia, 61p

The reported charter vessel catch of demersal scalefish in the waters of the Kimberley demersal fishery in 2013 was estimated to be 11.2 t (grass emperor – 2.1 t; golden snapper – 3.7 t; goldspotted/blackspotted rockcod – 0.9 t; saddletail snapper – 1.2 t). The Kimberley charter vessel catch is estimated to be ca. 0.9% of the Kimberley commercial catch of demersal fish.

Most of the recreational fishing effort targeting demersal finfish in the Kimberley region is concentrated in the Broome sector of Area 1, which is closed to commercial fishing on demersal species. The magnitude of recreational fishing catch in offshore areas is small relative to the total commercial catch. However, the increasing number of people associated with oil and gas developments in the Kimberley region has the capacity to significantly increase the level of recreational catch of these species taken from nearshore and inshore demersal waters of the NDSF.

Fishing effort/access level

Pilbara

Fishing effort utilisation by the trawl and trap sectors of the commercial fishery are monitored using VMS. Fishing effort for the trawl fishery is also recorded as the net bottom time (hours) in statutory logbooks. Information on fishing effort (days) for the trap and line fisheries are recorded in monthly catch and effort returns (North Coast Table 3).

The trawl fleet had the equivalent of three full-time vessels in the 2012/13 season. The percentage of allocated hours used by the trawl fleet during the 2012/13 season were 91% in Area 1, 100% in Area 2, 96% in Area 4 and 93% in Area 5. Trawling has not been permitted in either Area 3 or Area 6 since 1998 and both trap and line fishing has not been permitted in Area 3 since 1998 (North Coast Figure 1).

In 2013, trap fishers were allocated 5,456 trap days (capacity is set in trap days with a value per unit of 1 unit = 1 trap day), with 81% of the units used as calculated from the VMS.

In 2013, line fishers reported operating for 357 days, compared with 395 days in 2012.

Kimberley

The eight fish trap vessels that fished in the NDSF in 2013 reported using between 20 and 36 fish traps per day. A small amount of line fishing was reported in the deeper water area of Zone C. Effort across all zones of the fishery in 2013 was 1,199 days (North Coast Table 8).

The total effort allocated in Zone B in 2013 was 986 standard fishing days (i.e. using 20 traps per day) (North Coast Table 8). The number of standard fishing days (SFDs) recorded in Zone B using VMS data was 930 SFD's (94%). That is, 6% of effort allocated to Zone B in 2013 was not used. A total of 616 standard fishing days was allocated to Zone A. The number of SFDs recorded using VMS data was 233 (162 SFDs in 2012), indicating that ~62% remained unutilised in Zone A at the end of the season. The effort expended in Zone C in 2013 was 36 SFD's.

Thus, latent effort exists in all Zones of this fishery.

Stock Assessment

Assessment complete:

Pilbara	**Yes**
Kimberley	**Yes**

Assessment level and method:

Pilbara

Level 2 - Catch and catch rates (Annual)

Level 3 - Fishing mortality (Periodic - most recent in 2008)

Level 5 - Integrated model (Periodic - most recent in 2007)

Kimberley

Level 2 - Catch and Catch rates (Annual)

Level 5 - Integrated Model (Periodic - most recent in 2009)

Breeding stock levels:

Pilbara

Trawl Fishery	**Adequate**
Trap Fishery	**Adequate**
Line Fishery	**Adequate**
Kimberley	**Adequate**

Pilbara

There are three tiers of assessment used in the Pilbara, that when combined constitute a weight-of-evidence approach to determine overall stock status based on the performance of indicator species that represent the entire demersal suite of species. The different tiers of assessment (see How to Use This Volume for more details) are applied to the various indicator species of this suite. Catch and catch rate analyses are used to assess five indicator species and the total combined retained catch on an annual basis. Fishing mortality estimates (*F*) derived from age structure data are used to assess red emperor, Rankin cod, goldband snapper and bluespotted emperor relative to internationally recognised biological reference points (BRP) based on ratios with natural mortality[1] on a periodic basis with the last analysis completed using 2008 data. An age-structured model incorporating catch rates, catch history and age structure data is used to assess spawning biomass levels for red emperor and Rankin cod also on a periodic basis (~5 years) with the last assessment completed in 2007.

Catch Rates

Catch rates are derived from logbook catch data and adjusted according to the unload data, so that catches match reported unloads with the spatial (i.e. management areas) component obtained from logbooks. There are two measures of effort used to derive catch rates including the duration of the trawl shots as reported in logbooks and the time spent in each management area on each trip derived from VMS data. VMS data have only been available since 2000. Catch rates were

1 The BRPs for long-lived (> 20 years) species include (1) the Target level, where *F* ≤ 2/3 the ratio of natural mortality (M), for which fishing mortality is sustainable; (2) Threshold level, where F = M, which indicates fishing has exceeded sustainable levels; and (3) Limit level, where F = 1.5M, which indicates that fishing has greatly exceeded sustainable levels.

calculated using the adjusted catch divided by effort (separately for both methods) by area for each trip. A moderate efficiency increase (0-4% per year) is applied to nominal catch rates based on trawl-time as this level of efficiency increase is typical for many trawl fisheries internationally.

Mean trawl catch rates of the indicator species and the total catches decreased each year from ca. 2004 to 2008 (North Coast Figure 2). From 2009-2011, the catch rates of the shorter lived indicator species (bluespotted emperor and brownstripe snapper) and total catch increased each year. The trends in catch rates of these shorter lived species from 2011 to 2013 varied, with similar rates between years in Areas 4 and 5 but decreasing rates in Areas 1 and 2 for both species. Catch rates for the total retained catch in 2012 remained stable relative to recent years in Areas 2, 4 and 5, but decreased in Area 1. The trends in catch rates for longer lived indicator species (red emperor, Rankin cod and goldband snapper) in recent years (i.e. since 2011) were inconsistent between species and areas, with increasing or stable catch rate trends in trawl Areas 1 and 4 for Rankin cod and Areas 1, 4 and 5 for red emperor, but decreasing trends for in Areas 2 and 5 for Rankin cod and Area 2 for red emperor (North Coast Figure 2).

Fishing Mortality

The high rate of fishing mortality of red emperor (> BRP Limit level) in the western areas (Areas 1 and 2) of the trawl fishery (North Coast Table 4), and the declining catch rates of several species including the indicator species of red emperor and Rankin cod led to a reduction in effort of 16% in Areas 1 and 2 and 4% in Area 4 in 2009. This followed an industry agreed effort reduction in Area 1 in 2007 and 2008.

Age Structured Model

The age-based stock assessment models for the two indicator species, red emperor and Rankin cod, were last run in 2009 based on age data up to 2007. The outcomes of these model runs indicated that; 1) red emperor spawning biomass was greater than 40% of virgin biomass overall, with declining trends forecast for Areas 1 and 4 and stable forecast trends for Areas 2 and 5 for future years; and 2) Rankin cod spawning biomass was greater than 40% of virgin biomass overall, with a declining trend forecast for future years across most management areas. However, this assessment indicated that the spawning biomass for these indicator species of the Pilbara Demersal Fishery as a whole were above their target levels, indicating satisfactory breeding stock levels and a moderate risk of recruitment overfishing. These assessments were last run prior to effort reductions in the trawl fishery and the fishing mortality estimates from age structures of indicator species collected in 2007, 2008 and 2011. These age-based stock assessment models are scheduled to be updated following the completion of fishing mortality estimates derived from age structures of these indicator species collected in 2011.

Current Assessment

Following concerns for the sustainability of the Pilbara demersal scalefish resource based on; 1) declining trends in catch rates of all indicator species and the total catch from ca 2004-2008, and; 2) fishing mortality estimates that exceeded limit references levels for red emperor in Areas 1 and 2 in 2007, voluntary effort reductions were taken by the trawl industry in 2008 in Area 1 and implemented legislatively in 2009, in Areas 1, 2 (16% combined) and 4 (4%). This has resulted in the lowest historic levels of effort for the trawl fishery since the individual transferable effort system was introduced in 1998. It has been five years since these effort reductions were introduced and early signs of stock rebuilding are evident from stabilising catch rates of the shorter lived indicator species (bluespotted emperor and brownstripe snapper). These species are expected to display positive responses earlier than the longer lived indicator species (red emperor and Rankin cod) considering they are selected by the trap and trawl fisheries at a younger age (i.e. 2-3 vs. 5-6 years) and they have inherently higher population productivity. Since 2008 and following the implementation of effort reductions, the longer lived indicator species (red emperor and Rankin cod) have generally displayed stable or marginal increases in catch rates in most management areas, with the exception of red emperor in Area 2. If these longer-lived species are also recovering, it is expected that increases in catch rates will become evident from approximately 2013/14 onwards due to the lag between recruitment and vulnerability to the trawl fishery (5-6 years of age). Otoliths of the indicator species, red emperor, Rankin cod, bluespotted emperor, brownstripe snapper and ruby snapper were collected in 2011 from each management area of the trawl, trap and line fisheries. The age structures derived from these otolith collections will be used to evaluate changes in fishing mortality since previous estimates in 2007/08 and therefore the sustainability of current exploitation levels.

Pilbara: The major performance measures for the fish stocks in the Pilbara demersal fisheries relate to breeding stock levels of the long-lived indicator species, i.e. red emperor and Rankin cod. The target level of spawning biomass is 40% of the initial level when the catch was first recorded. The limit level is 30% of the initial spawning biomass. The spawning biomass levels of the target species were assessed as adequate (spawning biomass was greater than 40% of virgin biomass) in 2009 by synthesising the available data in an age-structured model.

Kimberley

Assessment of the indicator species in the NDSF is also undertaken using a multi-tiered approach. Catch and catch rates are assessed annually and an age structured stock assessment model is applied using relevant data on a periodic (5 year) basis with the last assessment completed in 2009. Age composition data for the next assessment was collected during 2012. The next assessment of the fishery is scheduled for 2014.

Catch Rates

The catch rate (or catch per unit of effort, CPUE) presented in this status report is a nominal catch rate statistic calculated as the annual mean of the landed catches divided by corresponding units of fishing effort expended within Zone B of the fishery, which is the traditional core area fishing activity. Effort is adjusted for gear type used (based on standard fishing days). Nominal CPUE from data recorded on monthly catch and effort returns (1998-2008) were calculated as the sum of landed catches divided by total standard fishing days reported by each vessel in each month. Nominal CPUE from data recorded on daily trip returns (from 2010 onwards) were calculated as the landed catch

divided by the total standard fishing days reported for each trip. For the 2009 reporting year, since some vessels had not yet switched to reporting their catch and effort on daily trip returns, the annual mean CPUE was calculated as the mean of monthly and trip CPUEs weighted by effort.

Nominal catch rates for Zone B only are presented in North Coast Figures 4-6, as this area represents the historical core fishing area of the NDSF prior to zoning in 2006. During 2013, Zone B catch rates for the indicator species were 120 kg/std day for red emperor, 490 kg/std day for goldband snapper and 178 kg/std day for cods/groupers. Catch rates for red emperor in 2013 are consistent with those reported in 2011 and 2012 (119 and 125 kg/std day, respectively), while the catch rate for cods/groupers decreased from 198 kg/std day in 2012. The catch rate for goldband snapper continued a steady decline from a peak catch rate of 544 kg/std day in 2011. There is some evidence of recent fishing practices having an effect on catch rates which may bias estimates calculated using historical methods.

The 2013 catch of cods/groupers from all zones exceeded the average of the previous four years, and also exceeded the ESD trigger point of a 20% increase in catch above the average of the past four years. The 2013 catches of red emperor and goldband snapper were both below the average of the previous 4 years.

Increases in catch levels are, by themselves, not very sensitive indicators of stock status but combined with the previous estimates of fishing mortality of goldband snapper being close to the upper acceptable limit, further material increases in their catch would represent an unacceptable risk given the information currently available. While several scenarios may explain the increased catches of goldband snapper in recent years, their validity should be resolved following the next collection and analysis of the representative age samples. A recent study by Marriott *et al.* (in press) examined catch rate data for goldband snapper and red emperor. For goldband snapper, standardised catch rates displayed an increasing trend, although the underlying cause could not be determined. As such, the standardised index for goldband snapper should be used with caution. In contrast, the standardised index generated for red emperor is the best available indication of historical trends in abundance for that stock and therefore should be used for future stock assessments. The results of this work will be incorporated in the next stock assessment advice.

Age Structured Model

The spawning biomass of the key target species in the NDSF was last estimated by an age-structured stock assessment model using age data collected prior to 2007, which indicated the spawning biomass was above the international target reference point of 40% of virgin biomass but with a slight declining trend for both red emperor and goldband snapper. These model outputs were reviewed by Prescott and Bentley in 2009, who concluded that the model was appropriate for use but would benefit from modifications, including the better determination of levels of model uncertainty. The model is currently being updated with continuous ongoing improvements being undertaken ahead of the next assessment.

Current Assessment

The most recent model based assessment estimates indicated that there was a high probability that the spawning stocks of the indicator species were both above their respective threshold levels at that time. The overall catch levels and the species based catches were all within the acceptable ranges for the fishery, noting significant increases in goldband catches since 2007. The catch rates for the indicator species were either stable or declining gradually and the F based assessments indicated that the fishing level on the indicator species were either lower than the target level or between target and threshold levels. Consequently the stocks for the suite of species targeted by this fishery are effectively fished and currently considered to be at acceptable levels. If catches in Zone B are maintained at current levels, there is a low likelihood that the spawning stocks of any species within this suite declining to unacceptable levels. The current risk to sustainability for this suite is therefore at acceptable levels. Zone A of the fishery continues to receive increasing levels of effort and catch. There is currently only a low to moderate risk to the sustainability of the fishery resources in this zone. Zone C of the fishery received a negligible level of effort in 2013. Therefore, there is currently a very low risk to the sustainability of the fishery resources in this zone.

NDSF: The performance measures for this fishery relate to the maintenance of adequate breeding stocks for the key indicator species as indicated by the catch levels. In 2013, the catch of both goldband snapper and red emperor were similar to that reported in 2012, and both were below the performance indicator of a 20% increase in catch above the average catch of the preceding four years. In contrast, the 2013 level of catch of cods/groupers complex was above that landed in 2012, and exceeded the performance indicator of a 20% increase in catch above the average catch of the preceding four years. Combined with the spawning biomass for both red emperor and goldband snapper having been assessed as greater than 40% of virgin biomass in 2009, all species/groups are considered to currently have adequate breeding stock levels.

Non-Retained Species

Bycatch species impact:

Pilbara	**Low - Moderate**
Kimberley	**Low**

Pilbara

Species of teleosts caught as bycatch by the trawl fishery are typically small bodied and/or short lived. Such species are considered less vulnerable compared to longer-lived teleost species based on their population production potential. Thus, the indicator species used in the weight-of-evidence stock assessments for the Pilbara demersal scalefish resources are considered to provide an adequate indication for similar or less vulnerable retained and bycatch species. In 2010, an ecological assessment of fish assemblages and habitat characteristics in trap, trawl and a 12 year targeted fishery closed area was undertaken. The results of this study are being collated.

An intense six month observer program was completed in the last half of 2012 that investigated catch rates and subsurface expulsion rates in trawl nets. This program used dual-lens above water and subsurface within-net, secure camera systems to achieve a high level of observer coverage on all

trawl vessels operating in the Pilbara fishery (n = 3). Observer coverage rates of 85.2% of trawl catches above water (n = 1,916 trawls observed), and 71.7% of day-trawls (n = 774 trawls observed) and 53.9% day-trawl hours (n = 1,013 h observed) below water, were achieved. About two thirds of all chondrichthyans were expelled from escape hatches during trawling, with the majority expelled relatively quickly (< 10 min). This resulted in more than half of the trawl catches containing no chondrichthyan bycatch (51.4%).

The fish trap and line fisheries have minimal bycatch (see Kimberley below).

Kimberley

As a result of the catching capacity of the type of gear used and the marketability of most species caught, there is a limited quantity of non-retained bycatch in this fishery. The most common bycatch species is the starry triggerfish *(Abalistes stellaris)*, but the numbers taken are not considered to pose a significant risk to the sustainability of this species.

Listed species interaction:

Pilbara	**Low - Moderate**
Kimberley	**Negligible**

Pilbara

The Pilbara Fish Trawl Fishery (PFTF) has a long history of developing and adopting mitigation measures that have resulted in very low capture rates of endangered, threatened and protected (ETP) megafauna, i.e. dolphins, turtles, sea snakes and sawfish. However, there has been uncertainty over the potential for unaccounted mortality of ETP megafauna from subsurface expulsion through escape hatches in the trawl nets (particularly air breathing species). To examine this issue, all trawl operations in the fishery (n = 3) were fitted with dual-lens above water and subsurface within-net, secure camera systems. This resulted in a high level of observer coverage from June to December 2012 that far exceeded that stipulated in the Bycatch Action Plan (22%) and levels achieved from previous studies from the PFTF. Capture rates of ETP megafauna were very low, despite very high levels of attendance and depredation in and around trawl nets by bottlenose dolphins (> 75% of trawls). All observed catches of ETP species were reported in statutory logbooks and these catch rates were consistent with previous data since exclusion grids were mandated in March 2006. Therefore, there was no evidence to suggest that captures of ETP species were being unreported by commercial fishers. The subsurface expulsion of megafauna in poor condition was extremely rare (only one dolphin was observed from over 1,000 trawl hours of within-net observations) and thus reporting rates in statutory logbooks are likely to be close to census. Extensive subsurface observations determined that current mitigation strategies are highly effective for sea snakes and turtles, and that further mitigation strategies in the forward sections of trawl nets would likely be more effective for dolphins and sawfish. The very low levels of mortalities of these ETP megafauna by the PFTF were considered to pose a negligible risk to their sustainability based on 1) these levels are likely to be less than their natural mortality rates (e.g. at least 371 bottlenose dolphins stranded in Western Australia from 1981-2010, 2) they appear abundant in Western Australian waters despite large scale mortalities from historic foreign fishing (e.g. 13,459 cetacean mortalities from Taiwanese fishing from 1981-86), and 3) they have wide distributions and are highly mobile. The outcomes of this observer program were reported in Fisheries Research Report 244, published in 2014.

The reporting of interactions with listed species has improved for the Kimberley and Pilbara trap fisheries. These fisheries regularly capture sea snakes. In 2013, the Pilbara and Kimberley trap fisheries reported 114 and 187 sea snakes, respectively. Sea snakes are returned to the water alive.

Pilbara: The performance measures for the impact of the trawl fishery on listed species: skippers are required to record incidents of capture and to minimise mortality. Despite dolphins foraging in and around trawl nets during > 75% of trawls (FRR 244) their capture is very rare (~0.005 trawl^{-1} in 2012, FRR 244).

Based on estimates from independent observers, exclusion devices that were made compulsory in fish trawl nets in March 2006 reduced the incidental catch of dolphins by 64% and turtles by 97%. Subsequently, dolphin mortalities reported in statutory logbooks have reduced to less than 25 per year since 2006 (North Coast Table 5) and this rate has been independently verified.

Kimberley

Using trap gear in continental shelf regions is very unlikely to interact with listed species. Recent video observations indicate that the potato cod (*Epinephelus tukula*), a totally protected species, can be present in high numbers at discrete locations within the fishery. Potato cod rarely enter traps due to their large size and girth limiting their capacity to pass through the entrance funnel into the traps.

Ecosystem Effects

Food chain effects:

Pilbara	**Low**
Kimberley	**Negligible**

Pilbara

The Pilbara Fish Trawl Interim Managed Fishery operates with standard stern trawling gear (single net with extension sweeps) within an area previously trawled by foreign vessels. Previous research by CSIRO has suggested that the extensive Taiwanese pair Trawl Fishery caused a significant decrease in the biomass of finfish on the North West Shelf, and a change in species composition towards smaller (shorter lived) species. The current WA Fish Trawl Fishery, which developed when the fish stocks had begun to recover, uses a much larger mesh size and much lighter ground gear, and operates at lower exploitation rates and only in restricted parts of the continental shelf. At the present levels of catch and effort by the fish trawl, fish trap, and line fisheries, the broader effect on the trophic levels and community structure of the North West Shelf is considered to be at an acceptable level. Hall and Wise (2011) demonstrated that there has been no reduction in either mean trophic level or mean maximum length in the finfish catches recorded within the Pilbara (i.e. no fishing down of the food web) over the past 30 years.

Kimberley
The need to maintain relatively high levels of biomass for the species caught in this fishery to meet stock recruitment requirements results in a negligible risk to the overall ecosystem from the fishery. Hall and Wise (2011) demonstrated that there has been no reduction in either mean trophic level or mean maximum length in the finfish catches recorded within the Kimberley (i.e. no fishing down of the food web) over the past 30 years.

Habitat effects:

Pilbara	**Moderate**
Kimberley	**Low**

Pilbara
Direct impacts to the habitat are limited to those of the Pilbara Fish Trawl Interim Managed Fishery, which is restricted to less than 5% of the North West Shelf (North Coast Figure 1). Area 3 and the waters inside the 50 m isobath are permanently closed to fish trawling, Zone 1 is closed to fish trawling, and Area 6 has had no fish trawl effort allocation since 1998.

Within the areas actually trawled, past research has indicated that approximately 10% of the sessile benthic fauna (e.g. sponges) are detached per year. It is not known whether the detachment rate exceeds the rate of re-growth. Considering effort for the trawl fishery is at historically low levels and the effective area trawled within the managed areas has been greatly reduced, it is likely that the trawl fishery imposes a moderate risk to the small amount of habitat in the Areas open to trawling (5% of NWS) but a negligible risk to the total habitat in the North West Shelf.

Kimberley
As a result of the gear design, the fishery has little impact on the habitat overall, although there may be some rare interactions with coral habitats which are not common in areas where the fishery operates.

Pilbara: The performance measure for the fish trawl impact on the North West Shelf habitat was set as a maximum area of operation by the trawlers. With the current closures within the licensed area of the fishery (50 m to 200 m depth), 46% of the area is accessible to the trawl vessels. Plots of trawl activity from VMS data indicate the actual area trawled is significantly less than this.

Social Effects

Pilbara
It is estimated that 14 fishers on 3 vessels were directly employed during 2013 in the Pilbara Fish Trawl Fishery, and 8 fishers on 3 vessels in the Trap Fishery, and at least 21 fishers on 7 vessels in the line fishery. Overall, at least 41 people were directly employed in the Pilbara Demersal Scalefish Fisheries.

This fishery supplies significant amounts of fish to Perth, with catches from the Pilbara fisheries dominating the Perth metropolitan markets and supporting the local fish-processing sector. The exports from this fishery have been minimal in the last few years due to the increased value of the Australian dollar.

Kimberley
Eight vessels fished in the 2013 fishing season, at least 24 people (assuming ~3 crew per vessel) were directly employed in the NDSF. Approximately half the fish from this fishery are supplied to Perth metropolitan markets, while the other half is supplied to east coast metropolitan markets.

Economic Effects

Estimated annual value (to fishers) for 2012-13:

Pilbara	**Level 3 - $5 - 10 million**
Kimberley	**Level 3 - $5 - 10 million**

The value of each of the North Coast Demersal fisheries is individually reported using the 6 categories defined in Fletcher *et al.* (2010) used to assess the relative economic (based on gross value product, GVP) and social amenity values associated with each regional level ecological asset. These values are based on GVP figures derived from the 2012-2013 financial year.

Pilbara
The fish trawl demersal scalefish catch is dominated by lower-valued species such as bluespotted emperor and threadfin bream, and its value is estimated to be Level 2 – $1-5 million. For social amenity some of the species may be caught recreationally and/or there is some specific interest in the asset by the broader community. The fish trap and line catches are dominated by valuable species such as red emperor and goldband snapper, and the demersal scalefish catch from these sectors was estimated to have an economic value of $1-5 million and the social amenity is also Level 2. For the line fishery the economic value is Level 1 < $1 million and social amenity is minimal because there is no recreational fishing for these offshore species and no specific broader community interests.

Kimberley
The NDSF principally targets the higher-value species such as the goldband snapper and red emperor resulting in an economic value of $5-10 million. The social amenity value is that this is an important asset locally.

Fishery Governance

Target commercial catch range:

Pilbara Fish Trawl	**2,000–2,800 tonnes**
Pilbara Fish Trap	**400–500 tonnes**
Pilbara Line	**50–115 tonnes**
Kimberley (NDSF)	**600–1000 tonnes (All Zones)**

Current Fishing (or Effort) Level

Pilbara	
Trawl Fishery	**Acceptable**
Trap Fishery	**Acceptable**
Line Fishery	**Acceptable**
Kimberley	**Acceptable**

Pilbara

In the Fish Trawl Fishery, the total catch was still well below the target catch range continuing a trend of the last seven seasons. Considering, 1) catch rates of indicator species are increasing or stable since effort reductions; 2) effort within the trawl fishery is currently at historically low levels, and 3) results from a higher level fishing mortality-based stock assessment and ecosystem based ecological assessment will be available in 2014 and 2015; current levels (2012) of effort and catch in the Pilbara fish trawl fishery are considered to impose a moderate risk for stock sustainability for the Pilbara Demersal Scalefish resource.

In the Fish Trap Fishery, the total catch was below the target catch range in 2013 due to less effort. The total catch in the Line Fishery was within the acceptable catch range in 2013.

Kimberley

For the 2013 calendar year, the total allowable effort was set at 986 standard fishing days in Zone B, and 616 standard fishing days in Zone A, of the fishery respectively. The Zone A allocation aims to facilitate the exploration and development of this area of the fishery, while there is also further scope for fishers to develop Zone C (the deep slope area). At these levels of total effort and at recent catch rates, the total catch of the fishery is expected to be in the range of 600–1,000 t. The 2013 catches were above the reported range. However, given the recent increases in fishing effort in Zone A, there is a need to review the target catch range for this fishery.

In addition to the overall catch target, ESD performance measures state that the annual catch of each of the key target species/groups (red emperor, goldband snapper and the cod/grouper complex) taken by the fishery should not increase by more than 20% above the average for the previous four years. Of the key target species/groups, only the 2013 catch of the cods/groupers complex was above the average of the previous four years, and also exceeded the ESD performance measure. Both the goldband snapper and red emperor catch remained significantly below the trigger level. Several different scenarios could explain the increased catches of goldband snapper in recent years and the validity of each of these scenarios should be resolved following assessment of the next representative age sample.

New management initiatives (2014/15)

Pilbara

In 2014, the Department will work with permit holders in the Pilbara Fish Trawl Interim Managed Fishery to adhere to the conditions of the recently (2014) re-accredited Wildlife Trade Operation approval.

Kimberley

In 2013 the industry agreed zoning and effort allocation arrangements of Area 2 of the NDSF was incorporated into the management plan. The Department continues to address the findings of the Prescott Review ahead of the next Level 5 assessment.

All commercial fisheries in the North Coast Bioregion undertook MSC pre-assessment in late 2013. Outcomes are expected in 2014.

External Factors

The Commonwealth's North-west Marine Bioregional Plan incorporates the aim of introducing marine reserves, which are likely to contain areas closed to fishing. This has the potential to restrict access to fishing in parts of the North Coast Bioregion to all sectors, i.e. commercial, recreational and charter.

Under the Offshore Constitutional Settlement, commercial trawl vessels licensed by the Commonwealth may operate in waters outside of a line that is meant to represent the 200 m isobath as part of the North West Slope Trawl Fishery (NWSTF). However, as this line encompasses waters in Zone B of the NDSF, any future catches by Commonwealth trawl vessels in the these waters that are shallower than 200 m will impact on the demersal fish resources of the NDSF.

Climate change and climate variability has the potential to impact fish stocks in a range of ways including influencing their geographic distribution (e.g. latitudinal shifts in distribution). However, it is unclear how climate change may affect the sustainability risk to North Coast demersal fisheries.

Pilbara

The available fishing area has decreased slightly over recent years as a result of exclusion zones for gas pipelines and associated facilities. Seismic surveys also restrict the operation of fishers. However, there is little information as to the impacts and therefore the risks from seismic operations on demersal scalefish.

Kimberley

The impacts of environmental variation on the fishery are not considered to be large as target species are long-lived and inter-annual variability is likely to be 'smoothed'. Some commercial fishers within the fishery have raised concerns about the increasing numbers of charter vessels operating in the offshore waters of the NDSF, which could generate resource-sharing issues in the future. In addition, offshore developments in the energy/gas industry may involve exclusion zones thus potentially limiting fisher access to some areas of the fishery. Increasing development of the Kimberley region is also likely to see a marked increase in the recreational effort and this may impact on stock sustainability.

NORTH COAST TABLE 1

Commercial catches (tonnes) and the percentages of each major species taken by trawl, trap and line in the Pilbara in 2013 (catches rounded to the nearest tonne).

Species		Trawl catch		Trap catch		Line catch		Total catch
		tonnes	%	tonnes	%	tonnes	%	tonnes
Bluespotted emperor	*Lethrinus punctulatus*	98	70%	41	29%	-	-	139
Crimson snapper	*Lutjanus erythropterus*	132	79%	32	19%	4	2%	168
Rosy threadfin bream	*Nemipterus furcosus*	76	99%	< 1	< 1%	-	-	76
Brownstripe emperor	*Lutjanus vitta*	66	81%	15	19%	-	-	81
Goldband snapper	*Pristipomoides multidens*	80	47%	61	35%	31	18%	172
Red emperor	*Lutjanus sebae*	54	52%	49	47%	1	1%	104
Saddletail snapper	*Lutjanus malabaricus*	53	73%	15	21%	5	7%	73
Spangled emperor	*Lethrinus nebulosus*	11	28%	16	40%	13	33%	40
Frypan snapper	*Argyrops spinifer*	32	96%	1	3%	< 1	1%	33
Rankin cod	*Epinephelus multinotatus*	11	20%	43	77%	2	4%	56
Ruby snapper	*Etelis carbunculus*	-	-	-	-	12	100%	12
Other demersal scalefish		461	85%	66	12%	17	3%	544
All demersal scalefish		**1,074**	**72%**	**339**	**23%**	**85**	**6%**	**1,499**

NORTH COAST TABLE 2

Summary of reported commercial catches (catches rounded to the nearest tonne) of demersal scalefish by line, trap and trawl in the Pilbara fishery, as well as by–product from the fish trawl fishery for the past decade.

	Demersal Scalefish				Byproduct*
Year	Line	Trap	Trawl	Total	Trawl
2004	240	395	2,837	3,449	113
2005	260	408	2,371	3,005	80
2006	105	473	2,222	2,800	46
2007	102	460	1,704	2,266	36
2008	86	508	1,210	1,804	37
2009	123	455	1,044	1,622	37
2010	117	489	1,259	1,865	32
2011	112	459	1,097	1,656	18
2012	90	416	1,312	1,806	17
2013	**85**	**339**	**1,074**	**1,499**	**9**

* Byproduct in 2013 consists mainly of bugs, cuttlefish, and squid.

NORTH COAST TABLE 3

Summary of the fishing effort in the Pilbara Demersal Scalefish Fisheries for the past decade. The trap, line and trawl effort (days) are derived from monthly catch and effort returns. The trawl effort (hours) is nominal effort from operators' logbook data.

Year	Line (days)	Trap (days)	Trawl (days)	Trawl (hours)
2004	816	418	953	15,372
2005	993	425	886	14,721
2006	418	467	914	15,792
2007	344	429	841	14,197
2008	278	428	831	11,966
2009	282	483	712	10,605
2010	366	472	658	9,723
2011	376	420	544	7,338
2012	395	441	706	10,269
2013	**357**	**357**	**562**	**8,237**

NORTH COAST TABLE 4

Estimates of fishing mortality (F) relative to Exploitation Reference Points (ERPs) calculated for each of the indicator species collected in different management areas of the commercial trawl and trap fisheries in the Pilbara region from 2006 to 2008. ns = not sampled.

Indicator species	Year	Trawl area (Zone 2)				Trap
		1	2	4	5	
Red emperor	2007	$F > F_{limit}$	$F > F_{limit}$	$F_{threshold} > F > F_{target}$	$F_{threshold} > F > F_{target}$	$F_{limit} > F > F_{threshold}$
Rankin cod	2006	$F = F_{target}$	$F < F_{target}$	$F_{threshold} > F > F_{target}$	$F = F_{threshold}$	$F < F_{target}$
Goldband snapper	2008	$F_{threshold} > F > F_{target}$	$F < F_{target}$	$F < F_{target}$	$F_{threshold} > F > F_{target}$	ns
Bluespotted emperor	2008	$F_{threshold} > F > F_{target}$	ns	ns	ns	ns

NORTH COAST TABLE 5

Reported bycatch of listed species by skippers in the Pilbara trawl fishery in 2013.

	Number released Alive	Number deceased*	Total Reported
Bottlenose dolphins	4	22	26
Pipefish	7	13	20
Green sawfish	10	19	29
Narrow sawfish	15	22	37
Seahorses	1	0	1
Sea-snakes	83	34	117
Turtles	1	0	1

*Where the condition was not reported, the animal was considered deceased.

NORTH COAST TABLE 6

Recent total annual catches of major target and byproduct species or species groups across all zones in the NDSF.

Species	NDSF annual catch (tonnes)								
	2005	2006	2007	2008	2009	2010	2011	2012	2013
Goldband snapper (*Pristipomoides* spp.)	429	331	405	457	485	524	487	487	493
Red emperor (*Lutjanus sebae*)	192	164	179	173	156	142	128	135	131
Saddletail snapper (*Lutjanus malabaricus*)	92	78	99	104	108	126	87	100	116
Spangled emperor (*Lethrinus nebulosus*)	21	27	15	17	23	30	20	25	21
Cod/grouper (Epinephelidae)	110	127	126	149	142	153	155	170	195
Other species	78	62	107	102	132	144	161	191	273
Total demersal scalefish catch	**922**	**789**	**933**	**1002**	**1046**	**1117**	**1037**	**1109**	**1228**

NORTH COAST TABLE 7

Catches of major target and byproduct species or species groups by zone in the NDSF in 2012 and 2013.

Species	NDSF annual catch (tonnes)			
	2012		2013	
	Zone A & C	Zone B	Zone A & C	Zone B
Goldband snapper (*Pristipomoides* spp.)	17.2	470.2	25.6	467.5
Red emperor (*Lutjanus sebae*)	32.8	102.2	43.5	87.1
Saddletail snapper (*Lutjanus malabaricus*)	11.6	88.8	18.8	97
Spangled emperor (*Lethrinus nebulosus*)	1.3	24.0	2.7	17.9
Rankin cod (*Epinephelus multinotatus*)	18.3	33.9	28.4	33.5
Other Cods/groupers (Epinephelidae)	23.1	94.6	42.8	90.6
Other species	70.3	120.3	154	119.1
Total demersal scalefish catch	**175**	**934**	**316**	**913**

NORTH COAST TABLE 8

Total catches (t) of demersal finfish and effort (days) by line and trap vessels in the NDSF since 2001.

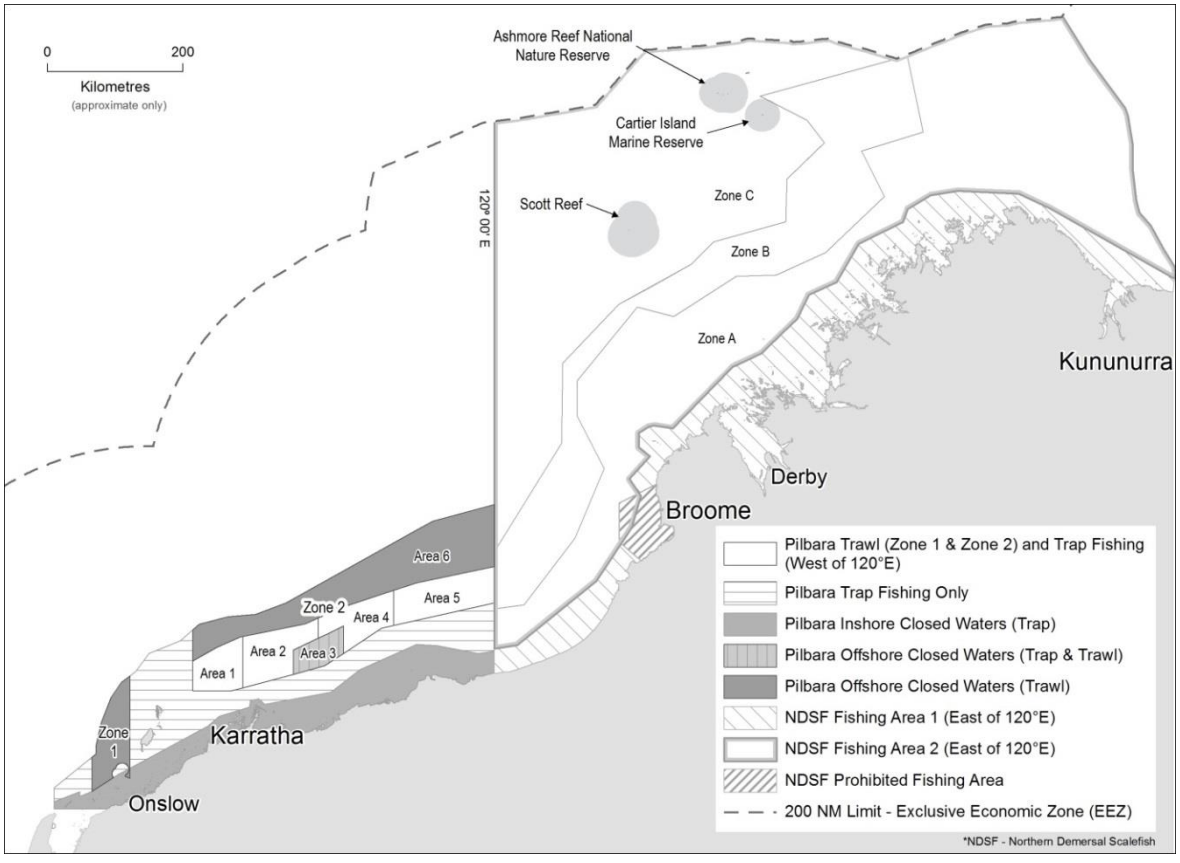
Year	Total allowable effort (days)	Line catch (t)	Line effort (days)	Trap catch (t)	Trap effort (days)	Total catch (t)
2001	1,672	47	136	462	928	509
2002	1,760	0	0	434	900	434
2003	1,760	0	0	552	1,060	552
2004	1,760	0	0	690	1,300	690
2005	1,760	0	0	922	1,318	922
2006	1,144	0	0	801	1,193	801
2007	1,144*	0	0	933	1,235#	933
2008	1,144*	7	0	1,003	1,150#	1,010
2009	1,144*	0	0	1,046	1,090#	1,046
2010	1038*	0	0	1,116	1,178#	1,116
2011	986*	0	0	1,037	1,042#	1,037
2012	986*	0	0	1,109	1,059#	1,109
2013	986*	**<1**	**4**	**1,228**	**1,195#**	**1,228**

(* = TAE is for B Zone only; # = total effort is from all zones; 2013 Estimated Catch: Zone A = 291 t, Zone B = 913 t; 2013 Estimated Effort: Zone A = 233 SFDs, Zone B = 930 SFDs)

NORTH COAST TABLE 9

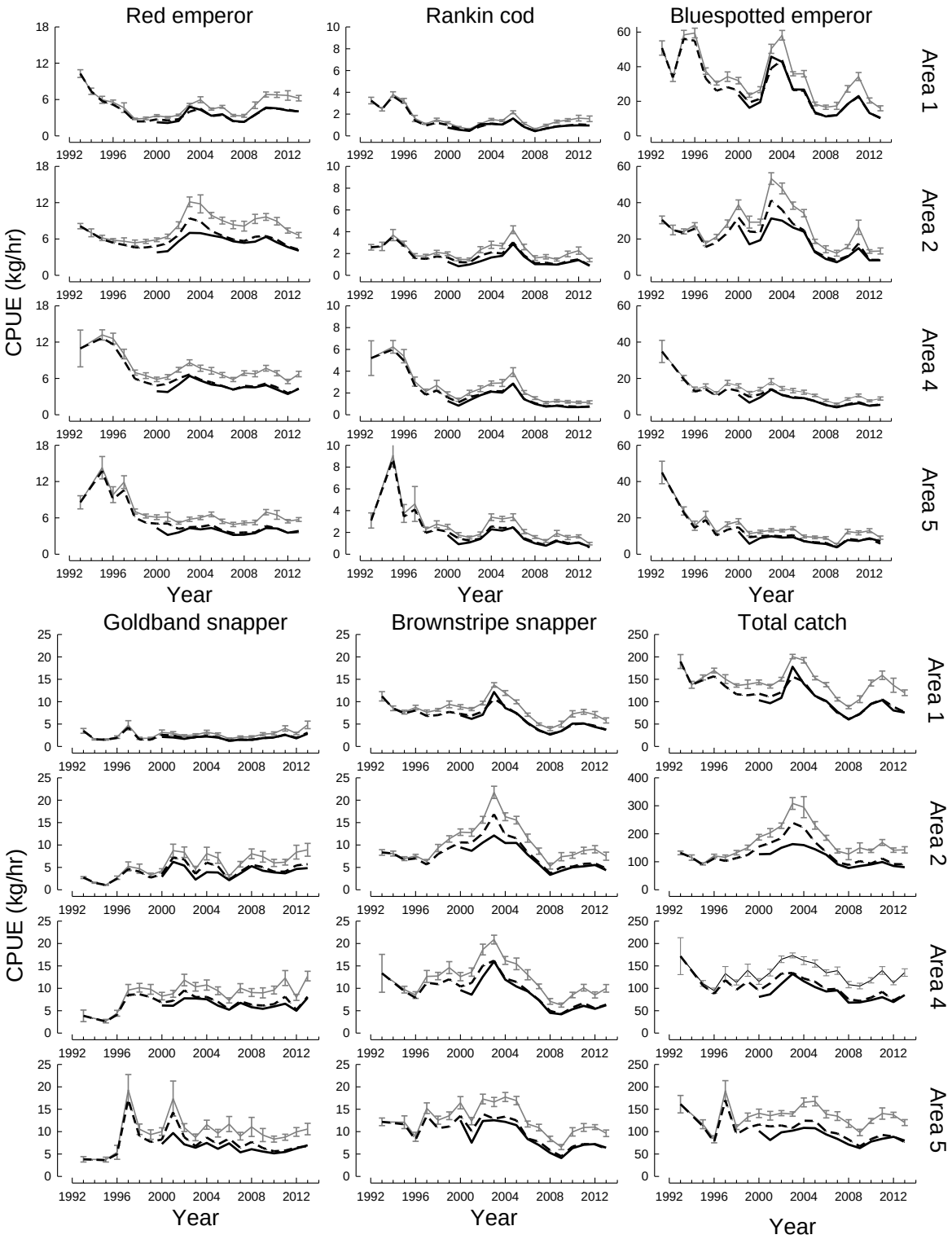
Summary of the commercial catches and the relative contribution (% composition) of each of the major or iconic species taken within the Pilbara and Kimberley sectors of the North Coast Bioregion in 2013.

Species	Pilbara catch		Kimberley (NDSF) catch		Total catch
	tonnes	% total	tonnes	% total	tonnes
Red emperor	104	44	130.7	56	234.7
Saddletail snapper	73	39	115.8	61	188.8
Crimson snapper	168	65	89.0	36	257
Brownstripe snapper	81	91	7.8	9	88.8
Goldband snapper	172	26	493.1	75	665.1
Spangled emperor	40	66	20.6	34	60.6
Bluespotted emperor	139	70	59.1	30	198.1
Rankin cod	56	48	61.8	52	117.8
Frypan snapper	33	> 99	< 0.1	< 1	33
Rosy threadfin bream	76	> 99	< 0.1	< 1	76
Moses snapper	28	69	12.4	31	40.4
Longnose emperor	10	45	12.2	55	22.2
Mozambique bream	-	-	7.9	100	7.9
Grass emperor	0.3	6	5.0	94	5.3
Barcheek coral trout	8	52	7.3	48	15.3
Other demersal scalefish	510.7	71	208.4	29	719.1
Total all demersal scalefish	**1499**	**55**	**1228**	**45**	**2727**



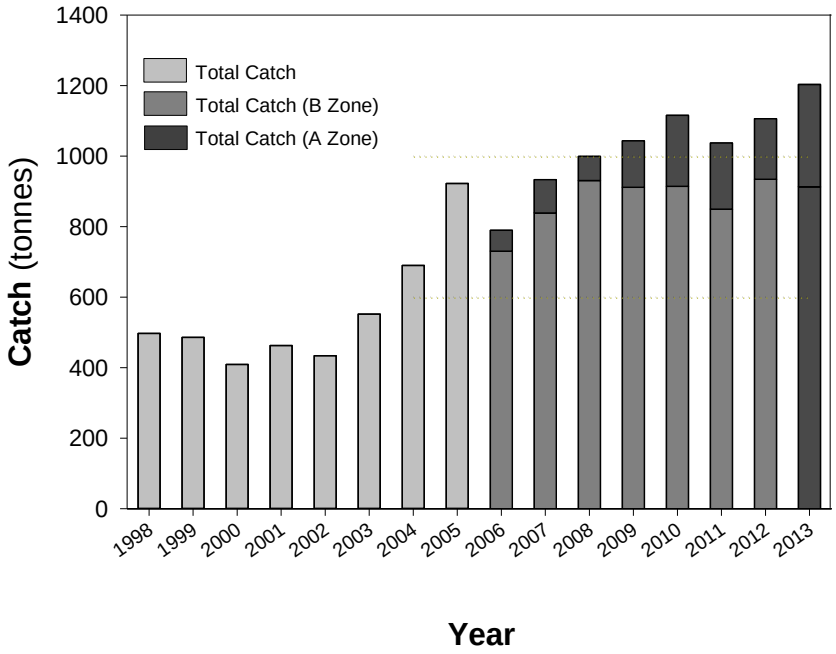
NORTH COAST FIGURE 1

Demersal scalefish fisheries of the North Coast Bioregion of Western Australia. In the Pilbara subregion: Areas 1 to 6 refer to the management regions in Zone 2 of the trawl fishery. Zone 1 has been closed to trawling since 1998. In the Kimberley subregion: Zones A, B and C lie in Area 2 of the NDSF.



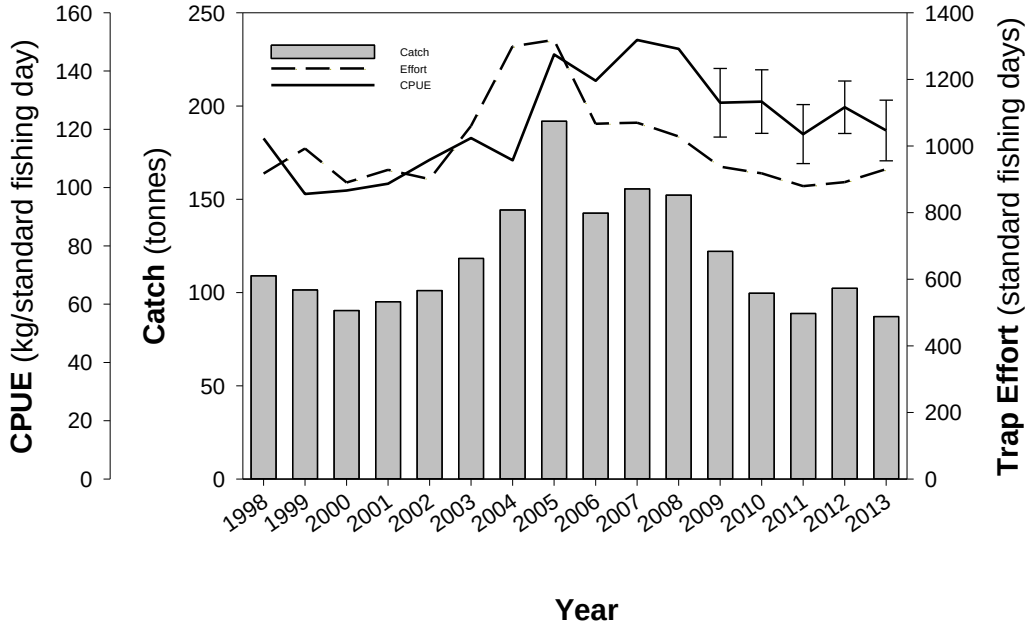
NORTH COAST FIGURE 2

Annual mean Catch Per Unit Effort (CPUE, kg/hour) for five indicator species and the total catch in Areas 1, 2, 4 and 5 of the Pilbara Trawl Fishery from 1993–2013. The solid grey line is nominal annual catch rate (±1 se) with trawl time as the effort measure, the dashed black line is that catch rate incorporating efficiency increase (trawl time as the effort measure) and the solid black line is annual catch rate using the time spent in each area as the effort measure (derived from VMS, data available since 2000).



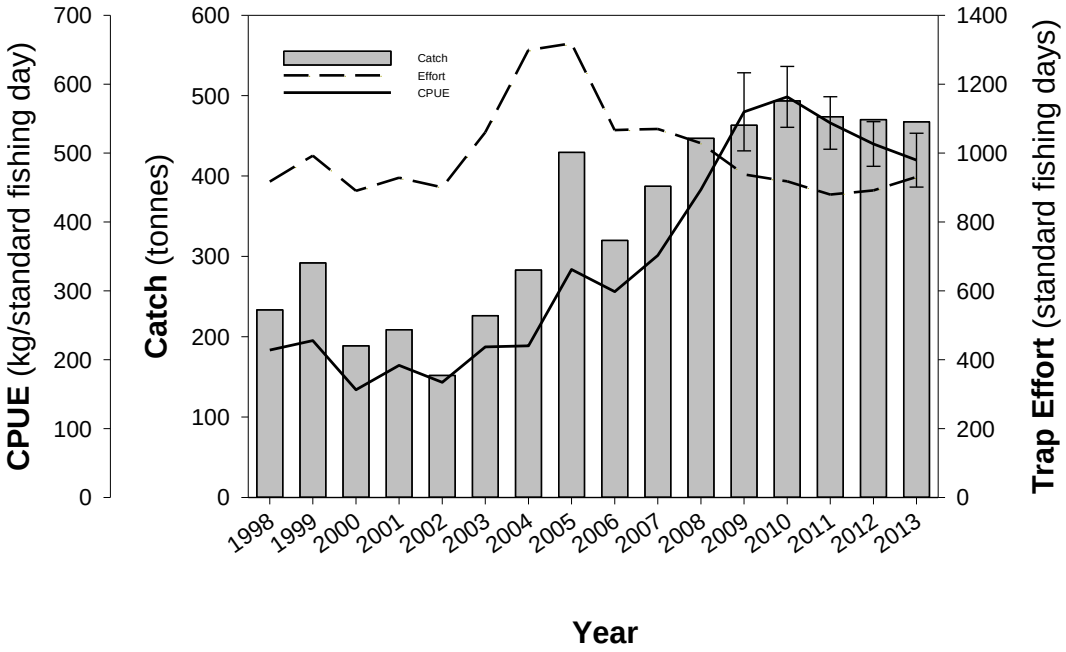
NORTH COAST FIGURE 3

Catch levels of demersal finfish in the NDSF by line and trap from 1998–2013. Note that prior to 2006 the NDSF was not differentiated in zones. Since 2006 catches are reported separately by zones within Area 2 of the fishery. The dashed lines represent the acceptable catch range of 600-1000 tonnes for the fishery.



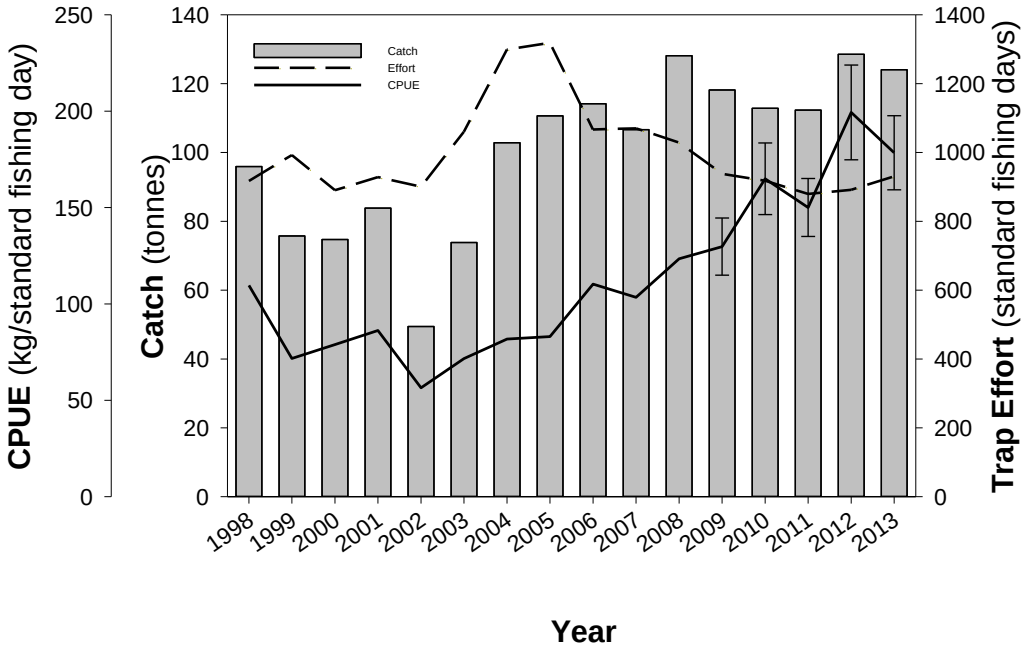
NORTH COAST FIGURE 4

Catch, effort and catch per unit of effort of red emperor in the NDSF by trap, 1998–2013 (2006-2013 for Zone B only, catches represent total landings in B Zone, whereas effort and catch rate (CPUE) are determined from commercial vessel activity only). The catch rate (CPUE) presented here is a nominal catch rate that is calculated as the mean of monthly fleet catches divided by effort adjusted for gear type within Zone B of the fishery only, except for data from daily trip returns, where catch rates are calculated as the mean of all catch rates attained during separate fishing trips. Standard error bars illustrate variability in CPUE from the two sources of catch returns in 2009, and variability in trip CPUE data from daily logbooks (2010-13).



NORTH COAST FIGURE 5

Catch, effort and catch per unit of effort of goldband snapper in the NDSF by trap, 1998–2013 (2006-2013 for Zone B only, catches represent total landings in B Zone, whereas effort and catch rate (CPUE) are determined from commercial vessel activity only). The catch rate (CPUE) presented here is a nominal catch rate that is calculated as the mean of monthly fleet catches divided by effort adjusted for gear type within Zone B of the fishery only, except for data from daily trip returns, where catch rates are calculated as the mean of all catch rates attained during separate fishing trips. Standard error bars illustrate variability in CPUE from the two sources of catch returns in 2009, and variability in trip CPUE data from daily logbooks (2010-13)



NORTH COAST FIGURE 6

Catch, effort and catch per unit of effort of the cod/grouper complex in the NDSF by trap, 1998–2013 (2006-2013 for Zone B only, catches represent total landings in B Zone, whereas effort and catch rate (CPUE) are determined from commercial vessel activity only). The catch rate (CPUE) presented here is a nominal catch rate that is calculated as the mean of monthly fleet catches divided by effort adjusted for gear type within Zone B of the fishery only, except for data from daily trip returns, where catch rates are calculated as the mean of all catch rates attained during separate fishing trips. Standard error bars illustrate variability in CPUE from the two sources of catch returns in 2009, and variability in trip CPUE data from daily logbooks (2010-13).

Mackerel Managed Fishery Report: Statistics Only

B. Molony, S. Newman, E. Lai and N. Blay

Fishery Description

Commercial

The Mackerel Fishery uses near-surface trolling gear from vessels in coastal areas around reefs, shoals and headlands to target Spanish mackerel *(Scomberomorus commerson)*. Jig fishing is also used to capture grey mackerel *(S. semifasciatus)*, with other species from the genera *Scomberomorus*, *Grammatorcynus* and *Acanthocybium* also contributing to commercial catches.

Recreational

Recreational fishers target similar species using a range of gears including trolling, shore-based drift fishing with balloons and spear guns.

Boundaries

Commercial

The Fishery extends from the West Coast Bioregion to the WA/NT border, with most effort and catches recorded north of Geraldton, especially from the Kimberley and Pilbara coasts of the Northern Bioregion. Catches are reported separately for three Areas: Area 1 - Kimberley (121º E to WA/NT border); Area 2 - Pilbara (114º E to 121º E); Area 3 - Gascoyne (27º S to 114º E) and West Coast (Cape Leeuwin to 27º S) (Spanish Mackerel Figure 1).

Recreational

The fishery operates between the West Coast Bioregion and the WA/NT border, with most activity occurring between Perth and Dampier.

Management arrangements

Commercial

The Fishery transitioned from an interim managed fishery to a managed fishery on 1 January 2012. The Mackerel Managed Fishery (MMF) operates under an Individual Transferable Quota (ITQ) system which includes the setting of Total Allowable Commercial Catches (TACCs) for each Area of the Fishery, allocation of the entitlement to take quota in the form of units, and establishment of minimum unit holding requirements to operate in the Fishery.

The maximum quantity of mackerel that may be taken from each Area of the Fishery during any licensing period (1 January to 31 December) is limited to the quantity of mackerel determined by the Director General. The TACC for each Area of the Fishery for 2013 was:

	Spanish and other mackerel	Grey mackerel
Area 1:	205 t	60 t
Area 2:	126 t	60 t
Area 3:	79 t	60 t

The Plan includes limitations on the number of licences to fish in the Fishery and the type of gear that can be used. Boats operating in the Fishery are monitored by VMS and the master of an authorised boat is required to submit logbook returns and catch and disposal records. Seasonal closures were removed in May 2008, as they were no longer a necessary tool to maintain sustainable and efficient management of the Fishery after quotas were put in place in 2006.

Licence holders may only fish for mackerel by trolling or handline. There are currently 50 licences in the Fishery with 15, 15 and 20 licences in Areas 1, 2 and 3 (respectively), with the combined quota allocations being consolidated onto 14 boats operating within the fishery.

A comprehensive ESD assessment of this Fishery determined that levels of Spanish mackerel breeding stock should be used as an annual performance measure for the Fishery. In November 2009, the Fishery was exempt from the export controls of the *Environment Protection and Biodiversity Conservation Act 1999* for a period of five years.

A revised statewide combined daily bag limit of three Spanish mackerel and grey mackerel was introduced in 2013 as an outcome of the statewide recreational fishing review. Previously a combined daily bag limit of two in the West Coast and South Coast Bioregions and four in the Gascoyne and North Coast Bioregions applied.

Landings and Effort (Season 2012)

Spanish mackerel	**277.2 tonnes**
Grey mackerel	**11.4 tonnes**
Other mackerel	**0.1 tonnes**

Commercial

A total of 13 boats operated in 2013, with three, four and six vessels operating in the Kimberley, Pilbara and Gascoyne/South Management Areas (Spanish Mackerel Figure 2). A total of 684 fishing days of effort were reported in 2013, with most (more than 44%) of days reported from the Kimberley Area.

The majority of the catch is taken in the Kimberley Area, reflecting the tropical distribution of mackerel species (Spanish Mackerel Figure 2). Estimates of catches are monitored through mandatory logbook systems with the total catch of Spanish mackerel in the 2013 season estimated at 277.2 t which is similar to the levels that have been taken in this fishery (averaging about 300 t) since quotas were introduced in 2006 (Spanish Mackerel Figure 2).

A total of 11.5 tonnes of other species of mackerel were landed in the 2013 season, including 11.4 t of grey mackerel. The catch of grey mackerel in 2013 was of a similar magnitude to grey mackerel catches by the fishery since 2006 but well below the TAC and the historical high catches of ‘other mackerel’ recorded in the late 1980s and 1990s.

All commercial estimates reported do not include fish caught and released or lost to sharks.

Recreational

Estimates of recreational catches of Spanish mackerel were generated from data collected in the integrated survey of boat-based recreational fishing in WA conducted during 2011/12. Estimates are available at the level of individual Bioregions (Spanish Mackerel Table 1). A total of 68.1 t of Spanish mackerel were landed by recreational boat-based fishers in 2011/12, with most (26.2 t) landed in the North Coast Bioregion. An additional 61.2 t were captured and subsequently released. Recreational anglers also reported much lower catches of other mackerel, including blue mackerel (*Scomber australasicus*), grey mackerel (*Scomberomorus semifasciatus*), school mackerel (*Scomberomorus queenslandicus*), shark mackerel (*Grammatorcynus bicarinatus*), spotted mackerel (*Scomberomorus munroi*) and wahoo (*Acanthocybium solandri*). Recreational anglers also reported small amounts of unidentified mackerel. A second Statewide integrated survey of boat-based recreational fishing in WA, conducted during 2013/14 is currently being finalised.

Reported annual catches of Spanish mackerel by recreational charter boats are relatively minor.

Fishery Governance

Target commercial catch range:

246 – 410 tonnes

The total catch in 2013 of 277.2 t was within the acceptable catch range for the Fishery. The reported catch from the Kimberley Area of 144.5 t was within the Area's acceptable catch range (110 – 205 t), and within the range reported since 2005. Catches in the Pilbara Area have been relatively stable since 2006, with the 2013 catch of 99.0 t (acceptable catch range 80 – 126 t) the highest catch since 2005. Catches from the Gascoyne/West Coast Area in 2013 were 33.8 t, below the acceptable range of 56 – 79 t but similar to the range of catches from this Area since 2004.

Current Fishing (or Effort) Level: Acceptable

Fishing effort throughout the Fishery has been relatively stable since 2006 following reductions due to management changes (Spanish Mackerel Figure 2). The high catch rates for the two main (Northern and Pilbara) fishery areas, both near record levels, indicates a relatively high abundance of Spanish mackerel in these management Areas (Spanish Mackerel Figure 3). Catch rates in the Gascoyne/West Coast have remained stable at relatively high levels since 2007.

As the minimum legal size for Spanish mackerel is 900 mm total length which is similar to the size at maturity for this species, the spawning stock is essentially the same as the exploited stock. Therefore the status of the Spanish mackerel spawning stock is measured using the catch rates for each areas of the Fishery. As catch rates are either continuing to increase or are stable at relatively high levels within each management Area, this suggests that the overall spawning stock is increasing. Additionally, the total catches of Spanish mackerel remain within the target range. Spanish mackerel in Western Australia is not considered to be recruitment overfished, and the level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

Grey mackerel catch levels in the Mackerel Managed Fishery from 2000 to 2013 have been relatively low and stable, ranging between 10 and 24 t, with catches only reported from a small area of their range. This level of catch is well below the TAC for grey mackerel. Grey mackerel in Western Australia is not considered to be recruitment overfished, and the level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished.

New management initiatives (2014)

The Mackerel Managed Fishery underwent pre-assessment for Marine Stewardship Certification in early 2014. Outcomes will be available late in 2014.

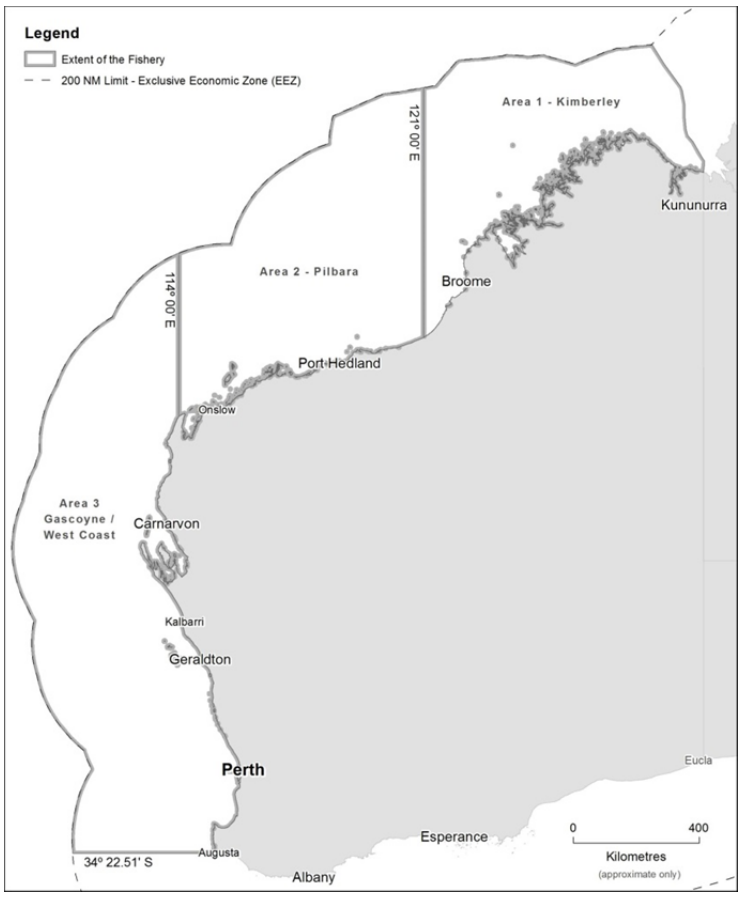
A harvest strategy is currently being developed for the fishery which will assist the monitoring and performance of the fishery.

An operator's guide is also being developed for licence holders and skippers to enhance their understanding of the management arrangements for the fishery.

SPANISH MACKEREL TABLE 1

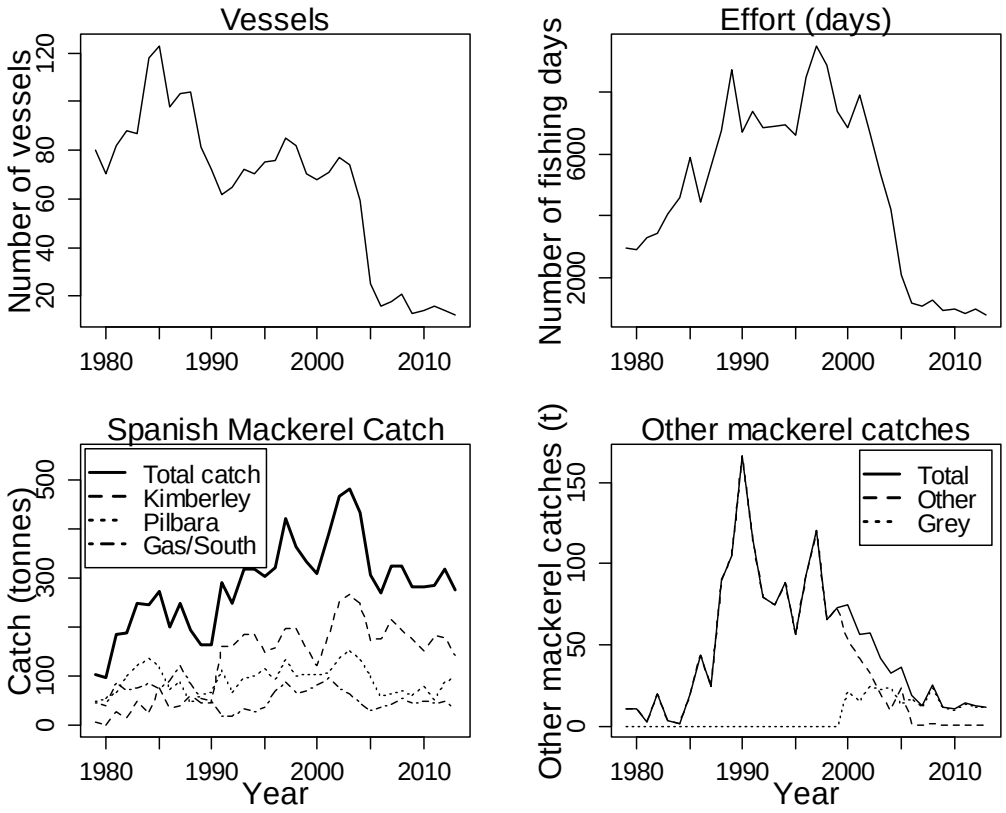
Recreational boat-based catch estimates (in tonnes, t) of Spanish mackerel in Western Australia 2011/12. Estimates are based on an average weight of a Spanish mackerel of 6.9 kg. No Spanish mackerel were reported from the South Coast Bioregion during 2011/12.

Bioregion	Retained catch (std. error)	Released catch (std. error)	Total catch (std. error)
North Coast	26.2 t (3.66 t)	30.8 t (6.58 t)	57.0 t (8.59 t)
Gascoyne Coast	21.3 t (2.80 t)	24.0 t (4.81 t)	45.2 t (6.61 t)
West Coast	20.7 t (3.02 t)	6.3 t (1.46 t)	27.0 t (3.81 t)
Statewide (total)	68.1 t (9.47 t)	61.2 t (12.84 t)	129.3 t (19.01 t)



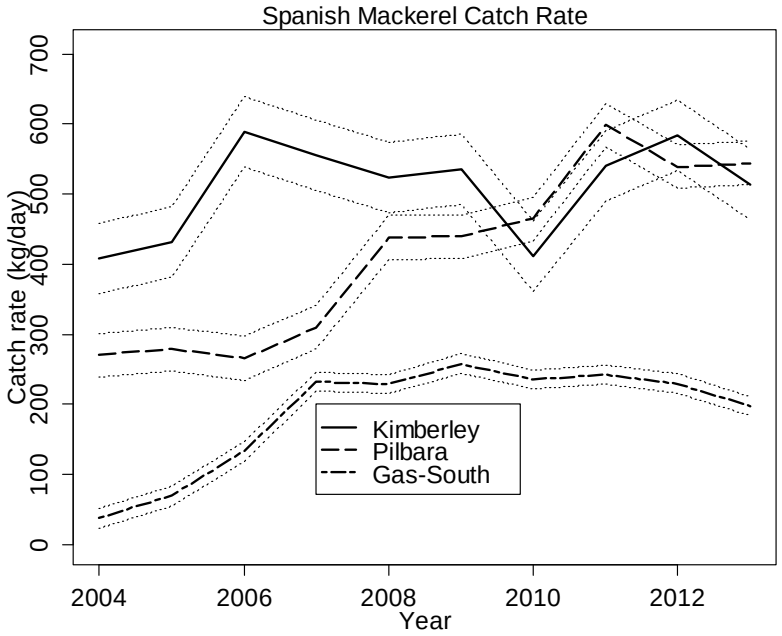
MACKEREL MANAGED FISHERY FIGURE 1

Map of the extent of the Mackerel Managed Fishery.



SPANISH MACKEREL FIGURE 2

Annual number of vessels, effort (days) and catches of Spanish mackerel (by management Area) and other mackerel in Western Australian Mackerel managed Fishery, 1979–2013. Note: quota management was introduced in 2006 and the fishery became fully managed in 2013.



SPANISH MACKEREL FIGURE 3

Nominal annual catch rates of Spanish mackerel (by management Area) in the Western Australian Mackerel managed Fishery, 1979–2013 derived from daily logbooks, 2004–2013. Dotted lines around each line represent +/- 1 standard error of the mean of each series.

Pearl Oyster Managed Fishery Status Report

A. Hart and D. Murphy and R. Jones

Main Features

Status		Current Landings	
Stock level	Adequate	Commercial Pearl Oyster Catch	
Fishing level	Acceptable	Shell numbers (All Zones)	517,653 shells

Fishery Description

The Western Australian pearl oyster fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. It is a quota-based, dive fishery, operating in shallow coastal waters along the North-West Shelf.

The harvest method is drift diving, in which six to eight divers are attached to large outrigger booms on a vessel and towed slowly over the pearl oyster beds, harvesting legal-sized oysters by hand as they are seen. The species targeted is the Indo-Pacific, silver-lipped pearl oyster (*Pinctada maxima*).

Governing legislation/fishing authority

Pearling Act 1990

Pearling (General) Regulations 1991

Commonwealth Government *Environment Protection and Biodiversity Conservation Act 1999* (Export Exemption)

Consultation process

The Department undertakes consultation directly with the Pearl Producer's Association (PPA) and licensees on operational issues. Formal license holder engagement is convened by the West Australian Fishing Industry Council (WAFIC) under a Service Level Agreement with the Department.

Boundaries

The fishery is separated into 4 zones (Pearl Figure 1), as follows:

Pearl Oyster Zone 1: NW Cape (including Exmouth Gulf) to longitude 119°30´ E. There are 5 licensees in this zone. This zone has not been fished since 2008.

Pearl Oyster Zone 2: East of Cape Thouin (118°20´ E) and south of latitude 18°14´ S. The 9 licensees in this zone

also have full access to Zone 3. This zone is the mainstay of the fishery.

Pearl Oyster Zone 3: West of longitude 125°20´ E and north of latitude 18°14´ S. The 2 licensees in this zone also have partial access to Zone 2.

Pearl Oyster Zone 4: East of longitude 125°20´ E to the Western Australia/Northern Territory border. Although all licensees have access to this zone, exploratory fishing has shown that stocks in this area are not economically viable. However, pearl farming does occur.

There is also a 'buffer zone' between zones 1 and 2, which may be accessed by licensees from both Zones, although in practice, it is generally only utilised by Zone 1 licensees.

Management arrangements

The Western Australian pearling industry comprises three main components: the collection of pearl oysters from the wild; production of hatchery-reared pearl oysters; and the seeding of pearls followed by grow-out in pearl oysters on pearl farm leases. Quota limits are set for the take of pearl oysters from the wild to ensure the long-term sustainability of the resource.

The pearl oyster fishery is managed primarily through output controls in the form of a total allowable catch (TAC) divided up into individually transferable quotas (ITQs). There are 572 wild-stock ITQ units allocated across three management zones (Zone 1 – 115; Zone 2 & 3 – 457). Hatchery production is also controlled by ITQs; currently there are 350 hatchery ITQ units allocated amongst 14 pearling licensees, however this restriction is currently under review.

The value of a hatchery quota unit is 1,000 shell. The value of wild-stock quota units varies, depending on the status of wild stocks in each management area. Between 2008 and 2011 it was set at historically high levels (3,500 shell in 2011) in Zone 2&3 due to increased stock abundance. The 'culture-sized' (or 100 – 174 mm) wild stock quota unit for Zone 2/3 for the 2013 season was 1,200 shell for oysters, as a result of stock levels returning from record high levels (Pearl Figure 2). In addition, a quota for 'MOP' only (oysters ≥ 175 mm) of 163 shells per unit (TAC = 74,791 MOP oysters) was also granted, resulting in a total TAC of 1,363 shells per unit. The Zone 1 wild stock quota unit remained at 478 shell per unit.

Wild stocks are reviewed each year by the Department of Fisheries to enable the TAC to be set for each zone of the fishery. There is a new minimum legal size of 100 mm shell length which is under trial for seasons 2012 - 2014. Historically the legal size limit has been 120 mm shell length, and maximum legal sizes and area-specific TACs have been set where appropriate (e.g. in Exmouth Gulf in Zone 1). The catch of pearl oysters is divided up into two size classes; "culture" shell, between 100 and 175 mm, and "MOP" shell, which are greater than 175 mm.

A comprehensive Ecologically Sustainable Development assessment of this fishery has been undertaken to identify any potential sustainability risks requiring direct management. The only issue identified through this process related to the breeding stock levels of pearl oysters. Boxed text in this status report provides the annual assessment of performance for this issue.

The Pearl Oyster Fishery was re-assessed in 2013 under the *Environment Protection and Biodiversity Conservation Act 1999* and is currently exempt from export controls under the List of Exempt Native Species until December 2018.

Research summary

Current stock assessment research is focused on 5 main areas: (1) catch and effort statistics, (2) monitoring an index of settlement for predicting future years' catch levels, (3) stock and habitat surveys using length frequency data and diver observations, (4) development of control rules for determining the TAC; and (5) investigating environmental drivers of pearl oyster abundance.

The Department of Fisheries' Research Division's Fish Health Unit also provides a comprehensive disease-testing program to the industry.

There are several other significant research projects being carried out by the pearling industry focusing on environmental management, improved health and safety for pearl divers and pearl oyster health. The main aims of the pearl oyster health study are to investigate aspects of oyster oodema disease (OOD) in *Pinctada maxima*, to assist in mitigating the impacts and understand pathways to disease and disease response in pearl oysters.

Retained Species

Commercial landings (season 2013):

517,653 shell

In 2013, catch was only taken in Zone 2/3 and the number of wild-caught pearl oyster shell was 517,617 comprised of 381,632 culture shells and 135,721 MOP shells (Pearl Figure 2). The TAC for culture shells was 548,400, thus 70% of the TAC was caught. In comparison, 556,000 culture shells were caught in 2012. The reduced catch in 2013 was due to a lower quota and abundance returning to more normal levels with some culture shell not fished for economic reasons. The take of 135,721 shells for MOP, which are large oysters (>175 mm shell length), was similar to 129,000 MOP caught in 2012 and represents the second year of the trial fishery for MOP (Pearl Figure 2).

There has been no fishing in Zone 1 since 2008.

Fishing effort/access level

Total effort was 11,993 dive hours (Pearl Figure 2), a decrease of 31% from the 2012 effort of 17,396 hours (highest effort level since the early 1990s). Of this total effort, 10,780 hours was focused on culture shell fishing, and the remaining 1,213 hours was applied to MOP fishing.

Stock Assessment

Assessment complete: **Yes**

Assessment level and method **Level 3**

Catch rate predictions, standardised CPUE

Breeding stock levels: **Adequate**

A stock assessment of the *Pinctada maxima* fishery was undertaken for the 2013 fishing season based on catch and effort statistics, settlement analysis (42,000 shell sampled for 'piggyback' spat to obtain estimates of age 0+ and 1+ relative abundance), length-frequency sampling (5,000 shells measured), shell discard rates by size and location, population dive surveys, and an evaluation of the predictive capacity of 0+ and 1+ spat settlement data.

These were used to generate trends in stock indicators, from which the assessment of the TAC for 2014 was undertaken and provided to the Stock Assessment Working Group (SAWG). The SAWG is a Department-Industry group that provides integrated advice to the Director General on the sustainable harvest of the pearl oyster resource. The results for each zone, and issues relevant to stock sustainability were:

Zone 2/3: The catch rate achieved by the fishery is an indicator of the abundance of the 3/4 to 6/7-year-old oysters specifically targeted for pearl production. Year-to-year variations reflect changes in recruit abundance, while the long-term trend in catch per unit effort (CPUE) involves an element of effort efficiency change. In 2013, a standardised SCPUE index was developed and provides the best estimate of annual abundance accounting for environmental and efficiency effects. SCPUE in 2013 was 24 shells per hour which is at the lower end of the target range, but still above the threshold SCPUE (Pearl Figure 3). Raw CPUE was 35 shells per dive hour, a similar level to 2012 (36 shells per dive hour; Pearl Figure 3). This stabilisation of catch rate indicates that stock levels have returned to normal levels after record high levels in 2008 - 2011 as a result of good spat settlement in 2005. The MOP catch rate of 112 shell per hour in 2013 was much higher than the 72 shell per hour in 2012.

Catch rate prediction: Recruitment to the Zone 2/3 fishery, as measured by the standardised catch rate (SCPUE), is predicted by the piggyback spat abundance index at 4 to 6 years prior to the current fishing year. The predicted recruitment is then used to set the quota for forthcoming years according to the harvest control rule (Pearl Figure 4). A very high 0+ spat abundance detected in the Zone 2 fishery in 2005 was confirmed in the 1+ spat year class in 2006, and again in the 2+ age class from population surveys in 2007. This cohort entered the commercially fished population between 2009 and 2011 resulting in the highest CPUE for over 30 years (Pearl Figure 3; Pearl Figure 4), but CPUE has now returned to normal levels as a result of spat settlements returning to normal levels.

Using the catch rate prediction system, the culture catch quota for 2014 was reduced to a unit value of 1,100 shells (TAC = 502,700) which is an 8% reduction in the 2013 TAC of 548,400 shell (Pearl Figure 4). A small increase in CPUE is predicted for the following two years, 2015 and 2016. Fishers were also given an MOP quota of 328 shell per unit to further explore the potential of the MOP fishery, resulting in a total quota of 1,428 shells per unit.

Zone 1: The Zone 1 fishery has not been fished since 2008.

Breeding stock: Under average growth and mortality and recent levels of TAC, recruitment into the pearl oyster breeding stock exceeds natural mortality, and hence breeding stocks are likely to be increasing in most years. This results from the 'gauntlet' fishing strategy employed by the industry, in which the young, fast-growing shell (principally males) of 120 – 165 mm shell length are targeted for their fast pearl-producing qualities. Despite the fishery trialling a minimum size of 100 mm for 3 years, the basis for quota setting remains the abundance within the 120-165 mm size class.

Animals that survived this 'gauntlet' were effectively protected from the age of 6 to 7 years onward, and could have lived for another 15 to 20 years. With very low natural mortalities, this results in a large broodstock being built-up over time. The fishery is trialling the capture of a conservative level of MOP shell which should not make a significant impact on the breeding stock. In Zone 1, breeding stock should also be increasing due to the low effort since 2002, including no fishing in 2004, 2009 – 2013.

The performance measures for this fishery, which relate to breeding stock biomass, include the area of fishing compared to the distribution of the stock and the catch rates of young oysters within each of the fishing zones.

All performance measures were met for 2013. The area of fishing remains substantially less than 60% of the distribution of oysters within this region. The catch rates in Zones 2 and 3 were both still above their respective performance levels, with a combined catch rate of 36 oysters/hour.

Non-Retained Species

Bycatch species impact: **Negligible**

Divers have the ability to target pearl oysters of choice (species, sizes and quality of P. maxima). Pearl oysters brought to the vessel after hand collection are young and have relatively little epiphytic growth (fouling organisms). A small number of over-sized or under-sized oysters are returned to the substrate.

Listed species interaction: **Negligible**

There is no interaction between the pearl oyster fishing operation and listed species.

Ecosystem Effects

Food chain effects: **Negligible**

The fishery removes only a small proportion of the biomass of pearl oysters on the fishing grounds and is considered to have negligible impact on the food chain in the fishing area.

Habitat effects: **Negligible**

Pearl divers have minimal contact with the habitat during fishing operations. The main habitat contact is by pearl oysters held in mesh panels on holding sites following capture. However, these sites cover a very small proportion of the habitat and the activity concerned is unlikely to cause any lasting effect.

Similarly, the pearl farming operation, which uses longline systems in areas of high tidal flow to culture pearls, has limited impact on the environment. Physical effects are limited to static anchoring systems in typically sand/mud

habitats. Environmental management research has demonstrated that pearl farming has negligible impacts on habitat and environment.

Social Effects

Direct

Pearl oyster fishing vessels operate from the Lacepede Islands north of Broome to Exmouth Gulf in the south. The number of vessels in the fishing fleet has been slowly reducing from 16 in 1997 (overall), mostly due to increased fleet efficiency and increased reliance on hatchery-produced shells. In 2009, with the negative impact of the Global Financial Crisis (GFC) on the industry, only two vessels fished. The number of vessels fishing in 2013 was five.

Most vessels presently operate 10 – 14 crew for the fishing of pearl oysters between March and June each year. These vessels also support shell operations and a number of other pearl farm functions throughout the year.

Indirect

Prior to the GFC, the pearling industry provided employment for approximately 500 people in the northern coastal regions, including in the operation of the pearl farms. However the impact of the GFC resulted in a substantial reduction in personnel employed in the pearling industry.

Economic Effects

Estimated Total Industry value for 2013

Level 5 - > $20 million ($61 million)

A precise estimate of the total industry value is difficult to achieve, owing to the variable time lags that occur between harvesting and sale to offshore buyers, and the costs incurred in marketing before sales take place. Based on information provided by the industry, the value of cultured pearls and by products in 2013 was considered to be approximately $61 million, which is 23% lower than 2012, in which it was $79 million.

Fishery Governance

Target effort range: 14,071 - 20,551 hours

Target SCPUE range (Zone 2/3 fishery): 25 - 90 shells per hour

The target effort range relates to the time required to achieve the TAC (culture shell only) in all zones of the pearl oyster fishery. Acceptable effort ranges for individual management zones are 11,456 – 15,819 dive hours for Zone 2/3 and 2,615 – 4,732 dive hours for Zone 1. These ranges are based on the 5-year period (1994 – 1998) following the introduction of global positioning systems (GPS) into the fishery, and reflect the typical variation in abundance of the stock under natural environmental conditions.

Historically, the target effort range has been the main governance / performance measure, however recent changes in the fishery such as the cessation of fishing in Zone 1 and Zone 3 for economic reasons, and new management initiatives such as the MSC assessment process has resulted in the development of new, more relevant indices for management. In 2013, a target SCPUE range was developed based on the 11 year time period 2003 – 2013 considered to reflect the typical variation in abundance of the stock under natural environmental conditions. This replaces the old target effort range, which has been provided for comparison.

Zone 2/3 of the pearl oyster fishery achieved its catch with 10,778 dive hours of effort, which was just below the lower limit of the old target range.

Zone 2/3 of the pearl oyster fishery achieved its catch at an SCPUE of 25 shells per hour, which was within the target range of SCPUE.

Zone 1 of the pearl oyster fishery was not fished in 2013.

Current effort level: Acceptable

Overall fishery effort level is acceptable.

New management initiatives (2014)

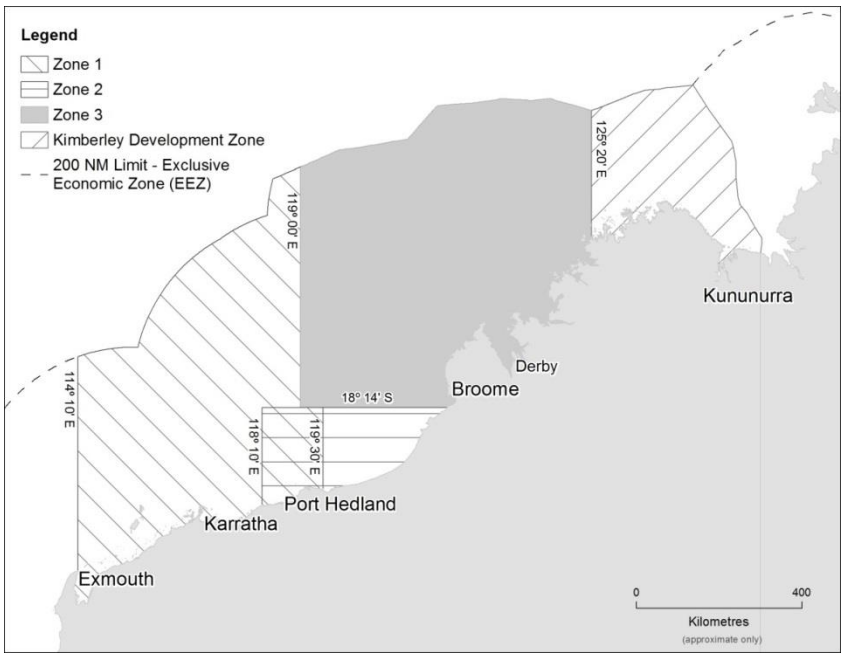
The Department has approved the continuation of a trial for industry to take smaller shell legally, 100 - 119 mm until the end of 2016. The request to take smaller shell was put forward by industry to evaluate the economics for their business model. The Department advised that there were no sustainability issues under a fixed TAC.

The Pearl Oyster Fishery underwent MSC pre-assessment in 2014.

A new State Act of Parliament to ensure the sustainability and management of all WA's aquatic biological resources is planned for introduction into Parliament in 2014. The new Act will replace both the *Fish Resources Management 1994* and *the Pearling Act 1990*. The Department is facilitating a review of the current legislative framework ahead of the introduction of the new Act to adopt a more streamlined governance structure for the pearl oyster fishery and activities associated with pearl culture.

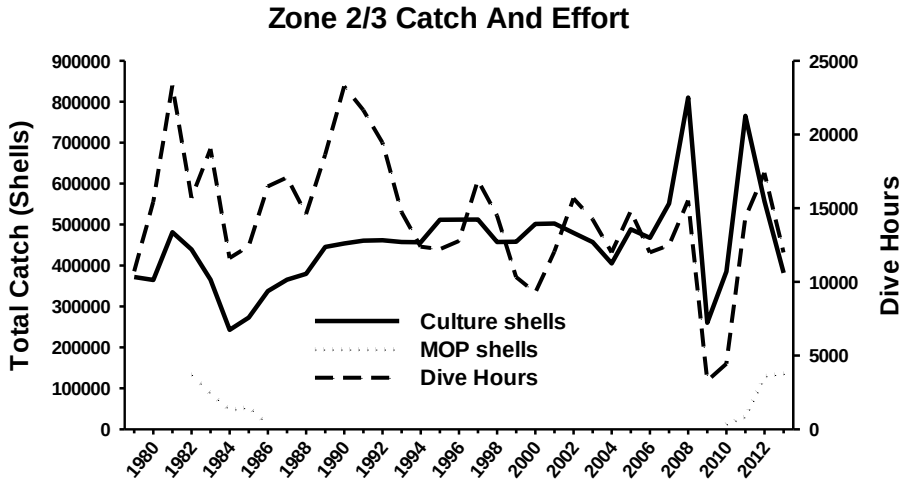
External Factors

The pearl oyster stocks underpinning the fishery in Zone 2/3 continue to provide a sufficient level of production to support this major Western Australian industry, however preliminary research points to environmental factors being an external driver of the high abundance in 2008-2011. The industry will continue to experience difficulty from the Global Financial Crisis, which had a major impact on the market for luxury goods, including pearls. Future signs for 2014 suggest a market recovery but natural declines in oyster abundance due to lower settlement. Finally, the on-going issue of the OOD (oyster oedema disease) continues to hamper hatchery-production capacity in some sectors of the Industry, however to date there is no evidence the disease has affected wild stocks.



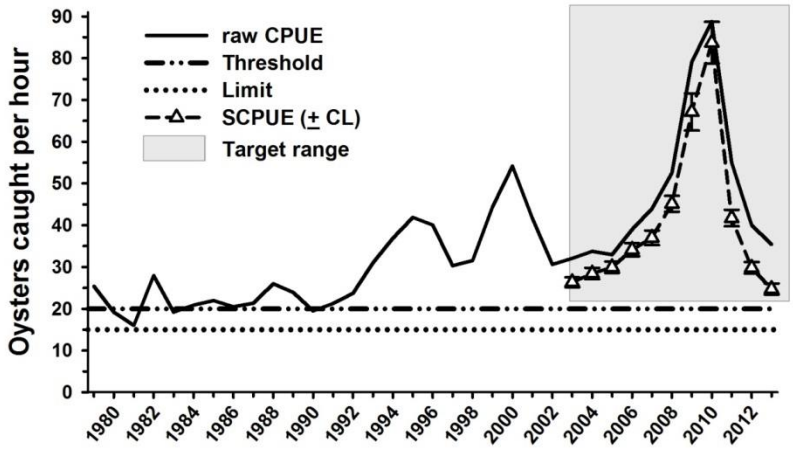
PEARL FIGURE 1

Distribution of pearl oyster stocks and fishing zones in Western Australia.



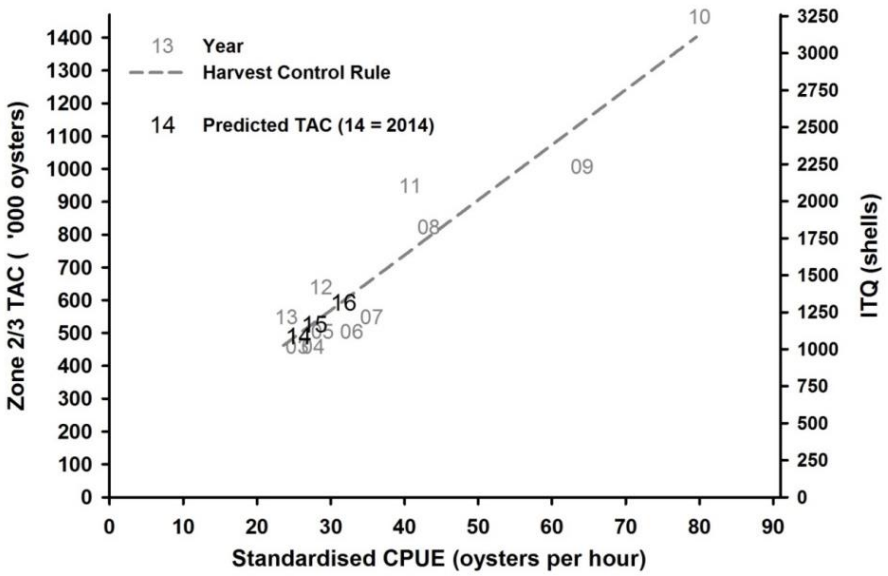
PEARL FIGURE 2

Pearl shell catch and effort – Broome area (Zone 2/3)



PEARL FIGURE 3

Standardized and raw Pearl shell catch per unit effort (CPUE) in the Zone 2/3 fishery with threshold and limit reference points and target range indicated.



PEARL FIGURE 4

Harvest control rule for the Zone 2/3 pearl oyster fishery. The current rule takes the form TAC (Total Allowable Catch) = 16.8 * SCPUE + 66.5 (r^2 = 0.89). The harvest rule is updated with each annual assessment and prediction of future SCPUE

Beche-de-mer Fishery Status Report

A. Hart, D. Murphy and K. Green

Main Features

Status		Current Landings	
Stock level	Acceptable	*Holothuria scabra* – Sandfish	0 t
Fishing level	Acceptable		

Fishery Description

Beche-de-mer, also known as 'sea cucumbers' or trepang, are in the Phylum Echinodermata, Class Holothuroidea. They are soft-bodied, elongated animals that usually live with their ventral surface in contact with the benthic substrate or buried in the substrate.

The Western Australian *beche-de-mer* fishery is primarily based in the northern half of the State, from Exmouth Gulf to the Northern Territory border, however fishers do have access to all Western Australian waters. It is a hand-harvest fishery, with animals caught principally by diving, and a smaller amount by wading. While six species have been taken, prior to 2007 it was primarily a single species fishery, with 99% of the catch being sandfish (*Holothuria scabra*). An additional species (deepwater redfish - *Actinopyga echinites*) was also targeted during 2007-2010.

Governing legislation/fishing authority

Fisheries Notice no. 366

Exemption under Section 7(3)(c) of the *Fish Resources Management Act 1994*

Commonwealth Government *Environment Protection and Biodiversity Conservation Act 1999* (Wildlife Trade Operation)

Consultation process

Industry Annual Management Meetings are convened by the Western Australian Fishing Industry Council (WAFIC), under a Service Level Agreement with the Department. Annual Broome Consultative Forum.

Boundaries

The *beche-de-mer* fishery is permitted to operate throughout Western Australian waters with the exception of a number of specific closures around the Dampier Archipelago, Cape Keraudren, Cape Preston and Cape Lambert, the Rowley Shoals and the Abrolhos Islands.

Management arrangements

The developing fishery for *beche-de-mer* is managed through input controls including limited entry, maximum number of divers, species-dependent minimum legal size limits, and gear restrictions. Access to the fishery is limited to the 6 Fishing Boat Licence holders listed in the Instrument of Exemption enabling the take of *beche-de-mer*.

Beche-de-mer may only be harvested by hand or diving by licensed commercial fishers operating under the authority of a Fishing Boat Licence that is listed on the Instrument of Exemption.

The maximum number of divers (per endorsed fishing boat licence) allowed to dive for *beche-de-mer* at any one time is four, with a maximum number of six crew allowed on the vessel.

There are six species of *beche-de-mer* harvested in Western Australia. At present, the minimum target lengths for these commercial *beche-de-mer* species are based on the Northern Territory's minimum sizes, which have been set based on size at sexual maturity.

A comprehensive Ecologically Sustainable Development assessment of this fishery has been undertaken to identify any potential sustainability risks requiring direct management. The only issue identified through this process related to the breeding stock levels of *beche-de-mer*. Boxed text in this status report provides the annual assessment of performance for this issue.

Research summary

Current research is focused on reporting of annual catch and effort statistics. A daily catch and effort logbook designed for the fishery was implemented in 2007. The logbook obtains species-specific, fine-scale catch and effort data and appropriate environmental information, such as depth fished.

Retained Species

Commercial landings (season 2013

0 tonnes (live weight)

Landings

No fishing for *beche-de-mer* occurred in 2013. Industry has advised they are adopting a rotational fishing strategy for both the traditional sandfish *Holothuria scabra* fishery and recently discovered deepwater redfish *A. echinites* fishery. Fishing activity within the Western Australian fisheries is in a resting phase. Current trends of catch and effort within the fisheries are shown in Figure 1.

This is the third year in the last 7 years that *Actinopyga echinites* has not been caught and represents an effort reduction on this new target species. This is the first year since 1995 that *Holothuria scabra* have not been caught.

Fishing effort/access level

None of 6 licensed vessels fished for *beche-de-mer* in 2013, therefore nil hours fished.

Stock Assessment

Assessment complete: **Yes**

Assessment level and method:

Level 2 - Catch rate

Breeding stock levels: **Adequate**

Estimates of Maximum Sustainable Yield (MSY) of sandfish were obtained for the entire WA fishery and Kimberley sub-regions using a biomass dynamics model. Current average catch of sandfish is below the MSY (Beche-de-mer Table 2), indicating that the level of fishing is sustainable. However, large variability in the estimates of q (0.21 – 0.55) for the same species suggests that a cautious interpretation of the model outputs is required. The model is updated with new data every year.

The species performance measure for the Sandfish fishery are catches remaining in the range 20 – 100 t and catch rate remaining above 25 kg/hour. In 2013, there was no fishing for this species so the performance measures could not be evaluated.

The species performance measure for the Redfish fishery are catches remaining in the range 40 – 150 t and catch rate remaining above 60 kg/hour. In 2013, there was no fishing for this species so the performance measures could not be evaluated.

Non-Retained Species

Bycatch species impact: **Negligible**

No bycatch species are known to be taken in this fishery. Given the selective method of fishing used (diving or wading, collection by hand only), the minimal level of interaction with other species is likely to be maintained.

Listed species interaction: **Negligible**

There are currently no known interactions with listed species in this fishery and given the methods of collection this is likely to remain the case.

Ecosystem Effects

Food chain effects: **Negligible**

This fishery harvests only a small amount of sandfish and redfish per annum. The effect from this harvesting on the rest of the ecosystem, given that the catch is spread over a wide region, would be insignificant.

In addition, predation on the *beche-de-mer* is relatively infrequent due to the toxins present in their body tissues. It is highly unlikely these animals are a major diet for higher-order predators, due to these toxins acting as an effective defence system.

Habitat effects: **Negligible**

Divers collect *beche-de-mer* as they drift over the bottom; there is minimal impact on the habitat as divers are highly selective in their fishing effort and no fishing gear or lines contact the seabed. The vessels work during the day and anchor at night, usually further inshore where they are protected from the open ocean that is subject to higher seas and wind. Most fishers are mindful of the habitat they choose to anchor over, so they avoid more diverse bottom habitat.

There are some areas where fishers can access *beche-de-mer* by wading through shallow water mangrove lagoons and estuaries. This is a minor component of the fishery. This method may be applied in areas of the Kimberley that are accessible and prone to extreme tidal movements. Wading usually occurs on soft sandy substrates, with minimal impact on these habitats.

Social Effects

Generally a vessel employs 4 to 6 crew with one of those a master, a deckhand and remaining divers. Additional individuals are employed for the processing of the product. These activities are mostly located in the Northern Territory where the fishing fleet is based.

Economic Effects

Estimated annual value (to fishers) for 2013:

Level 1 - < $ nil

Fishery Governance

Sandfish catch range: **20 – 100 tonnes**

Redfish catch range: **40 – 150 tonnes**

New management initiatives (2014)

A review of the developing Beche-de-mer fishery is planned for 2014/15.

The species-specific information on catch and effort from the daily logbook, implemented in 2007, has facilitated the development of species-specific performance indicators and these will be refined as more information arises.

External Factors

The remoteness of the currently fished stock and the large tidal ranges where it occurs are natural barriers to uncontrolled expansion of fishing of *beche-de-mer*. Marine park planning has to date restricted this fishery from general use zones of MPAs. However consideration of removal of this restriction is currently underway as all other fisheries have access to general use zones. If successful, this action will likely see some expansion into previously unfished areas. Currently, lack of experienced fishers and suitable vessels is restricting catch to low levels. This situation is expected to change within the next two years.

BECHE-DE-MER TABLE 1

Catch and effort of *Beche-de-mer* in Western Australia for the last decade.

Year	Live Wt (t) (all species)	Hours fished (all methods)	Live Wt (t) (Sandfish)	Hours fished (Sandfish)	Live Wt (t) (Redfish)	Hours fished (Redfish)	Live Wt (t) (Teatfish)
2001	90	2,434	88	2,414	2	20	0.2
2002	87	3,235	87	3,235	0		0
2003	122	4,877	121	4,867	1	10	0
2004	81	2,117	81	2,117	0		0.2
2005	78	1,876	75	1,876	0		0
2006	58	2,662	55	2,632	3	30	0.3
2007	113	1,804	26	976	87	828	0
2008	196	1,544	27	448	169	1096	0
2009	129	1,423	31	701	98	722	0
2010	121	1,053	35	754	86	299	0
2011	56	1539	56	1539	0	0	0
2012	13	413	13	413	0	0	0
2013	0	0	0	0	0	0	0

BECHE-DE-MER TABLE 2

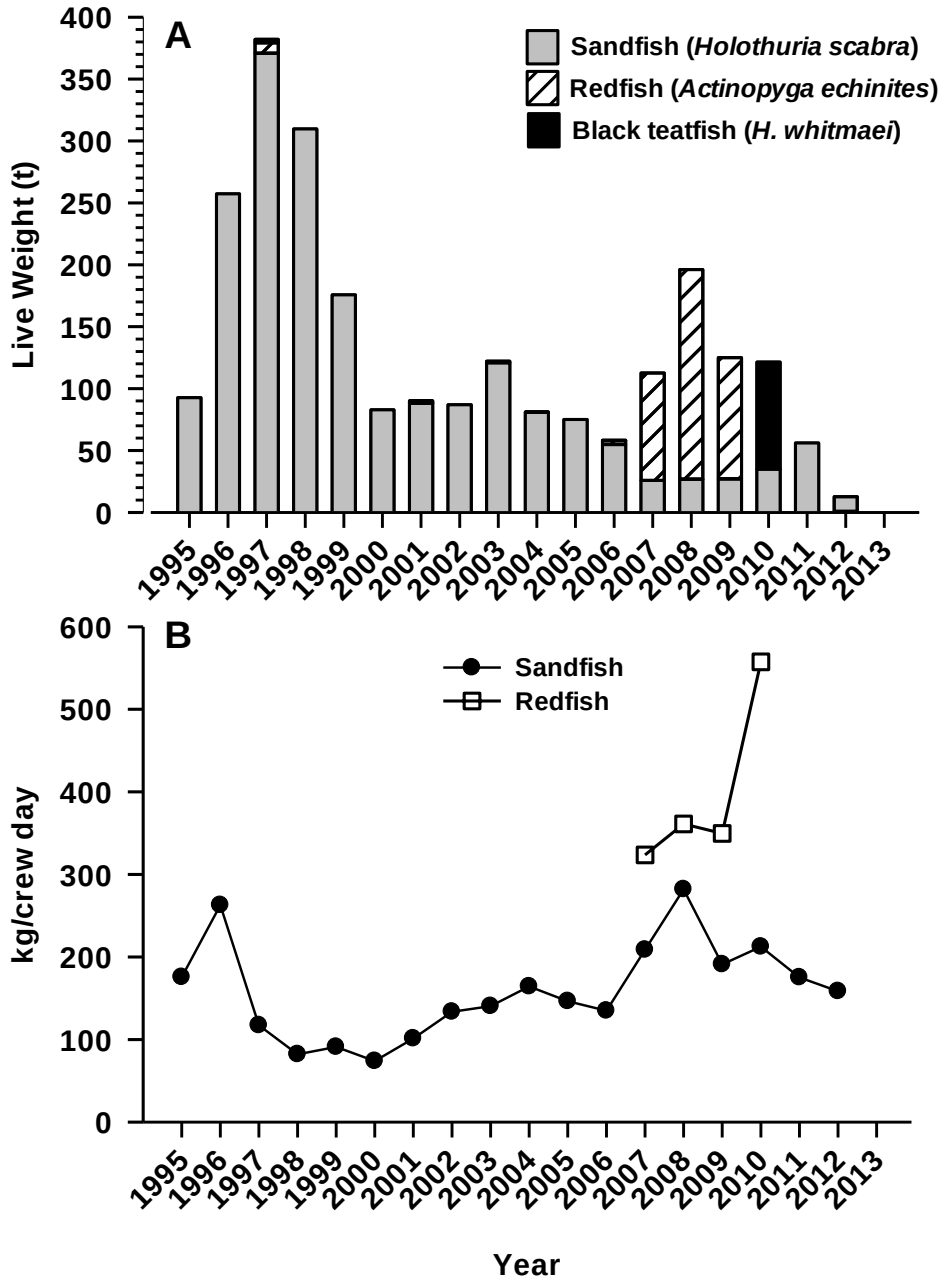
Estimates of Maximum Sustainable Yield (MSY) of sandfish in the Western Australian Beche-de-Mer fishery.

Area	MSY (t)	Current average catch (2005-2012) (t)	Parameter estimates*		
			r	K (t)	q
Entire Fishery	143	40	0.84	966	0.21
Kimberley region (Grid 1425 and 1426)	70	34	0.95	423	0.55

* r – intrinsic rate of increase

k – carrying capacity (Virgin biomass)

q – catchability or fishing power



BECHE-DE-MER FIGURE 1

A) Production (tonnes/live weight) by species, and B) catch rate (kg per crew day) from the Western Australian *Beche-de-mer* fishery.

North Coast Crab Fishery Status Report

D. Johnston, C. Marsh, R. Evans, N. Blay and D. Wallis

Main Features

Status		Current Landings	
Stock level		Blue swimmer crab	
Blue swimmer crab	Acceptable	Commercial	5.8 t
Mud crab	Unknown	Recreational (boat-based) (Mar 11- Feb 12)	3.4 t
Fishing Level		Mud crab	
Blue swimmer crab	Acceptable	Commercial	7.9 t
Mud crab	Acceptable	Recreational (boat-based) (Mar 11- Feb 12)	9387 retained animals

Fishery Description

Blue Swimmer Crab

The blue swimmer crab (*Portunus armatus*) is found along the entire Western Australian (WA) coast, in a wide range of inshore and continental shelf areas, from the inter-tidal zone to at least 50 m in depth. However, the majority of the commercially and recreationally-fished stocks are concentrated in the coastal embayments and estuaries between Geographe Bay in the south west and Port Hedland in the north.

Blue swimmer crabs are targeted using a variety of fishing gear but most commercial crab fishers in WA now use purpose-designed crab traps. Operators in the Pilbara Developmental Crab Fishery are only permitted to use 'hourglass' traps. The Onslow and Nickol Bay prawn trawl fisheries also retain crabs as a by-product.

The Pilbara Developmental Crab Fishery was established in 2001 via the Developmental New Fisheries process, following the granting of an exemption from existing trap prohibition legislation, pursuant to section 7 of the *Fish Resources Management Act 1994* (FRMA). The exemptions were issued to allow for the sustainable exploration of the commercial viability of fishing crab stocks along the Pilbara coastline.

Mud Crab

Four species of mud crab (*Scylla* spp.) have been identified in the Indo-West Pacific region, of which the green mud crab (*Scylla serrata*) and brown mud crab (*Scylla olivacea*) occur in Western Australia (Keenan *et al.*, 1998)[1]. The maximum size reported for green mud crabs is between 250 – 280 mm carapace width (CW) (Lloris, 2001)[2], whereas the maximum size of brown mud crabs is between 135 – 139 mm CW (Tongdee, 2001)[3]. A species identification waterproof card outlining minimum legal size limits and defining characteristics between green and brown mud crabs was produced by the Department of Fisheries in 2011 and is widely available to members of the public.

The green mud crab is predominantly found in estuarine habitats in north-western Australia from the Northern Territory border to Shark Bay, but have also been found as far south as the Wilson Inlet at Denmark in years of strong southern coastal Leeuwin Current flow (Gopurenko *et al.*, 2003)[4]. The brown mud crab has a more restricted distribution limited to northern embayments, with most catches from King Sound 200 km northwest of Broome. Brown mud crabs are more tolerant of low salinity than green mud crabs, but less tolerant of lower temperatures. They are also considered to exhibit a strong preference for the intertidal zone, while green mud crabs make regular use of both intertidal and subtidal habitats up to 20 m depth offshore (Hill, 1994[5], Robertson, 1996[6]).

The Kimberley Developing Mud Crab fishery is currently a small developing fishery that targets the green (giant) mud crab and the brown (orange) mud crab via the use of crab traps, between Broome and Cambridge Gulf near the WA and Northern Territory border, with fishing effort concentrated around Cambridge Gulf, Admiralty Gulf, York Sound and King Sound (see North Coast Crab Figure 1 and 2). From 1994 to 2005 commercial fishing for mud crabs was authorised through permissive conditions on Fishing Boat Licences. From 2006 to present, access to the Kimberley Developing Mud Crab Fishery has been granted via Exemptions, which were formerly issued under Section 7(3)(c) of the Fish Resources Management Act 1994, for 'the exploration or development of fisheries or the development of fishing technology'.

The design of mud crab trap permitted to be used is not prescribed in the management arrangements at present, in order to allow some flexibility for exemption holders to

1 Keenan, C.P., Davie, P.J.F., and Mann, D.L. (1998). A revision of the genus Scylla de Hann, 1833 (Crustacea: Decapoda: Brachyura: Portunidae). Raffles Bulletin of Zoology. 46(1): 217-245.

2 Lloris, D. (2001). FAO/SIDS species identification sheet: *Scylla serrata*

3 Tongdee, N. (2001). Size distribution, sex ratio and size at maturity of mud crab (Scylla spp.) in Rangong Province, Thailand. Asian Fisheries Science 14: 113-120.

4 Gopurenko, D., Hughes, J.M., and Bellchambers, L.M. (2003) Colonisation of the south-west Australian coastline by mud crabs: evidence for a recent range expansion or human-induced translocation? Marine and Freshwater Research. 54. 833-840.

5 Hill, B.J. (1994) Offshore spawning by the portunid crab Scylla serrata (Crustacea: Decapoda). Marine Biology. 120:3. 379-384.

6 Robertson, W.D. (2011) Abundance, population structure and size at maturity of Scylla serrata (Forskal)(Decapoda: Portunidae) in Eastern Cape estuaries, South Africa. South African Journal of Zoology. 31:4. 177-185.

determine the most appropriate gear for the high tidal conditions. However, prior to using the trap, the design of mud crab traps must be approved by the Department of Fisheries. At present in the Fishery there are two styles of mud crab trap used, a rectangular trap and a round trap. The rectangular design generally follows the dimensions of not more than 1000 mm length, 600 mm width and 300 mm height with a rigid mesh of 50x70 mm with 2 openings for crabs to enter the trap. The round trap design is generally 500 mm high; 1000 mm diameter with flexible nylon mesh of around 50 mm mesh size (knot to knot) with 4 openings for crabs to enter the trap.

Access to the Kimberley Developing Mud Crab Fishery is made up of two broad groups: Aboriginal Community Commercial Mud Crab Exemption holders and Commercial Exemption holders. There are currently 3 commercial operators and 2 Aboriginal corporations holding exemptions to fish for mud crabs in WA. The fishers generally operate from March to November, with May to September being the most productive months, to avoid summer and associated seasonal cyclone weather events. Commercial operators generally fish on a part-time basis with most operating other endorsements including Kimberley Gillnet and Barramundi Managed Fishery Licences and fishing boat charters. Operators tend to fish remote waters for long periods of time in large mother ships, using small dinghies known as dorys to enter mangrove estuaries with crab traps generally checked each daylight high tide.

Governing legislation/fishing authority

Commercial

Blue Swimmer Crab

Fish Traps Prohibition Notice 1994

Exemptions under Section 7 of the *Fish Resources Management Act 1994*

Nickol Bay Prawn Fishery Management Plan 1991

Nickol Bay Prawn Managed Fishery Licence

Onslow Prawn Fishery Management Plan 1991

Onslow Prawn Managed Fishery Licence

Mud Crab

Exemptions under Section 7 of the *Fish Resources Management Act 1994*

Notice 539 – Crab Fishing Restrictions (Roebuck Bay) Notice 1991

Notice 194 – Mud Crabs (*Scylla* sp)

Recreational

Fish Resources Management Act 1994; Fish Resources Management Regulations 1995 and other subsidiary legislation

Consultation process

Commercial

Industry Annual Management Meetings are convened by the West Australian Fishing Industry Council (WAFIC), under a Service Level Agreement with the Department. Annual Broome Consultative Forum (Mud crabs)

Recreational

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

Boundaries

Blue Swimmer Crab

Crabbing activity along the Pilbara coast is centred largely on the inshore waters from Onslow through to Port Hedland, with most commercial and recreational activity occurring in and around Nickol Bay.

The boundaries of the Onslow Prawn and Nickol Bay Prawn Managed Fisheries which also capture crabs as by-product are described in the relevant status report elsewhere within this document.

Mud Crab

Three commercial operators are permitted to fish from King Sound to the Northern Territory border, with closed areas around communities and fishing camps. One Aboriginal Corporation is permitted to fish in King Sound, with the other Aboriginal Corporation permitted to fish in a small area on the western side of the Dampier Peninsular, north of Broome.

Notices issued under the *Fish Resources Management Act 1994* prohibit all commercial fishing for mud crabs in Roebuck Bay and an area of King Sound near Derby.

Management Arrangements

Blue Swimmer Crab

Commercial access to blue swimmer crab stocks in WA is governed by a series of separate management arrangements provided for under the legislative framework of the *Fish Resources Management Act 1994*. Individual fisheries are managed under an input control system, primarily through the regulation of vessel and trap numbers. Supplementary controls cover retainable species and associated minimum size limits, gear specifications, and spatial, seasonal and daily time restrictions. The principal management tool employed to ensure adequate breeding stock in the commercial crab fisheries involves maintaining minimum size limits well above the size at sexual maturity. The commercial minimum size of 135 mm carapace width which applies in the Pilbara Developmental Crab Fishery should ensure adequate egg production for associated blue swimmer crab stocks under typical environmental conditions.

The management arrangements for the Pilbara Developmental Crab Fishery are set by conditions on the exemption and are aimed at ensuring the stock and environment are protected. A maximum of 400 crab traps are permitted in the fishery.

Management controls for the Onslow and Nickol Bay Prawn Managed Fisheries are based on limited entry, seasonal and spatial closures, moon closures, and gear controls including bycatch reduction devices (grids). The fleet is composed of trawlers up to 23 metres in length; operating twin- or quad-rigged otter trawls to a maximum head-rope length of 20 fathoms (36.6 m). The Department of Fisheries' Vessel Monitoring System (VMS) monitors the activities of all trawlers in these fleets.

Recreational fishing for blue swimmer crabs in WA is managed through a series of input and output controls. As with commercial fishing, the principal management tool employed to sustain an adequate breeding stock involves maintaining minimum size limits well above the size at sexual maturity. A minimum legal size limit of 127 mm carapace width applies in the waters of the North Coast Bioregion, along with a bag limit of 20 crabs per person with a boat limit of 40 crabs. Restrictions also govern gear types that can be used to take blue swimmer crabs (drop nets, scoop nets only).

Mud Crab

Since 2006, access to the Kimberley Developing Mud Crab Fishery has been granted via Instruments of Exemption, issued under Section 7 of the *Fish Resources Management Act 1994.* The mud crab fishery is managed under an input control system, primarily through the regulation of vessel and trap numbers (maximum of 1,070 traps), gear restrictions and spatial closures. Three commercial operators are permitted to fish 300 traps from King Sound to the Northern Territory border, one Aboriginal Corporation is permitted to fish in King Sound using 150 traps, with the other Aboriginal Corporation permitted to fish in a small area on the western side of the Dampier Peninsular, north of Broome using 20 traps. Prior to the exemption not being renewed in 2011, a third aboriginal corporation fished in Carnot Bay and Camp Inlet using 20 traps.

From 1 May 2013, mud crab exemption holders have been permitted to retain bycatch of other *Portunid* crabs for a two year trial period ending 30 April 2015. This is likely to result in small numbers of blue swimmer crabs being retained. A minimum size limit of 135 mm for blue swimmer crabs has been imposed, consistent with the size limit used in the Pilbara Developmental Crab Fishery. No limits have been placed on the number of blue swimmer crabs retained.

Breeding stocks are protected by maintaining minimum size limits (150 mm CW for green mud crab and 120 mm CW for brown mud crabs) set well above the size at sexual maturity (90-120mm CW for green and 86-96mm CW for brown). This was later revised to 131-138mm CW for green mud crabs after reclassification of the *Scylla* genus (Knuckey, 1999)[1]. These size limits apply to both the recreational and commercial take of the species.

Recreational fishers for mud crabs are restricted to a daily bag limit of 5 mud crabs, with a boat limit of 10 mud crabs.

Research Summary

Blue Swimmer Crab

Data for the assessment of blue swimmer crab stocks in the North Coast Bioregion is obtained from trap fishers' compulsory monthly catch and effort returns and daily research log books, and trawl fishers' daily logbooks.

Baseline information on the biology and ecology of blue swimmer crabs has been generated by a number of Fisheries Research and Development Corporation (FRDC)-funded projects conducted by the Department of Fisheries and Murdoch University over the past decade.

1 Knuckey, I.A. (1999). Mud crab (*Scylla serrata*) population dynamics in the Northern Territory, Australia and their relationship to the commercial fishery. PhD Thesis. Northern Territory University, Darwin.

Mud Crab

Data for the assessment of mud crab stocks in the North Coast Bioregion is obtained from trap fishers' compulsory catch and effort returns and daily research logbooks. Relevant research information is sourced from 2 recent FRDC funded projects involving NT Fisheries investigating escape gap sizes of traps (Grubert & Lee., 2012)[2] and environmental correlations with mud crab catches in the Northern Territory (Meynecke *et al*., 2010)[3]. A third FRDC project has also been recently completed on equipping the mud crab industry with innovative skills through extension of best practice handling (Poole *et al.,* 2012) [4].

Retained Species

Commercial landings (season 2012/13):

Blue swimmer crabs	**5.8 tonnes**
Mud crabs	**7.9 tonnes**

Blue Swimmer Crabs

The combined commercial catch of blue swimmer crabs from trap based crab fishers and prawn trawlers operating along the Pilbara coast during 2012/13 was 5.8 t, a 53% decrease on the 2011/12 catch of 12 t (North Coast Crab Figure 4). The majority of the recorded catch was taken by the trap fishery, with trawlers retaining 0.3 t of crab catch during 2012/13.This Pilbara catch accounted for 2% of the state commercial blue swimmer crab catch of 277 t for 2012/13 (West Coast Blue Swimmer Crab Figure 1). The crab trap catch continues a declining trend and is the lowest in over 10 years primarily due to a decline in effort with one of the 2 exemptions not being renewed in 2008 and the remaining exemption holder exploring other employment opportunities in recent years.

Mud Crab

The total trap catch of mud crabs for the Kimberley Developing Mud Crab Fishery during 2013 was 7.9 t which represented 100% of the total catch of mud crab in Western Australia (North Coast Crab Figure 5). Logbooks submitted during 2013 reported that 22% or 1,4 t were brown mud crab and 78% or 4.8t were green mud crab. With the remaining 1.7 t not reported as either species or not identified due to neglecting to report catch in daily research logbooks. This catch level is significantly higher than the 3.7 t reported in 2012 (catch has been updated from figure in last year's report) due to an increase in effort, with three commercial operators fishing and 2 Aboriginal Corporations fishing in the May to November 2013 period. Catch in 2013 was higher than the 5 year (2008 – 2012) mean of 3.1 t and may be attributed to the absence of cyclonic and flooding weather events and difficulty in retaining crew and securing local markets commonly reported in previous years.

2 Grubert, M.A, and Lee, H.-S. 2012. Improving gear selectivity in Australian mud crab fisheries, Northern Territory Department of Resources, Fishery Report.

3 Meynecke, J-O., Lee, S-Y., Grubert, M., Brown, I., Montgomery, S., Gribble., Johnston, D. and Gillson, D (2010) Evaluating the Environmental Drivers of Mud Crab (Scylla serrata) Catches in Australia. Final Report 2002/012. FRDC and Griffith University.

4 Poole, S., Mayze, J., Calogeras, C. (2012) Equipping the mud crab industry with innovative skills through extension of best practice handling. FRDC Project 2010-302. 183p.

Recreational catch:

Blue Swimmer Crab
(boat-based) (Mar 11- Feb 12) 3.4 tonnes

A statewide survey of boat-based recreational fishing was conducted between 1st March 2011 and 29th February 2012 and was a collaboration between the Department of Fisheries, Edith Cowan University and RecfishWest. Approximately 3,000 fishers from the "Recreational Fishing from Boat" licence database participated in a 12 month phone-diary survey in conjunction with boat ramp surveys of boat-based fishers. Catch data were recorded in numbers of crabs, and have been converted to weight for this report using a mean statewide estimate of 229 g/crab (based on 382 crabs weighed during the boat ramp surveys). The survey provided a statewide boat-based recreational estimate of retained blue swimmer crabs for the 12-month period of 97 t (Ryan *et al.*, 2013)[1]. The boat-based estimate for the North Coast Bioregion was 3.4 t, compared with total landings of 15 t by the commercial sector over the same period.

A survey of recreational crabbing was conducted along the Pilbara coast between December 1999 and November 2000. The survey estimated the recreational catch of blue swimmer crabs for the region over the 12-month period to be 22 t, with most of the catch (19 t) taken from Nickol Bay (Williamson *et al.*, 2006)[2]. This represented the majority of the catch from Nickol Bay in that year, as commercial operations targeting blue swimmer crabs in the area did not begin until the following year.

Mud Crab
The Department of Fisheries survey of boat recreational fishing conducted over 2011/12 reported that 9387 green and brown mud crabs were retained during this period (Ryan *et al.*, 2013). Unfortunately a conversion to weight is not possible as species and sex was not recorded during the surveys. Mud crab species vary significantly in weight with anecdotal evidence suggesting brown mud crabs average around 300 grams, whereas green mud crabs can vary between 500 grams and 1.5 kg. There are also marked differences in weight between males and females. The current survey has run from May 2013 to April 2014 with data analysis yet to be completed.

Fishing effort/access level

Blue Swimmer Crab
Crab trap fishers along the Pilbara coast reported 8100 traplifts during 2012/13, which is the lowest in over 10 years and a 42% decrease on the 13,880 traplifts reported for 2011/12.

Mud Crab
Mud crab fishers along the Kimberley coast reported 9190 traplifts during 2013, a 46% increase on the 4250 traplifts reported for 2012 (North Coast Crab Figure 5). This 2013 level of effort is significantly higher than the 5 year average of 4302 traplifts (2008-2012). This higher level of effort is due to 3 commercial fishers and 2 aboriginal corporations fishing compared with 4250 traplifts reported in 2012. The absence of adverse environmental events such as cyclones and flooding cited in previous years could account for this increase in number of operators and overall effort within the Kimberley mud crab fishery for 2013.

Stock Assessment

Assessment complete:

Blue Swimmer Crab	**Pilbara - Yes**
Mud Crab	**Kimberley - Yes**

Assessment level and method:

Blue Swimmer Crab	**Level 2 - Catch rate**
Mud Crab	**Level 2 - Catch rate**

Breeding stock levels:

Blue Swimmer Crab	**Pilbara - Adequate**
Mud Crab	**Kimberley- Adequate**

Blue Swimmer Crab
The development of appropriate mesh sizes for use on commercial crab traps has eliminated the catch of juvenile crabs (< 80 mm carapace width) and significantly reduced the catch of undersize crabs < 120 mm carapace width, without impacting on legal catches. Improved work practices have also reduced the mortality of returned undersize and berried crabs caught in commercial traps to negligible levels.

The minimum legal size (127 mm carapace width for recreational fishers; 135 mm carapace width for commercial fishers) for crab fisheries in the North Coast Bioregion is set well above the size at first maturity of the resident stocks (based on size at maturity of crabs in Shark Bay - 97 mm CW males and 92.4 mm CW females, de Lestang *et al.*, 2003[3]). Consequently, breeding stock levels are expected to be adequate to maintain stocks in all current fishing areas under normal environmental conditions. The breeding stocks along the Pilbara coast are also supported by the influence of the warmer waters that occur at these latitudes which extends the spawning period over the whole year, whereas spawning is restricted to the late spring and early summer months on the lower West Coast. However, while warm temperatures during the winter have been shown to positively influence the recruitment in Shark Bay, warm summer temperatures have been shown to have a negative effect.

Catch rates from the Pilbara trap fishery provides an index of abundance that can be used to assess fishery performance from year-to-year. Blue swimmer crab trap catch rates in the Pilbara Developmental Crab Fishery increased steadily during the first three years of exploratory fishing for blue swimmer crabs along the Pilbara coast. This reflected more efficient fishing of stocks in the Pilbara region, as the commercial operators' knowledge of the spatial distribution of resident stocks and localized environmental influences increased over time. The increase in catch rate can also be attributed to improvements to fishing gear and vessels.

1 Ryan KL, Wise BS, Hall NG, Pollock KH, Sulin EH, Gaughan DJ (2013). An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Fisheries Research Report No. 249, Department of Fisheries, Western Australia. 168pp.

2 Williamson, P. C., Sumner, N. R., Malseed, B. E. 2006. A 12-month survey of recreational fishing in the Pilbara region of Western Australia during 1999-2000. Fisheries Research Report No. 153. Department of Fisheries, WA. 61 pp.

3 de Lestang, S., Hall, N. G. and Potter. I. C. 2003. Reproductive biology of the blue swimmer crab, *Portunus pelagicus* (Decapoda: Portunidae) in five water bodies on the west coast of Australia. *Fish. Bull.* 101:745–757.

Favourable environmental conditions led to a significant increase in catch rates (~1.6-1.8 kg/traplift) from 2004/05 to 2006/07, before returning to longer-term mean catch rates (~0.7-1.0 kg/traplift).

The Pilbara Developmental Crab Fishery recorded a mean catch rate for 2012/13 of 0.7 kg/trap lift – a 22% decrease on the catch rate of 0.9 kg/traplift reported during the previous year (North Coast Crab Figure 4).

Mud Crab

Between 1994 and 2005, trap catch and effort for mud crabs in the Kimberley remained low, ranging between 68 kg and 2.9 t and between 40 traplifts and 5250 traplifts. Catch rate varied significantly during these years between 0.2 and 2.0 kg/traplift. When exemptions were formally established for commercial fishers and Aboriginal corporations in 2006, the catch and effort peaked at 9.3 t from 18720 traplifts. The majority of catch and effort was attributed to the extensive exploratory efforts of a single fisher with catch per unit effort for the fishery around 0.5 kg/traplift. Although catch and effort declined in 2007, catch rate increased significantly to 1.1 kg/traplift potentially due to greater knowledge of the fishery. Catch and effort remained fairly stable in 2008 and 2009 (~ 5 t from ~ 8000 traplifts) but has since declined significantly due to a lack of fishing by the majority of fishers, with one exemption not renewed in 2011. Catch rate over the past 5 years (2009 – 2013) has fluctuated between 0.5 and 1.0 kg/traplift, with a catch rate of 1.0 kg/traplift reported in 2013. Historically, the majority of commercial crabbing has occurred in the areas of Cambridge Gulf, Admiralty Gulf, York Sound and King Sound, with fishing reported from Camp Inlet, King Sound, York Sound and Cambridge Gulf in 2013.

The minimum legal size at first capture is 150 mm carapace width (CW) for green mud crab (*Scylla serrata*) and 120 mm CW for brown mud crab (*Scylla olivacea*). This is set well above the size at first maturity of 90-120mm CW for green and 86-96mm CW for brown mud crab fisheries in the North Coast Bioregion (Knuckey, 1999) [1].

Non-Retained Species

Bycatch species impact — Negligible

Blue Swimmer Crab

The shift from using gillnets to traps in most blue swimmer crab fisheries has resulted in a substantial reduction in bycatch from dedicated crab fishing. Pots are purpose-designed to minimise the capture of non-target species and are therefore an inefficient way to capture fish, the majority of which are able to escape through the entrance gaps when the pot is soaking or being hauled.

Small numbers of fish are infrequently captured in crab pots, but the fishers are not permitted to retain them. The low number of fish caught and returned by crab fishers is considered to pose a negligible risk to these stocks.

Discarded bycatch from trawl fisheries that retain crabs as a by-product is dealt with in those sections of this report specific to the trawl fisheries.

Mud Crab

Mud crab traps are purpose built to effectively target larger (legal sized) mud crabs. The overall trap design and large mesh size allows sub legal mud crabs and non-targeted bycatch species opportunity to escape the trap, preventing them from being retained. The gear needs to be pulled regularly, and undersized and berried crabs must be returned to the water.

Listed species interaction — Negligible

Blue Swimmer Crab

The crab trap longline system used in the targeted crab fisheries has little possibility of interacting with listed species. The 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.

Mud Crab

As mud crab traps are purpose built to target mud crab species and are set for relatively short periods of time, the possibility of causing harm to listed species is minimal.

Ecosystem Effects

Food chain effects — Low

Blue Swimmer Crab

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.

Mud Crab

As the retained commercial catch of mud crabs is low, the commercial fishery represents a small proportion of the available biomass. Therefore secondary chain effects would not be likely to be significant within the surrounding ecosystem of the fishery.

Habitat effects — Negligible

Blue Swimmer Crab

Fishing with traps results in limited habitat disturbance, with only minor dragging of traps on the sea bottom 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.

Mud Crab

Trap fishing in the shallow waters of associated mangrove tidal creeks and near shore embayments result in limited habitat disturbance. The large mesh size prevents capture of benthic organisms and only minor dragging of traps on the sea floor occurring in trap retrieval. The sheltered shallow mangrove environment is protected from wind and waves where the majority of traps are deployed, resulting in minimal habitat damage.

1 Knuckey, I.A. (1999). Mud crab (*Scylla serrata*) population dynamics in the Northern Territory, Australia and their relationship to the commercial fishery. PhD Thesis. Northern Territory University, Darwin.

Social Effects

Blue Swimmer Crab

During 2012/13, two people were employed as skippers and crew on vessels fishing for blue swimmer crabs along the Pilbara coast. Additional employment for several workers has been created in Point Samson through the development of post-harvest processing of the crab catch.

Mud Crab

Historically the mud crab fishery has had a high community value and a low commercial value. Commercial fishers travel vast distances due to the remoteness of their operations and stay in the vicinity for several weeks before returning to unload catch. In this scenario crabs are frozen and generally sold to local markets although live product may also be sold at premium prices.

Due to an absence of adverse weather including seasonal flooding and cyclone activity reported in previous years, there was a higher than normal fishing level with 3 commercial operators and 2 Aboriginal Corporations in the 2013 fishing season.

Economic Effects

Estimated annual value (to fishers)

Level 1 - < $1 million

Blue Swimmer Crab

The commercial blue swimmer crab catch in the North Coast Bioregion for 2012/13 was valued at approximately $53,300 - a 53% decrease on the $112,300 generated in 2011/12. Price data was generated by collecting monthly returns recording prices paid to fishers by fish processors, a weighted average price is then calculated for the financial year from the monthly data collected. Average prices for trap caught blue swimmer crabs in the North coast fisheries for the year were around $9.23/kg. The crab catch from the Pilbara region was sold through local and interstate markets

The economic value of the total commercial blue swimmer crab catch for the State of Western Australia for the 2012/13 financial year was estimated to be $2.6 million – a 1% increase on the estimated $2.5 million generated in 2011/12.

Mud Crab

Mud crab landings from the Kimberley mud crab fishery during 2013 were worth approximately $174,572 a 54% increase on the $95,394 generated in 2012. As the Kimberley region is the only commercial mud crab fishery in Western Australia this essentially represents the total value of the commercial mud crab fishery in Western Australia. The average beach price for green (uncooked) mud crabs in the Kimberley for 2013 was around $22/kg (however note this value is based on a small proportion of total catch from an individual processor). Aboriginal corporations may also trade and barter product adding value to the local communities that cannot be estimated.

Price data was generated by collecting monthly returns recording prices paid to fishers by fish processors, a weighted average price is then calculated for the financial year from the monthly data collected.

Fishery Governance

Target catch (or effort) range:

Blue Swimmer Crab Pilbara	**N/A**
Mud Crab	**N/A**

Current fishing (or effort) level:

Blue Swimmer Crab	**Pilbara - Acceptable**
Mud Crab	**Acceptable**

Blue Swimmer Crab

While the Pilbara Developmental Crab Fishery has undergone a steady expansion since exploratory fishing for blue swimmer crab stocks between Onslow and Port Hedland began in 2001, effort levels in the fishery are considered acceptable. The large area covered by the fishery and the remote nature of much of this coastline provides significant logistical and financial challenges in returning the harvested catch to market in an acceptable time period. Improvements to fishing gear and vessels, along with a substantial increase in the understanding of local environmental influences such as tide and wind, has allowed commercial fishers to improve fishing practices with effort decreasing in recent years. Fishing effort in this region is limited by very hot weather experienced during the summer months, which generally restricts fishing effort to between April and November.

Mud Crab

The mud crab fishery is currently being fished at low/precautionary levels due to the low number of fishers operating in the fishery and relatively low effort across a large area of the Kimberley. Although some fishing occurs in localised areas of the coastline it is believed that stock levels are not being significantly affected at this time.

New management initiatives (2014/15)

Blue Swimmer Crab

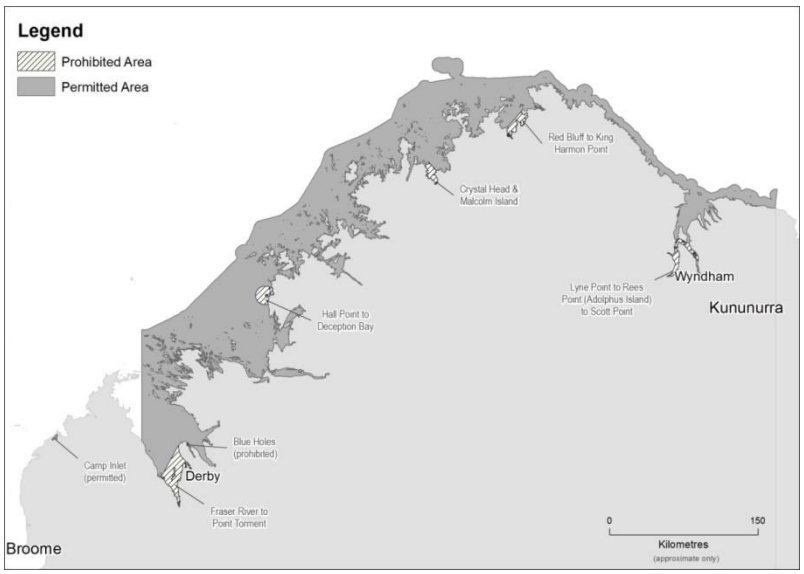
The Department is currently progressing formal management arrangements of the Pilbara Crab DNF through the development of a (Interim) Management Plan for the fishery. This is scheduled to be completed in early 2015.

Mud Crab

The Department proposes to bring the Kimberley Developing Mud Crab Fishery under formal management arrangements in the near future.

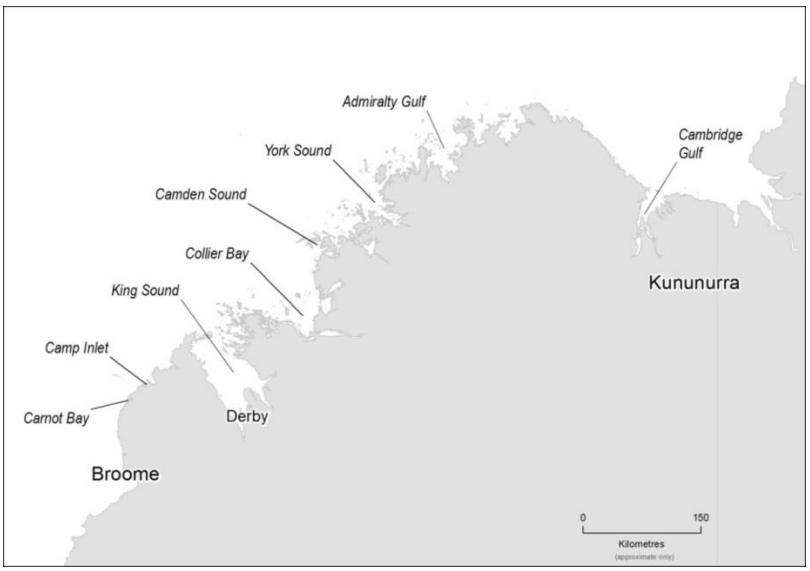
External Factors

Levels of recruitment to many of the crab fisheries fluctuate considerably. While the causes of these variations are not fully understood, it is considered most likely due to environmental influences on spawning success and larval survival through to recruitment. The relationship between environmental factors, recruitment and catch is being further evaluated as data becomes available.



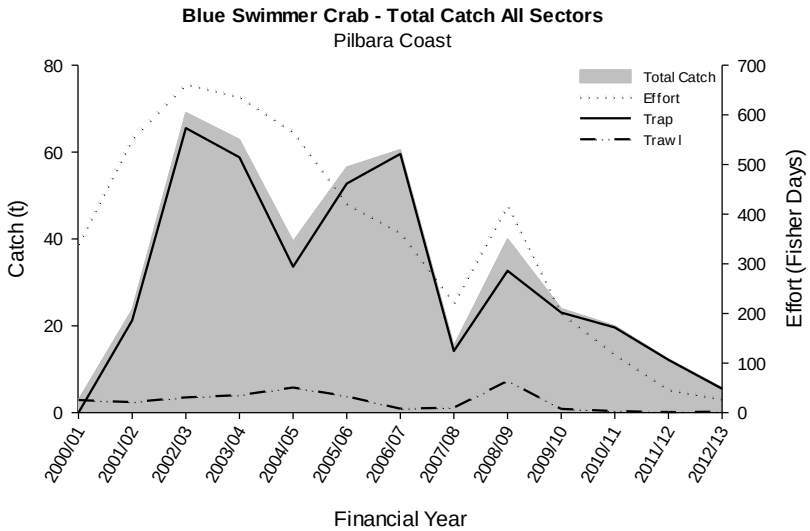
NORTH COAST CRAB FIGURE 1

Areas fished for mud crab along the Kimberley coast of Western Australia.



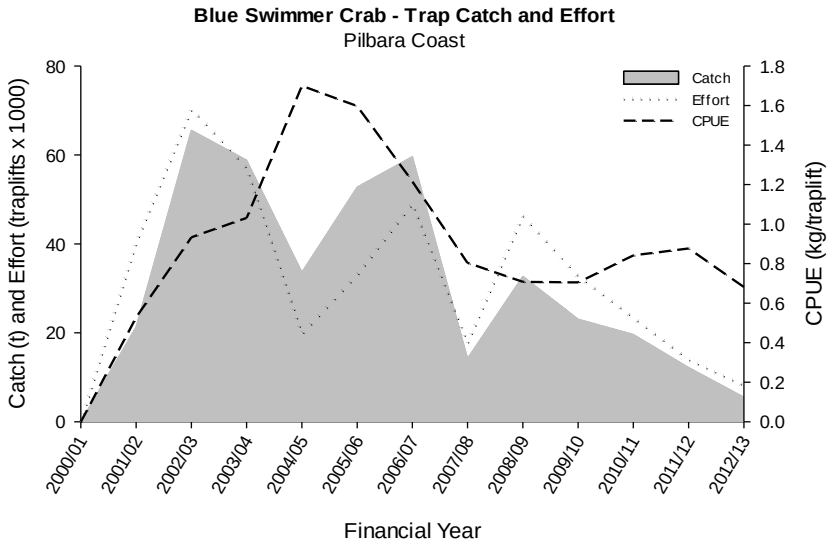
NORTH COAST CRAB FIGURE 2

Key areas fished by exemption holders operating in the Kimberley Developing Mud Crab Fishery in Western Australia.



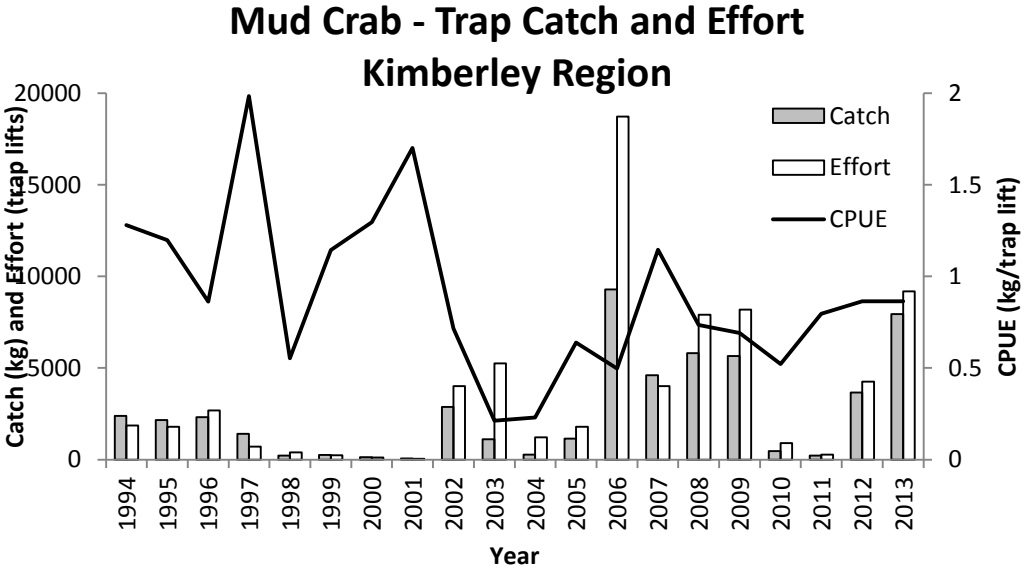
NORTH COAST CRAB FIGURE 3

Total commercial catch history for the blue swimmer crab (*Portunus armatus*) along the Pilbara coast since 2000/01. Data represents the total crab catch for trap and trawl sectors and effort in fisher days.



NORTH COAST CRAB FIGURE 4

Commercial trap catch history for the Pilbara Developmental Blue Swimmer Crab (*Portunus armatus*) fishery since 2000/01. Data represents the total trap crab catch, effort (traplifts x 1000) and catch per unit effort (CPUE) (kg/traplift).



NORTH COAST CRAB FIGURE 5

Annual catch, effort and catch rate (CPUE) for mud crab in the Kimberley Region since 1994 when permissive conditions of fishing boat licenses were issued. The Kimberley Developing Mud Crab fishery commenced by exemption in 2006.

AQUACULTURE

Regional Research and Development Overview

Aquaculture in the North Coast Bioregion is dominated by the production of South Sea pearls from the silver lip pearl oyster *Pinctada maxima*. This industry sector utilises both wild-caught and hatchery-reared oysters to produce cultured pearls. The wild-stock fishery is reported in the North Coast Bioregion section of this volume.

The Department of Fisheries also has a major role in the management and regulation of pearl hatcheries, seeding activities and pearl oyster farm leases.

A Memorandum of Understanding between the Western Australian and Northern Territory fisheries ministers, signed in June 2006, recognises that WA and the NT comprise the entire Australian south-sea pearling industry and that product from both jurisdictions supplies the same market.

The operator of a fish farm producing barramundi (*Lates calcarifer*) in Cone Bay is successfully increasing production following approval by the Environmental Protection Authority (EPA) to increase output to 2,000 tonnes per

annum. The operator is planning to gradually increase its production capability to 5,000 tonnes per annum, subject to receiving the requisite environmental approval.

A company developing a project culturing marine microalgae for the production of bio-fuels, omega-3 lipid and protein biomass previously established a demonstration facility near Karratha. The company is currently assessing alternative sites for the project.

To assist in addressing the regulatory and approvals issues concerning aquaculture development in WA, the Department of Fisheries has received Government funding of $1.85 million to establish two aquaculture zones in the Kimberley and Mid-West regions. Through this project, the Department of Fisheries will secure strategic environmental approvals for the zones, thereby streamlining the approvals processes for commercial projects within zoned areas and providing an "investment ready" platform for prospective investors. Located in the vicinity of Cone Bay, the Kimberley zone has now received environmental approval, through the Minister for Environment issuing an implementation statement. The Minister for Fisheries is now going through the process to formally declare the zone.

The Department of Fisheries manages the operations of the Broome Tropical Aquaculture Park, which provides the basic resources and facilities for supporting aquaculture development and training.

An indigenous project at One Arm Point operates a marine hatchery that focuses on a variety of ornamental and edible marine species.

COMPLIANCE AND COMMUNITY EDUCATION

The North Coast is one of the largest bioregions in WA – stretching from Onslow to the Western Australia/Northern Territory border with over 2600 kilometres of coastline.

The North Coast Bioregion has many biodiversity rich areas including the Rowley Shoals, Montebello Islands, Barrow Islands and hundreds of islands and atolls. These areas attract many people – especially for fishing.

Tourism is a major part of the coastal towns in the North Coast with over 600,000 additional people visiting the area each year. The transient population usually increases in the cooler months from May to October including international, interstate and intrastate tourists.

Many of the towns in this bioregion support mining communities where the majority of the population are fly in / fly out. Surveys have shown that a large proportion of mining community and tourists take part in fishing while visiting the bioregion.

Three district offices located in Kununurra, Broome and Karratha provide compliance and education across the region with thirteen permanent Fisheries and Marine Officers and one Community Education officer. An additional two officer Recreational Mobile Patrol operates in the area throughout the year. Compliance is delivered to several sectors including commercial and recreational fisheries, pearling, aquaculture, fish habitat and bio-security.

The North Coast Region is sparsely populated in most areas with much of the terrain remote and difficult to access. Remote patrols are undertaken for up to two weeks at a time to get to these areas. Specialised equipment is required for patrols including four wheel drive vehicles and a variety of vessels for inshore coastal and inland waters, when offshore patrols are conducted, a 23 metre vessel is utilised.

A range of compliance duties are carried out in the bioregion including investigations, catch, licence, gear, processor, retail and transport inspections. These are carried out through roadside checks, land & sea patrols and aerial surveillance.

FMOs not only spend time on compliance but also dedicate time to community education by maintaining a presence at a variety of expos, fishing competitions and community fairs. Annual fairs are held throughout the bioregion with the Department represented every year at most events.

The Community Education Officer develops programs and coordinates delivery of education activities to school-aged children and awareness raising activities with the broader community. In-school and school holiday programs are the main method of reaching students in both the Pilbara and the Kimberley, while attendance at shows and local events target the broader community. An increased emphasis has been placed on developing materials that focus on local issues and their dissemination through regional brochure stockists and local publications.

Activities during 2012/13

During 2012/13, the North Coast Bioregion's FMOs delivered a total of 7,751 officer hours of active compliance patrol time (North Coast Compliance Table 1). FMOs also achieved 19,215 personal compliance contacts with the fishers and non-fishers across the recreational and commercial sectors.

There was improved engagement with short and long term visitors to the Pilbara and the Kimberley through a dedicated education program targeting caravan parks.

In the commercial sector FMOs undertook prosecution action as a result of compliance operations in 2012/13. This resulted in 10 infringement warnings, 11 infringement notices being issued and 43 matters resulting in prosecution action.

Compliance inspections were also carried out on Pearl oyster fishing and seeding operations, during transport of Pearl oysters and at various Pearl oyster lease sites. Considerable travel time is required to reach many of the lease sites, due to their remote locations.

In the recreational sector 171 infringement warnings were issued, 152 infringement notices and 27 matters resulted in prosecution action.

Initiatives in 2013/14

The Department will continue dedicated compliance and education patrols of the Camden Sound and 80 Mile Beach Marine Parks.

At-sea compliance patrols of the 80 Mile Beach Marine Park will be carried out utilising the Departments first amphibious vessel, purposely built to be launched and retrieved in the large tides encountered in the Kimberley.

The Northern Region Mobile Patrol, comprising of two FMOs will continue to focus entirely on recreational fisheries compliance and education throughout the Northern Region.

A Fremantle based Statewide Mobile Patrol Unit will be based in the Pilbara District for July and August and will focus on recreational fishers operating in the area.

The North Coast Bioregions FMOs will continue to use a risk assessment based approach to fisheries compliance to ensure areas and activities of a high risk of non-compliance are targeted.

FMOs will continue to assist with ongoing bio-security checks of vessels entering the states' waters for introduced marine pests.

NORTH COAST COMPLIANCE TABLE 1

This table gives a summary of compliance and educative contacts and detected offences within the North Coast Bioregion during the 2012/13 financial year.

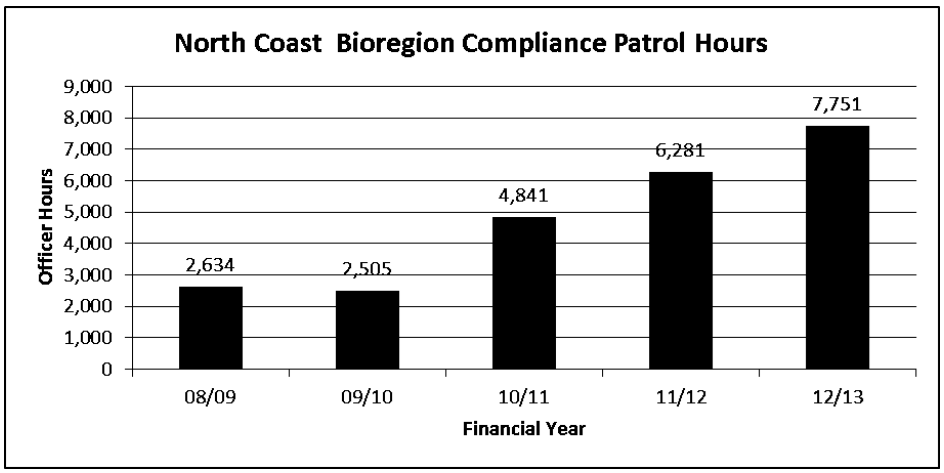
PATROL HOURS DELIVERED TO THE BIOREGION	7,751 Officer Hours
CONTACT WITH THE COMMERCIAL FISHING COMMUNITY*	
Field contacts by Fisheries & Marine Officers	244
Infringement warnings	10
Infringement notices	11
Prosecutions	43
Fishwatch reports***	2
VMS (Vessel Days)****	7,598
CONTACT WITH THE RECREATIONAL FISHING COMMUNITY	
Field contacts by Fisheries & Marine Officers	17,584
Infringement warnings	171
Infringement notices	152
Prosecutions	27
Fishwatch reports	39
OTHER FISHING-RELATED CONTACTS WITH THE COMMUNITY**	
Field contacts by Fisheries & Marine Officers	1,387
Fishwatch reports	1

* Pearling contacts are included in these totals.

** Contacts are classified according to the specific fishery, which is usually clearly delineated as being either commercial or recreational. The "other fishing related contacts within the community" category is used where multiple fisheries are contacted and it is not possible to accurately classify the contacts into one specific fishery – typically, the majority of these contacts are recreational in nature (e.g. personal contacts in marine parks), but contacts made in relation to fish kills, shark patrols and inspections of commercial fish wholesale and retail premises, etc, are also included in this category. This table includes contacts made by PV Houtman and PV Walcott while they were operating in the Bioregion.

*** Fishwatch reports are allocated to the District Offices relevant to the Bioregion. It is not possible to distinguish between calls relating to Inland Bioregions.

**** VMS (Vessel Days) represents the number of vessel days recorded in this bioregion. That is, a count for each day that each vessel was polled within the bioregion.



NORTH COAST COMPLIANCE FIGURE 1*

"On Patrol" Officer Hours showing the level of compliance patrol activity delivered to the North Coast Bioregion over the previous 5 years. The 12/13 total gives the patrol hours in the bioregion that resulted in the contacts detailed in Table 1. (The totals exclude time spent on other compliance related tasks e.g. travel time between patrol areas, preparation and planning time etc. and any services delivered by the Department's large Patrol Vessels: *PV Walcott, PV Houtman* and *PV Hamelin*).