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Ecological Risk Assessment of the Exmouth Gulf Prawn Managed Fishery

Department of Primary Industries and Regional Development

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Executive Summary

- The Department of Primary Industries and Regional Development in Western Australia uses an Ecosystem-Based Fisheries Management (EBFM) approach that considers all relevant ecological as well as social, economic and governance issues to deliver community outcomes. Ecological risk assessments (ERAs) are undertaken periodically to assess the impacts of fisheries on all the different components of the aquatic environments in which they operate.
- This report provides information relating to an ERA undertaken for the Exmouth Gulf Prawn Managed Fishery (EGPMF) in 2019. The assessment focused on evaluating the ecological impact of this fishery on all retained species, bycatch, endangered, threatened and protected (ETP) species, habitats, and the broader ecosystem.
- The risk assessment methodology utilised for the 2019 ERA is based on the global standard for risk assessment and risk management (AS/NZS ISO 31000). This methodology applied a consequence-likelihood analysis, which involves the examination of the magnitude of potential consequences from fishing activities and the likelihood that those consequences will occur given current management controls. All of the risk issues were assessed using a consultative and structured workshop held at the Western Australian Fisheries and Marine Research Laboratories in Hillarys on 12 September 2019.
- All issues were scored medium, low or negligible risk using the adopted methodology. Risk rankings of medium or less are considered acceptable risks for a well-managed fishery, subject to ongoing management practices and performance monitoring.

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List of Abbreviations

BRD	Bycatch Reduction Device
DPIRD	Department of Primary Industries and Regional Development (Western Australia, former Department of Fisheries)
EBFM	Ecosystem-Based Fisheries Management
EGPMF	Exmouth Gulf Prawn Managed Fishery
ERA	Ecological Risk Assessment
ESD	Ecologically Sustainable Development
ETP	Endangered, Threatened and Protected (species)
MSC	Marine Stewardship Council
VMS	Vessel Monitoring System
WA	Western Australia

INTRODUCTION

The Department of Primary Industries and Regional Development (DPIRD, Department) in Western Australia (WA) uses an Ecosystem-Based Fisheries Management (EBFM) approach that considers all relevant ecological as well as social, economic and governance issues to deliver community outcomes (Fletcher et al. 2010; 2012). Ecological risk assessments (ERAs) are undertaken periodically to assess the impacts of fisheries on all the different components of the aquatic environments in which they operate. The outcomes of the risk assessments are used to inform EBFM-based harvest strategies and to prioritise Department monitoring, research and management activities (Fletcher 2015; Fletcher et al. 2016).

This report provides information relating to an ERA undertaken for the Exmouth Gulf Prawn Managed Fishery (EGPMF) in 2019. The assessment focused on evaluating the ecological impact of this fishery on all retained species, bycatch, endangered, threatened and protected (ETP) species, habitats, and the broader ecosystem. The impact of the recreational fishing sector was only considered when assessing the overall impact of fishing on the target stocks. As there have been several previous risk assessments undertaken for the EGPMF (Department of Fisheries 2002; 2009), this current assessment did not consider the social and economic drivers that may affect the performance of the fisheries, as would typically be included in a full EBFM risk assessment.

The risk assessment methodology utilised a consequence-likelihood analysis, which involves examination of the magnitude of potential consequences from fishing activities and the likelihood that those consequences will occur given current management controls. The assessment was initially undertaken by Department research staff, updating the results of previous risk assessments undertaken for the EGPMF undertaken in 2001 and 2008 (Department of Fisheries 2002; 2009; see Appendix A). These risk scores were then reviewed and updated during an external ERA workshop held on 12 September 2019. This external workshop, to which a range of stakeholders were invited, was facilitated by Richard Stoklosa (E-Systems).

The first component of this report provides background information about the fishery and the ecosystem components that have the potential to be impacted by prawn trawling in Exmouth Gulf. It also gives a broad overview of the risk assessment methodology on which this ERA was based. The latter part comprises the report prepared by Stoklosa following the external ERA workshop. The results from this ERA will help inform the harvest strategy for the Exmouth Gulf Prawn Resources (Department of Fisheries 2014a).

PART 1

1 Aquatic Environment

Exmouth Gulf is a large (~4000 km^2) and shallow (predominately <20 m) tropical gulf within the Gascoyne Coast Bioregion of WA, located approximately 1100 km north of Perth (Figure 1.1). The Gascoyne Coast Bioregion represents a transition between the fully tropical waters of the northern coast and the temperate waters of the southwest region. The Gulf is open to the north and enclosed by the Cape Range and large sand beaches to the west and a narrow band of mangroves bordering extensive salt flats which lead on to arid plains to the east and south (Johnstone 1990; Wilson 1994; McCook et al. 1995). Water depths in Exmouth Gulf range from intertidal flats along the southern and eastern shores to ~20 m in the northern and western regions.

Rainfall and river runoff in the area are extremely low and with rare flooding events, primarily driven by summer tropical cyclones, altering the water quality of the gulf, e.g. salinity and turbidity, from what is normally a relatively stable hydrological environment (Penn & Caputi 1986). The Leeuwin Current affects the inshore and offshore waters of Exmouth Gulf, particularly during strong winter flows, with elevated water temperatures, depressed levels of dissolved nutrients and particle concentrations which inhibits the growth of macroalgae (Hatcher 1991). Consequently, fisheries production relies on nutrient sources from benthic habitats in nearshore waters, rather than from oceanic ecosystems (Lenanton et al. 1991).

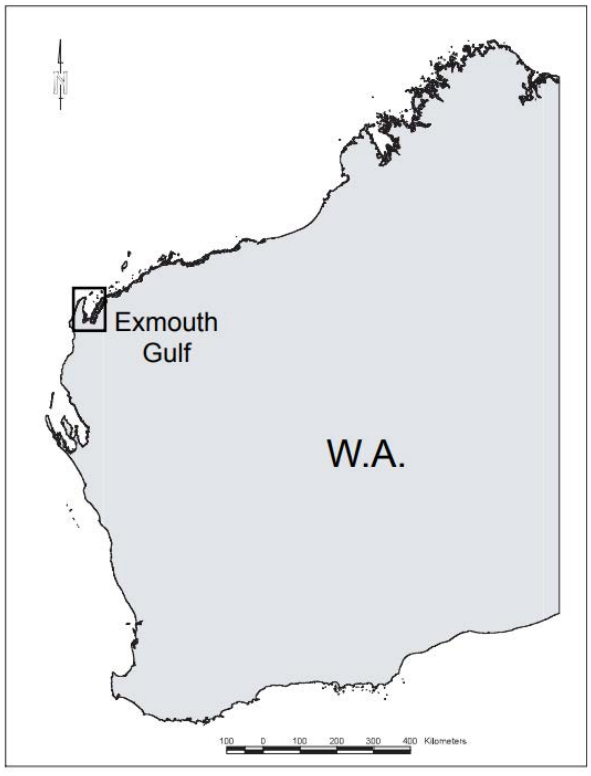

Figure 1.1. Location of Exmouth Gulf in WA.

Comprehensive habitat information for Exmouth Gulf is limited despite its size, proximity to the Ningaloo Coast World Heritage Area and State Marine Parks (see Figure 1.2), mining activities and the presence of highly productive fisheries. The majority of the existing habitat information is focussed around the shallow inshore areas within the EGPMF nursery grounds, with a particular focus on seagrass (Loneragan et al. 2013). The intertidal regions have very little vegetation with some areas comprised completely of sand and gravel (Morrison et al. 2003). The shallow waters of Exmouth Gulf which front the eastern mangals comprise of extensive seagrass beds that provide feeding habitats for turtles and dugongs (Wilson 1994). Seagrass species found are typically of a tropical distribution and found in very low abundances, rarely exceeding 5 – 10 % cover (Hutchins 1994; Kangas et al 2015). Small amounts of algae (e.g. *Caulerpa*, *Halimeda*, *Udotea* and *Penicillus* spp.) have been found mixed with these eastern seagrass beds, and large quantities of filamentous turfs, ephemeral epiphytes and perennial macrophytes, such as *Sargassum* spp., are frequently found attached to or tangled with the seagrasses (Kangas et al. 2015). On the west coast, seagrasses are more patchily distributed and generally do not occur below eight metres, with exceptions such as brown algae, e.g. *Sargassum* spp., present down to 10 m (McCook et al. 1995). The low abundance of seagrass within Exmouth Gulf has been attributed to the lack of suitable substrate, with observed substrate consisting of either hard or mobile coarse sediments (McCook et al. 1995).

Within Exmouth Gulf there are small areas of coral reefs, primarily located at the northern end (Bundegi Reef, Muiron Islands) and near the southern end of the Gulf (Point Lefroy to Roberts Island) which support a rich growth of hard corals, although only 28 species have been recorded in the area (Veron & Marsh 1988). Areas of extensive filter feeder communities have also been reported in the subtidal north west. Surveys of the deeper waters of the Ningaloo Mark Park and investigations at Ningaloo Reef, in the north and adjacent to Exmouth Gulf, revealed that sponges frequently represent the dominant component of the sessile benthic communities (Kangas et al. 2015). Broad-scale, on-board analysis shows that sponges represent a significant proportion of the benthos in the deeper water of the Ningaloo Marine Park and are a major habitat-forming group (Heyward et al. 2010). Various dense sponge communities or 'hotspots' have been identified including a few areas in the north at the Muiron Islands to Bundegi Reef and north of Tantabiddi, areas between Mandu Mandu and south of Point Cloates, and an area in the south between Gnaraloo and Red Bluff (Heyward et al. 2010). Dominant sponges were all in the class Demospongiae and presently comprise 155 species (a dominant sponge species was one where the total weight of the species was ≥ 1 kg wet weight per station). Many more species were collected that did not attain wet weights ≥ 1 kg per station and are yet to be studied. The total number of sponge species present in the Ningaloo filter-feeding communities will be significantly higher when all species have been identified (Heyward et al. 2010). Note that much of the Ningaloo Marine Park sampling area does not overlap with the areas trawled by this fishery.

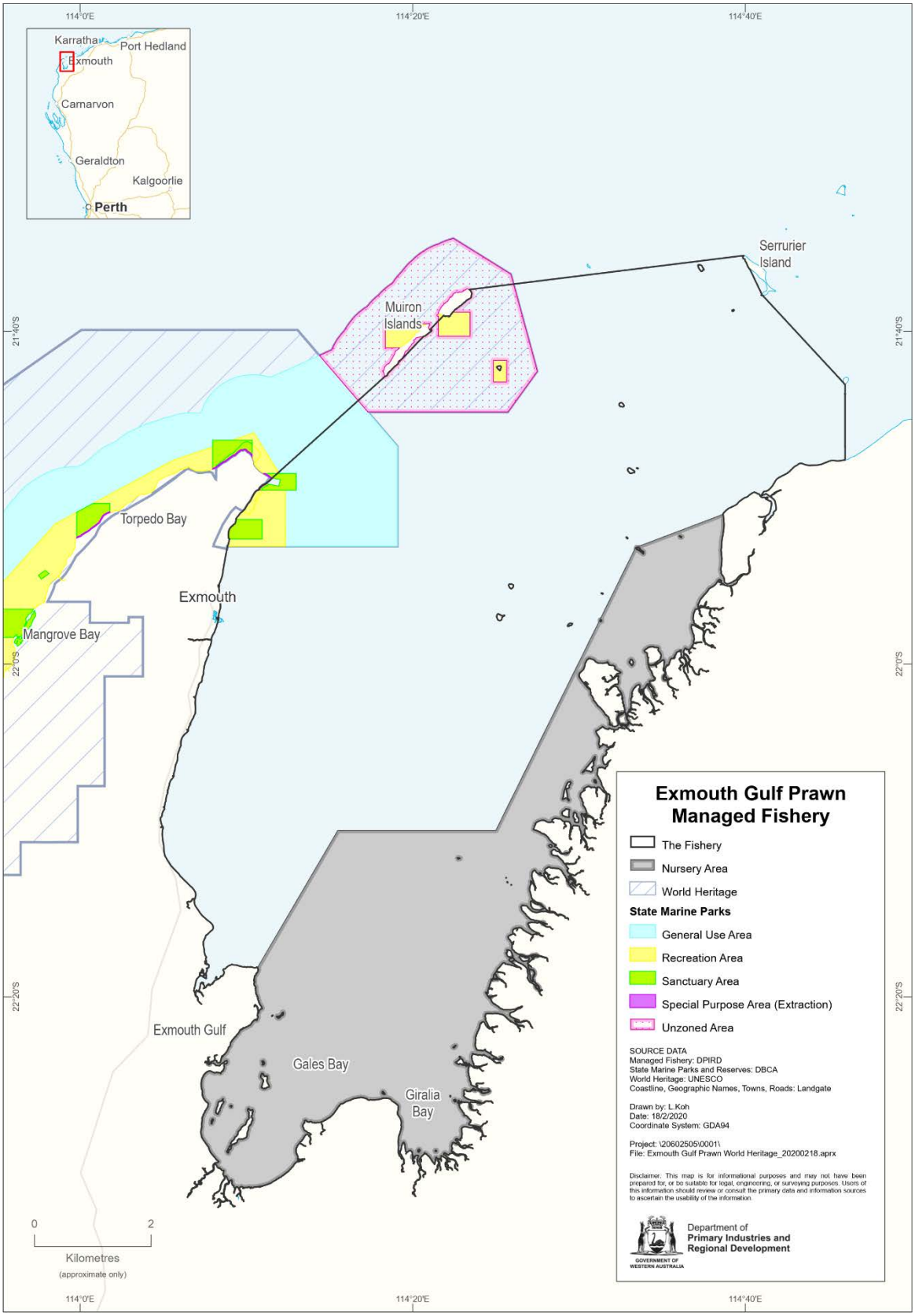

Figure 1.2. Boundaries of the Ningaloo Coast World Heritage Area, the Ningaloo Marine Park and the Muiron Islands Marine Management Area in relation to the EGPMF.

Limited information is available on the extent and type of soft sediment that covers a large part of the central seabed in Exmouth Gulf or its associated fauna. Apache Energy (1998) report that soft sediment regions above 20 m depth outside commercial trawl areas, including areas outside of Exmouth Gulf, have extensive invertebrate communities. The communities primarily consist of echinoderms, including sand dollars, Diadema urchins, heart urchins and crinoids, and some areas have abundant solitary corals. The channel between the Muiron Islands and North West Cape has only a thin veneer of coarse sediment overlying limestone pavement. This area is rich in gorgonians, sea whips, bryozoans, some hard corals, crinoids, ascidians and hydroids, but few fish species were recorded (Apache Energy 1998). Despite relative low coverage and abundance of vegetation, e.g. seagrass and coral, Exmouth Gulf is a highly productive ecosystem, with macroalgae, phytoplankton and salt-flat cyanobacteria the main primary producers (McCook et al. 1995).

Recent habitat mapping of Exmouth Gulf (Lyne et al. 2006; DPIRD unpublished data) support the description of the aquatic environments described above. There are two habitat maps currently available to describe the extent of broad habitats over the entirety of the EGPMF. The first is a habitat map produced as part of the North West Shelf Joint Environmental Management Study (NWSJEMS), which describes six biophysical habitats; coral reef communities, mudflats, sand, mixed assemblage (sand, limestone pavement, macro algae, seagrass, occasional bommies), filter feeder communities and low relief subtidal reef (Figure 1.3, Lyne et al. 2006). Based on Lyne et al. (2006), the biophysical habitats with the EGPMF are primarily sand (~50%) and mixed assemblage (~30%) with the remaining categories cumulatively accounting for ~20% (Figure 1.3). This map was validated in 2018 by DPIRD, in collaboration with MG Kailis (Figure 1.3) with the validation results showing a strong positive relationship with Lyne et al. (2006) map for coral reefs, sand and mixed assemblage, however, filter feeder communities are likely over represented.

The second habitat map available for the EGPMF was developed using data from the 129 validation survey sites conducted by DPIRD in 2018 to create a new interpolated predictive habitat map. This map identified four major habitat types with mixed assemblage (macro algae, seagrass, anemones, ascidians, bryozoans, soft coral) accounting for ~48% of EGPMF, sand (~44%), filter feeder communities (7.5%) and coral reef communities (0.5%) (Figure 1.4). The definition of the habitat types is comparable with the Lyne et al. (2006) map habitat types. However, given with the increased number of training sites used it is likely that the 2018 map provides a more accurate estimate of the spatial distribution of benthic habitats within the EGPMF.

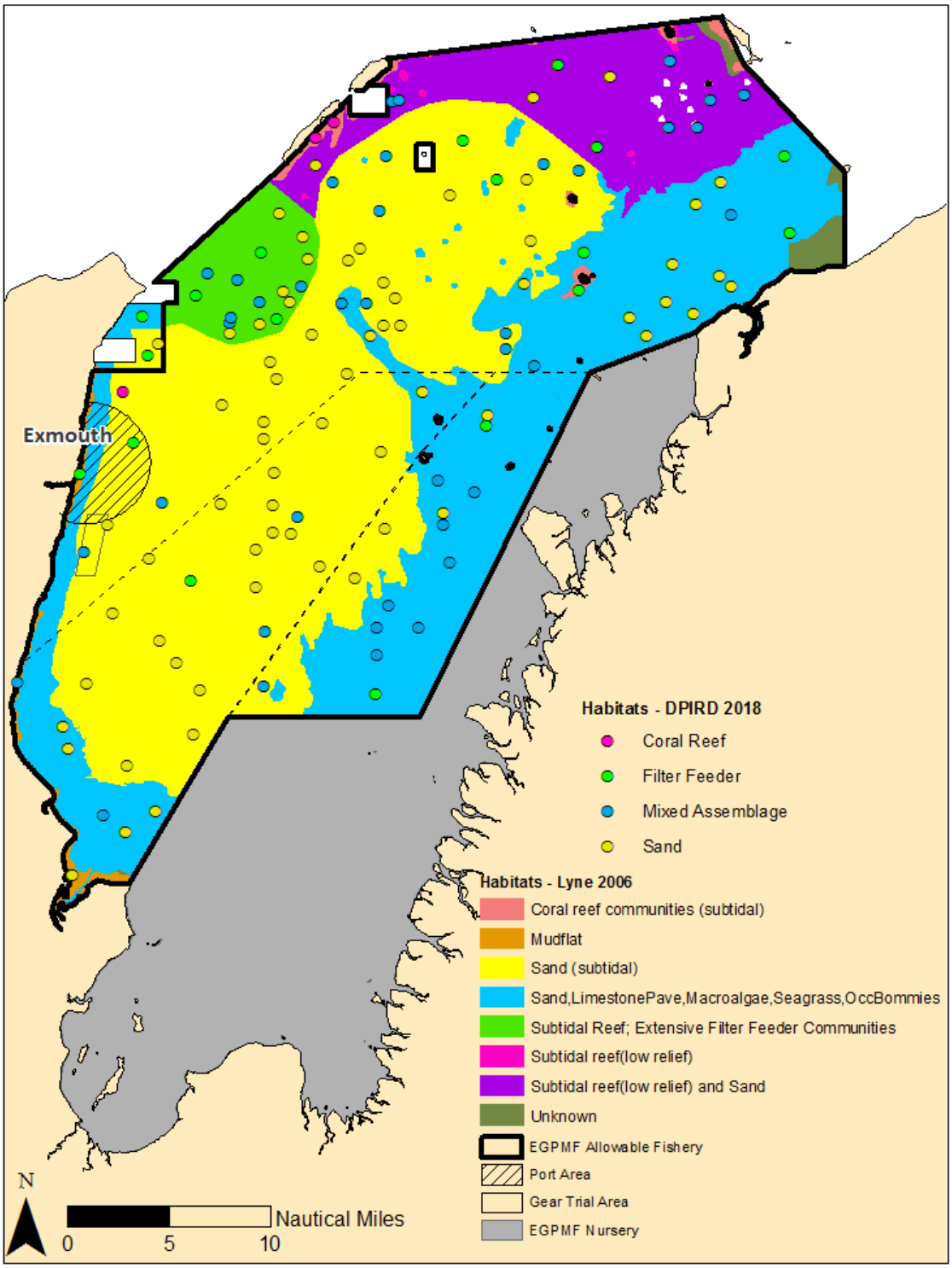

Figure 1.3. Validation surveys, showing benthic validation types, of Lyne et al. (2006) habitat map.

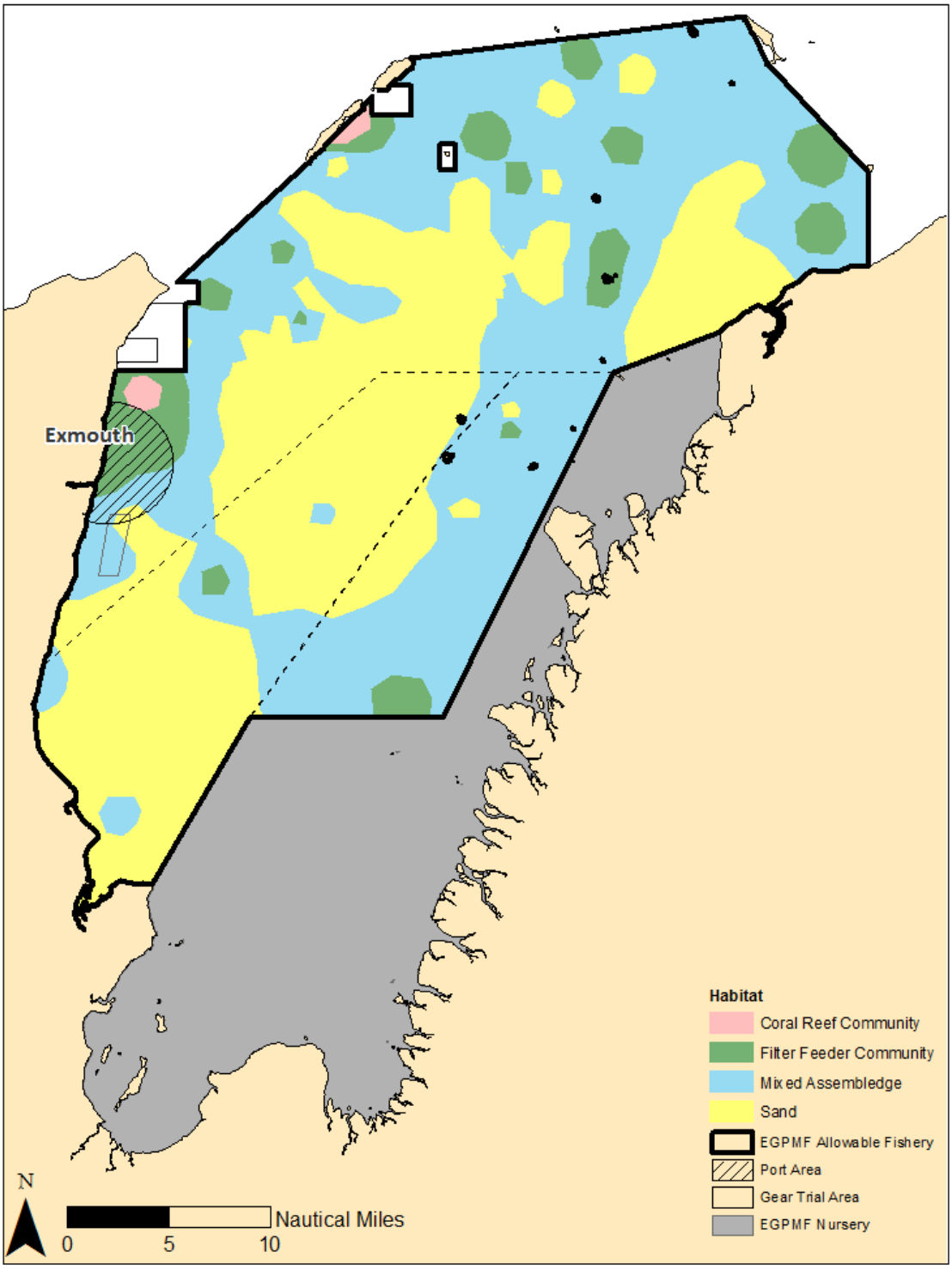

Figure 1.4. EGPMF habitat map developed by DPIRD/MG Kailis in 2018.

2 Exmouth Gulf Prawn Managed Fishery

2.1 Current Fishing Activities

The EGPMF targets prawns using low-opening demersal otter trawl nets. It has an estimated annual value of $10-20 million, landing around 500 to 1400 tonnes per annum. There are currently 15 managed fishery licences, all of which are held by a single licensee. The fleet currently consists of six boats, with each boat equipped with on-board processing and freezing facilities.

The EGPMF covers an area of ~2790 km^2, or 70%, of Exmouth Gulf with the remaining 30% permanently closed to trawling. Closed areas include sanctuary and recreation areas of the Ningaloo Marine Park and Muiron Marine Management Zone (~67.54 km^2 or ~2%; see Figure 1.2) and a permanent legislated fishery closure (nursery grounds) to the south and east of the gulf (~1139 km^2 or ~28%) (Figure 2.1,). In addition, the entire area of the EGPMF is not continuously available to the fishery, due to temporal closures, unsuitable topography, sediment preferences and migration patterns of the target species. Consequently, fishing generally only occurs in 20-40 % of the EGPMF annually.

Overall effort in the fishery is constrained by a cap on the number of licences / vessels (limited entry), limits on fishing gear (headrope capacity), restrictions on the number of available fishing days each year (seasonal closure) and restricted trawl hours (mainly night-time trawling). Monthly moon closures of at least four days around each full moon and significant permanent and temporary closed areas throughout the fishery also reduce the effective fishing effort. Fishing activity is monitored using the Vessel Monitoring System (VMS).

The EGPMF is managed based on a constant escapement harvesting approach (Department of Fisheries 2014a). The management activities related to this approach have been developed over time based on a comprehensive understanding of the biology of brown tiger, western king and blue endeavour prawns in Exmouth Gulf. The annual cycle of operation depends on the strength and timing of prawn recruitment and management actions within the season are based on established reference levels primarily related to the target prawn species. The harvest strategy aims to allow prawns to reach optimal market sizes before fishing commences, as well as to provide protection to the spawning stocks through temporal closures of key spawning areas (Department of Fisheries 2014a).

The EGPMF fishing season is generally open from April through to early December each year, with specific opening and closing dates set according to the lunar phase. After the season opening, the actual commencement date and extent of fishing in particular management areas (see Figure 2.1) throughout the season is determined based on fishery-independent monitoring (recruitment and spawning stock surveys) and real-time fishery-dependent monitoring (commercial catch rates) as well as focussed ‘industry-based’ surveys of areas that have been kept closed during the season (not permanent closures).

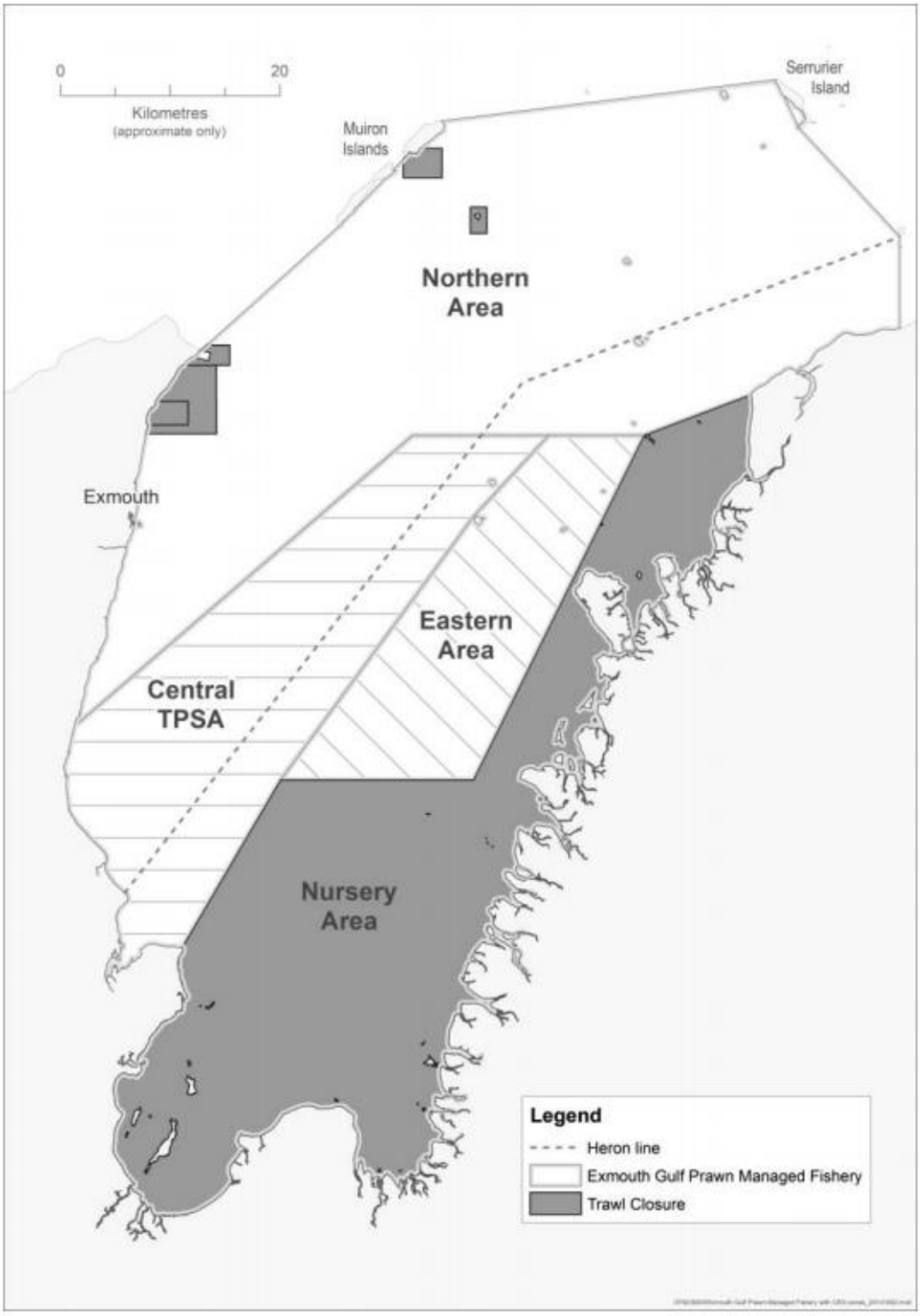

Figure 2.1. Boundaries of the EGPMF and areas permanently closed to trawling. TPSA refers to the brown tiger prawn spawning area. The nursery area includes extensive seagrass/algal beds and is permanently closed to trawling.

An annual closure is implemented in the Central Tiger Prawn Spawning Area (TPSA) and Eastern Area (Figure 2.1) to protect brown tiger prawn spawning stock during the key spawning period (August through October). This closure occurs irrespective of the abundance (kg/hr) of brown tiger prawns, however, the closure may be implemented before August if the target catch rate reference level (25 kg/hr) is approached prior to August. Maintaining prawn catch rates at or above this reference level ensures sufficient spawning biomass during the key spawning period. Also, during low brown tiger prawn abundance years there is generally no re-opening of the tiger prawn spawning area (after September) which further protects blue endeavour prawns in these areas.

The EGPMF has been assessed and accredited under the provisions of the Environment Protection and Biodiversity Conservation Act 1999 and has export approval until 2025. The fishery received third party accreditation by the Marine Stewardship Council (MSC) in October 2015, demonstrating its achievement of high standards in relation to sustainability of fish stocks, the minimisation of environmental impacts and effective management.

2.2 Fishing Gear and Methods

Vessels in the EGPMF use low-opening demersal otter trawl nets in quad-rigged formation (Figure 2.2), with a current maximum headrope allocation of 395.02 metres (216 fathoms). Otter boards are attached to the extremities of each net, with the height of the fishing gear set by the height at the point where they are connected to the otter boards. Forces produced by water flowing over the otter boards open the trawl nets laterally. This lateral spread controls the catching efficiency of trawl gear and determines the area swept. Generally, the headrope and footrope are spread between 60% and 85% of their length (Figure 2.2).

Attached to the footrope is the ground chain (maximum 10 mm diameter). The ground chain is designed to skim over the sand instead of digging into the seafloor. As the ground chain travels over the sea floor, it disturbs the prawns so they rise into the oncoming net. The low opening nets used have the headrope as a lead-ahead, which acts as a net veranda and is set in front of the footrope. This ensures that prawns disturbed by the ground chain do not pass over the headrope and thus, maintains the catch efficiency of the nets. Trawl shots range from two to three hours in duration.

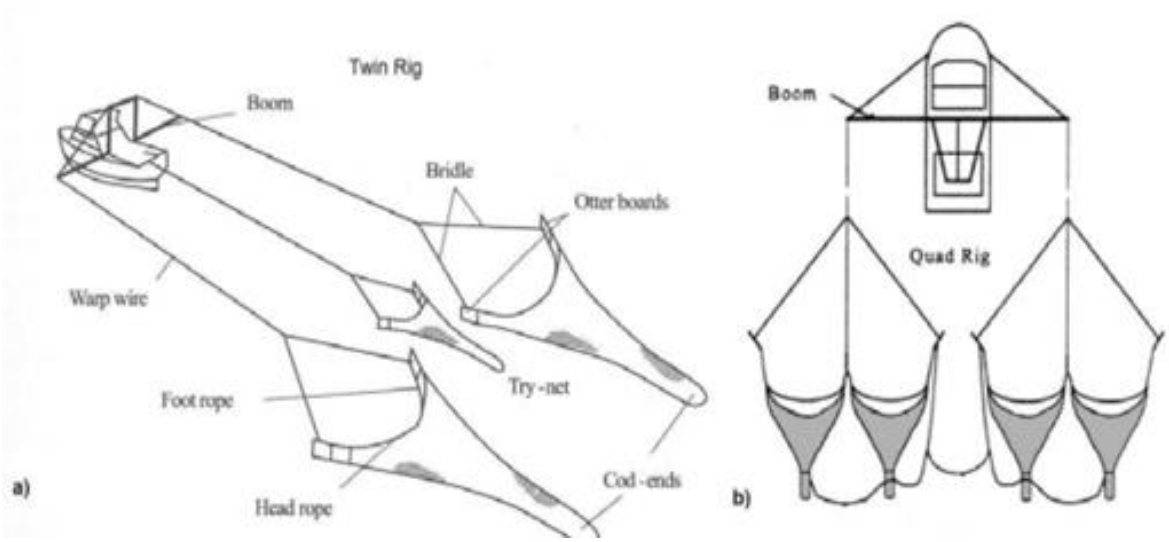

Figure 2.2. Standard (a) twin-rig and (b) quad-rig otter trawl (Adapted from Stirling 1998). The quad-rig configuration is currently used by all vessels in the EGPMF.

All trawl nets in WA are required to be fitted with bycatch reduction devices (BRDs). In WA, BRDs are defined as "a device fitted within a net, and any modifications made to the net, which allows bycatch, or part thereof, to escape after being taken in the net and consists of a grid and a fish exclusion device either in combination or as separate devices". Grids are a device fitted within a net, and any modification made to a net, which allows large animals (including turtles) and or objects to escape immediately after being taken into the net. In WA, grids must comply with the following specifications:

- Have a rigid inclined barrier (installed at an angle no greater than 60 °), comprising bars that are attached to the circumference of the net, which guides animals and / or objects towards and escape opening forward of the grid;
- Have an escape opening with the following minimum measures when measured with a taut net:
    - 75 cm across the widest part of the nets; and
    - A perpendicular measure of 50 cm from the midpoint of the width measure.
- Have a maximum vertical bar clearance spacing of 20 cm.

Within these requirements, the EGPMF industry has continued to develop, trial and implement fishery-specific BRDs for efficiency purposes. Since 2002, all vessels have used on board 'hopper' or 'well' in-water sorting systems, which provide an improved quality of prawns and reduce mortality of some bycatch species (Ocean Watch Australia 2004). Hoppers allow the catch to remain in recirculating seawater for an extended period, thereby maximising the survival of discarded species.

2.3 Retained Species

A summary of recent retained catches in the commercial EGPMF is provided in Table 2.1.

Table 2.1. Retained catches in the EGPMF between 2014 and 2018.

Species	Catch (tonnes)						% of total retained
	2014	2015	2016	2017	2018	Average	
Brown tiger prawns	162.4	433.2	356.0	366.3	391.9	342.0	42%
Western king prawns	170.7	191.7	200.6	130.1	174.3	254.2	31%
Blue endeavour prawns	101.3	396.7	243.8	216.6	312.7	173.5	21%
Coral prawns	5.0	0.3	29.1	24.8	20.4	15.9	2%
Banana prawns	29.1	45.9	21.3	0.2	0.6	19.4	2%
Blue swimmer crabs	1.6	6.6	2.9	4.5	0.9	3.3	0.4%
Bugs	2.8	3.0	4.0	3.7	2.8	3.2	0.4%
Cuttlefish	1.7	0.2	3.3	3.5	7.5	3.2	0.4%
Squid	3.1	1.8	3.6	2.0	2.2	2.5	0.3%
Mantis shrimps	0	0.0	0.1	1.1	1.2	0.5	0.1%
Octopus	0.3	0.2	0.3	0.7	0.3	0.4	<0.1%
Finfish	0.4	0	0.02	0	0	0.1	<0.1%

2.3.1 Brown tiger prawns

The brown tiger prawn (*Penaeus esculentus*) is a decapod crustacean of the family Penaeidae. The species is easily identified by its pattern of distinctive pale brown and darker bands. Brown tiger prawns are generally regarded as endemic to Australian and are distributed around the northern coast, from central New South Wales in the east to Shark Bay in WA (Ward et al. 2006). Major fisheries for this species in WA operate in Shark Bay and Exmouth Gulf, with smaller catches landed in the coastal waters of the North Coast Bioregion, around Onslow and in the Kimberley.

On average, the EGPMF retained 342 tonnes of brown tiger prawn annually between 2014 and 2018, which equates to 42% of the total catch (Table 2.1). There is very little recreational prawn fishing in Exmouth Gulf, with no brown tiger prawn catches reported by fishers in the Gascoyne Coast Bioregion in the most recent 2015/16 survey of boat-based recreational fishing (Ryan et al. 2017).

2.3.2 Western king prawns

The western king prawn (*Penaeus latisculcatus*) is a decapod crustacean of the family Penaeidae and is widely distributed throughout the Indo-West Pacific region (Grey et al. 1983). Within Australian waters, this species occurs from South Australia, WA, Northern Territory, Queensland and down the east coast to northern New South Wales (Grey et al. 1983). In WA, two major fisheries for western king prawns occur in Shark Bay and Exmouth Gulf, with smaller quantities landed in the North Coast Bioregion by prawn fisheries operating off Onslow and Broome.

On average the EGPMF retained 254 tonnes of western king prawns annually between 2014 and 2018, which equates to 31% of the total catch (Table 2.1). There is very little recreational prawn fishing in Exmouth Gulf, with no western king prawn catches reported by fishers in the Gascoyne Coast Bioregion in the most recent 2015/16 survey of boat-based recreational fishing (Ryan et al. 2017).

2.3.3 Blue endeavour prawns

Blue endeavour prawns (*Metapenaeus endeavouri*) are restricted to northern Australian waters between northern New South Wales and Exmouth Gulf in WA (Grey et al. 1983) and are generally found in coastal waters down to approximately 50 m in muddy or sand / mud substrates. They are considered more resilient to fishing pressure due to their smaller size and lower catchability, as well as the lower level of targeting compared to the other target species (Kangas et al. 2006). As their distribution overlaps that of brown tiger prawns, the permanent nursery area closure and seasonal TPSA closure protect a significant portion of the endeavour prawn breeding stock each year.

On average, the EGPMF retained 174 tonnes of blue endeavour prawns annually between 2014 and 2018, which equates to 21% of the total catch (Table 2.1). There is very little recreational prawn fishing in Exmouth Gulf, with no blue endeavour prawn catches reported by fishers in the Gascoyne Coast Bioregion in the most recent 2015/16 survey of boat-based recreational fishing (Ryan et al. 2017).

2.3.4 Other species

The EGPMF also retains a variety of minor prawn species, including coral prawns (various species but primarily *Metapenaeopsis crassissima*) and banana prawns (*Penaeus merguiensis*). Coral prawn landings are highly variable due to their low value and therefore not generally targeted by the fleet. The EGPMF retained between 0.3 and 29 tonnes coral prawns annually between 2014 and 2018, which on average equates to 2% of the total retained catch (Table 2.1).

Banana prawns are at their southern distribution limit in Exmouth Gulf, with relatively low numbers caught each year. Catches increase after consecutive years of higher rainfall levels, e.g. when cyclonic activity has occurred (Kangas et al. 2006). Banana prawns tend to aggregate during daylight hours and therefore the daylight fishing ban for the EGPMF fleet greatly reduces the potential effort on banana prawns in this fishery. Annual catches of banana prawns have fluctuated between 0.2 and 46 tonnes over the past five years (2% of the total retained catch; Table 2.1).

Cephalopods, including cuttlefish (*Sepia* spp.), squid and octopus, have been consistently retained in low numbers by the EGPMF (2 to 10 tonnes annually between 2014 and 2018; Table 2.1). Given the short life span, high fecundity and wide distributions of most cephalopods, they are typically considered highly productive and resilient to fishing.

The EGPMF also retains a low number of blue swimmer crabs (*Portunus armatus*), with annual catches ranging from 1-7 tonnes in the last five years (0.4% of total retained catch;

Table 2.1). Blue swimmer crabs are only captured in a comparatively small area of Exmouth Gulf by trawlers, with extensive refuge areas provided within the permanently closed nursery areas and in the deeper waters of the continental shelf adjacent to the Gulf.

Bugs (*Thenus* spp.) have a wide geographical range and, although marketable and retained, have comprised only 0.4% of the retained catch between 2014 and 2018 (Table 2.1). They are generally caught in the central and northern portion of Exmouth Gulf (Kangas et al. 2006). Although the retention of mantis shrimps has increased as markets for this species have developed, it represented 0.1% of the total retained catch in the past five years (Table 2.1).

The EGPMF also retains some minor catches of finfish species (less than 0.1% of total retained catch), including whiting and mullet (Table 2.1).

2.4 Bycatch Species

As it is not mandatory for fishers in the EGPMF to report on the component of their catches that are discarded (i.e. non-retained), available bycatch information is limited to data collected during fishery-independent trawl biodiversity surveys undertaken in 2004 (Kangas et al. 2007) and, more recently, between 2014 and 2017 as part of the EGPMF Bycatch Action Plan (Department of Fisheries 2014b).

The level of bycatch is variable, with quantities ranging from 2–5 times the prawn catch in early surveys. As recent data indicate that some finfish and cephalopod species are now being increasingly retained, the bycatch ratios have likely improved. Data from the most recent sampling period indicate that only around 40% of the total catch (in weight) may be discarded, however, this is likely an underestimate as it is based on the assumption that the groups of species reported in Table 2.1 are consistently retained (with the exception of mullets, of which only a small proportion is likely retained). Broadly, the catch composition in the two sampling periods has remained similar. The component of catches that are not typically retained by the EGPMF comprises a wide suite of several hundred small invertebrate and fish species (Table 2.2).

Invertebrate bycatch is dominated by a number of minor crab species (including *Portunus rubromarginatus*; 1.2% of total catch) but also include small prawns and echinoderms (including holothurians, sea urchins, sea stars and brittle stars). Finfish bycatch is dominated by lizardfish (mostly Harpodontidae), threadfin breams (Nemipteridae), goatfish (Mullidae), and trumpeters (Terapontidae) (Table 2.2). The four most common species were the large-scaled lizardfish (*Saurida undosquamis*; 4%), the notched threadfin bream (*Nemipterus peronei*, 3%) the asymmetrical goatfish (*Upeneus asymmetricus*; 3%), and the banded trumpeter (*Terapon theraps*; 2%). The majority of the bycatch species are not targeted by other fisheries in the region, with the exception of minor catches of demersal finfish such as emperors (0.6%).

Table 2.2. Target (bold blue), other retained (light blue), and discarded species by percentage weight caught in fishery-independent trawl survey shots in Exmouth Gulf between 2014 and 2017.

Common name	Species/Family name	% of total
Brown tiger prawns	***Penaeus esculentus***	**34.6**
Endeavour prawns	***Metapenaeus endeavouri***	**11.1**
Western king prawns	***Penaeus latisculcatus***	**8.5**
Whiting	*Sillago* spp.	3.1
Coral prawns	*Metapenaeopsis* spp.	1.1
Cuttlefish	*Sepia* spp.	0.7
Blue swimmer crabs	*Portunus armatus*	0.5
Mantis shrimp	Squillidae	0.2
Banana prawns	*Penaeus merguiensis*	0.1
Squid	Mostly *Photololigo edulis*	0.1
Octopus	*Octopus* sp.	<0.1
Bugs	*Thenus orientalis*	<0.1
Lizardfish	Mostly *Saurida undosquamis*	4.6
Threadfin bream	Mostly *Nemipterus peronei* and *Scolopsis taeniopterus*	4.6
Minor crabs	Mostly *Portunus* spp.	4.2
Goatfish	*Upeneus* spp.	4.1
Trumpeter	*Pelates* spp.	4.0
Flounder	Bothidae	2.5
Flathead	Platycephalidae	2.5
Ponyfish	Mostly *Leiognathus leuciscus*	2.2
Other finfish*		1.6
Dragonets	Callionymidae	1.1
Toadfish	Mainly *Torquigener whitleyi* and L*agocephalus sceleratus*	0.9
Trevallies	Carangidae	0.9
Leatherjackets	Mostly *Paramonacanthus choirocephalus*	0.9
Roach	Mostly *Gerres subfasciatus*	0.6
Other invertebrates*		0.5
Emperors	*Lethrinus* spp.	0.4
Red-barred grubfish	*Parapercis nebulosa*	0.4
Tuskfish	Mostly *Choerodon cephalotes*	0.4
Minor prawns	Penaeidae	0.4
Fusiliers	Mostly *Pterocaesio digramma*	0.4
Catfish	Mostly *Plotosus lineatus*	0.4
Cardinalfish	Mostly *Jaydia poecilopterus*	0.4
Blotched javelinfish	*Pomadasys maculatus*	0.4
Gulf damsel	*Pristotis obtusirostris*	0.4
Scorpionfish	Scorpaenidae	0.3
Herrings, sardines	Clupeidae	0.3
Echinoderms		0.3
White-spotted spinefoot	*Siganus canaliculatus*	0.2
Little jewfish	*Johnius borneensis*	0.2
Rays	Mostly *Gymnura australis*	0.2

The implementation of BRDs has largely eliminated the catch of large sharks and rays (Kangas and Thomson 2004; Table 2.2). In the recent bycatch study, only 0.2% of the total catch comprised small rays (mostly *Gymnura australis*) and 0.02% comprised small sharks. The use of hoppers on all EGPMF vessels reduces the time the catch spends out of water, makes for more efficient sorting and, consequently, bycatch is returned to the sea more quickly. The majority of invertebrate bycatch is likely to be returned to the water alive, whilst the post-release mortality of discarded finfish species is likely low.

2.5 ETP Species

It is a statutory requirement for commercial fishers to report any interactions of ETP species in their logbooks. An increase in reported interactions in recent years, in particular sea snakes and sawfish, is due to an increased awareness, education and commitment from both crew and skippers to improve reporting. Interactions with protected species are also recorded during Departmental fishery-independent surveys.

While protected species, including whales, dolphins, turtles, sea snakes and syngnathids (sea horses and pipefish) are abundant in Exmouth Gulf, only sea snakes are captured in larger numbers in the EGPMF and most are returned to the water alive (Table 2.3). A relatively diverse assemblage of sea snake is encountered in Exmouth Gulf with at least eight species being present in trawl bycatch. *Aipysurus apraefrontalis* and *A. duboisii* are the most common species, with lesser contributions of *A. laevis* and *Hydrophis major*. *Hydrophis stokesii*, *H. occelatus*, *H. elegans*, and *A. mosaicus* are minor contributors to the assemblage. Sawfish are also encountered in bycatch; however, these are not reliably reported to species level. Four sawfish species are thought to occur within the gulf; *Pristis pristis, P. clavata, P. zijsron and Anoxypristis cuspidata.*

The full implementation of BRDs in the EGPMF has markedly reduced the capture of turtles in prawn trawl nets (Table 2.3). Turtles are now mostly caught in try gear, which do not have grids. Due to the smaller size of these nets and very short duration of exploratory trawls, however, the turtles are usually returned alive.

Syngnathids are typically associated with seagrass and macroalgal habitats, with large proportion of these habitats in Exmouth Gulf permanently protected from trawling.

Table 2.3. Reported ETP species interactions in the EGPMF between 2014 and 2018.

Species / Fate	2014	2015	2016	2017	2018
Dolphin					
Alive	0	0	1	0	0
Dead	0	0	0	1*	0
Sawfish					
Alive	0	4	11	3	4
Dead	0	1	9	10	5
Unknown	0	1	0	2	1
Sea snakes					
Alive	50	496	1262	1436	1167
Dead	10	74	267	115	81
Syngnathids					
Alive	2	6	15	37	3
Dead	0	0	14	34	1
Turtles					
Alive	20	14	16	35	20
Dead	0	1	0	0	0

*Appeared to have been dead prior to capture

2.6 Habitat and Ecosystem Impacts

The EGPMF interacts with only a small proportion of the total area of Exmouth Gulf and the EGPMF management area, and therefore has a low potential to interact with benthic habitats. The spatial extent of fishing (referred to as the trawl footprint) is monitored annually for the EGPMF by combining the fishery-dependent logbook data and vessel monitoring system (VMS) data. This data set provides a fine scale spatial resolution (500 m x 500 m grid cells) of fishing effort based on the start and end of fishing from the logbook data and the spatial information provided in the VMS data. An entire grid cell is considered to be fished if a single VMS detection occurred within it, acknowledging that this method will overestimate the area trawled as a single pass of the trawl gear cannot cover the entire area of the 500 m x 500 m cell. For a five-year period (2012-2016) this method of effort calculation showed that the EGPMF interacted with ~42% (1174 km^2) of the total allowable fishing area (~2725 km^2) and ~29% of Exmouth Gulf (Figure 2.3).

Effort was categorised into level of fishing intensity; 0-None, 1-Low, 2-Moderate, 3-High. When overlaying this data (Figure 2.3) over the most recent habitat map for EGPMF (Figure 1.4), the majority of fishing between 2012 to 2016 is shown to occur on the sand habitats (72.1%), 25.3% over mixed assemblages, 8.1% over filter-feeder communities, and 0.1% over coral reef communities (Table 2.4). Owing to the predominantly mud and sand habitats of the trawl grounds, the trawl gear is considered to have relatively little physical impact. This is supported by other published assessments of the communities of Exmouth Gulf (Kangas et al. 2015, Pitcher et al. 2017; Mazor et al. 2017). Although EGPMF has one of the higher trawl footprints (when compared to other trawl fisheries in the Australian EEZ in relation to the spatial size of the allowable fishery), the protection provided by the permanent closures in this region is high, offsetting perceived higher exposure (Mazor et al. 2017).

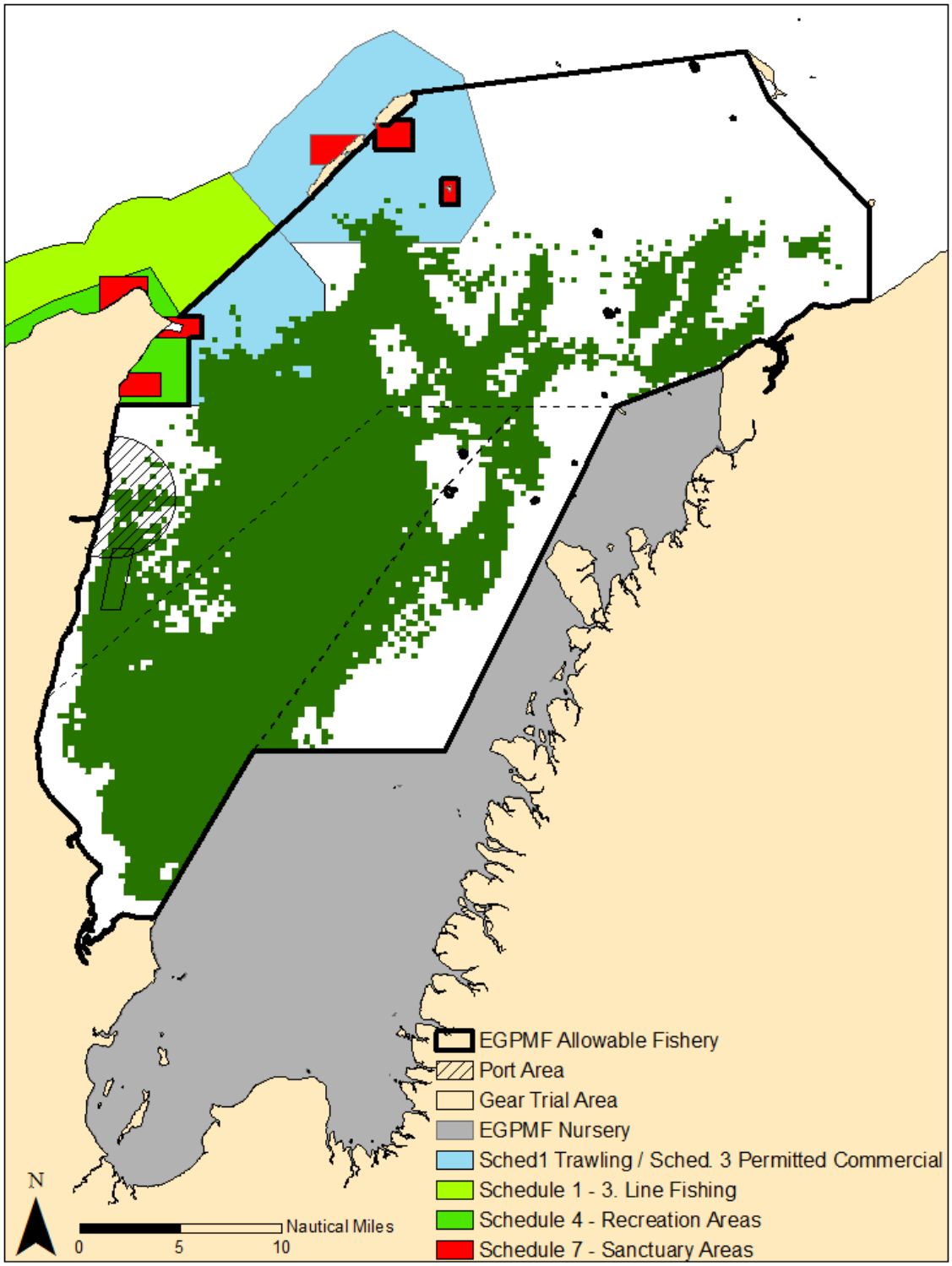

Figure 2.3. Extent of Exmouth Gulf Prawn Managed Fishery 'Trawl Footprint' (dark green shading) for 2012 to 2016.

Table 2.4. Intensity level of cumulative (2012-16) trawl footprint within each habitat type (%) (MG Kailis / DPIRD 2018).

Intensity	Coral Reef Community	Filter Feeder Community	Mixed Assemblage	Sand	Total
NONE (0)	99.9	91.9	74.7	27.8	55.6
1 (1 - 5)	0.1	6.6	13.6	18.2	15.0
2 (6 - 50)	0.0	1.4	10.6	43.6	24.3
3 (>50)	0.0	0.1	1.1	10.3	5.0
TOTAL	100.0	100.0	100.0	100.0	100.0

Pitcher et al. (2017) conducted a quantitative assessment for Exmouth Gulf, which found that the habitat and faunal absolute status of Exmouth Gulf were not impacted at the regional scale. Pitcher et al. (2017) used quantitative risk assessment, based on relative benthic status, to assess the impact of towed bottom fishing gear on the status of benthic habitats in Exmouth Gulf. Although the prawn species are managed at relatively high levels of annual harvest, the impact of the catch on local food chains is unlikely to be significant given the high natural mortality, extent of the non-trawled areas and the variable biomass levels of prawns resulting from changing environmental conditions such as cyclones.

3 Risk Assessment Methodology

Risk assessments have been extensively used as a mean to filter and prioritise the various identified fisheries management issues in Australia (Fletcher et al. 2002). The risk analysis methodology utilised for this risk assessment of the EGPMF is based on the global standard for risk assessment and risk management (AS/NZS ISO 31000), which has been adopted for use in a fisheries context (see Fletcher et al. 2002, Fletcher 2005; 2015). The broader risk assessment process is summarised in Figure 3.1.

The first stage establishes the context or scope of the risk assessment, including determining which activities and geographical extent will be covered, a timeframe for the assessment and the objectives to be delivered (Section 3.1). Secondly, risk identification involves the process of recognising and describing the relevant sources of risk (Section 3.2). Once these components have been identified, risk scores are determined by evaluating the potential consequences (impacts) associated with each issue, and the likelihood (probability) of a particular level of consequence actually occurring (Section 3.3).

Risk evaluation is completed by comparing the risk scores to established levels of acceptable and undesirable risk to help inform decisions about which risks need treatment. For issues with levels of risk that are considered undesirable, risk treatment involves identifying the likely monitoring and reporting requirements and associated management actions, which can either address and/or assist in reducing the risk to acceptable levels.

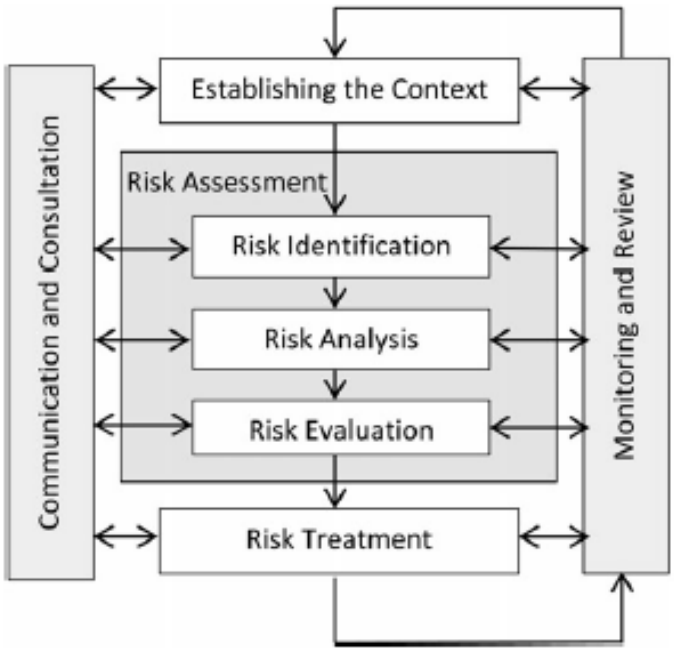

Figure 3.1. Position of risk assessment within the risk management process.

3.1 Scope

This risk assessment covers commercial prawn trawl fishing within the management boundaries of the EGPMF. The assessment considers only the ecological impacts of these fishing activities. The calculation of risk is usually determined within a specified period, which for this assessment is the next five years (i.e. until 2025).

3.2 Risk Identification

The first step in the risk assessment process was to identify issues relevant to the fishery being assessed. Issues were identified using a component tree approach (see Figure 3.2 for a generic example), where major risk components are deconstructed into smaller sub-components that are more specific to allow the development of operational objectives (Fletcher et al. 2002). The component trees are tailored to suit the individual circumstances of the fishery being examined by adding and expanding some components and collapsing or removing others.

The development of the component tree for evaluating the ecological sustainability of the EGPMF was based on:

- Previous risk assessments undertaken for the fisheries to achieve approval for Wildlife Trade Operations (Department of Fisheries 2002, 2009);
- Gaps identified during a pre-assessment of the EGPMF against the Marine Stewardship Council (MSC) Fisheries Standards in 2013;
- An internal risk assessment workshop undertaken by Departmental staff in May 2019; and
- Consultation with industry and external stakeholders during an external ERA workshop in September 2019.

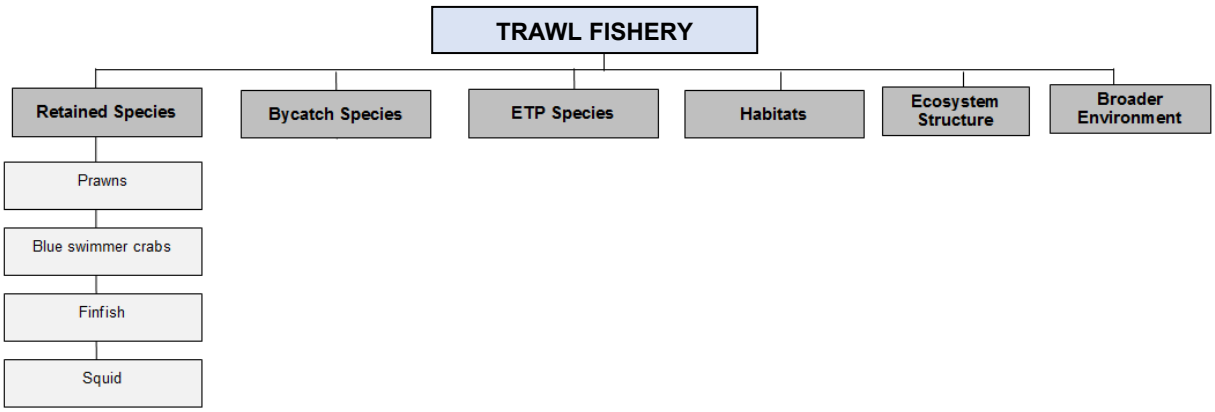

Figure 3.2. An example of a component tree for ecological sustainability, identifying the main components (dark grey boxes) and sub-components for retained species in a trawl fishery.

3.3 Risk Analysis, Evaluation and Treatment

The risk analysis process assists in separating minor acceptable risks from major, unacceptable risks and prioritising management actions. Once the relevant components and issues for the EGPMF were identified, the process to prioritise each was undertaken using the ISO 31000-based qualitative risk assessment methodology. This methodology utilises a consequence-likelihood analysis, which involves the examination of the magnitude of potential consequences from fishing activities and the likelihood that those consequences will occur given current management controls (Fletcher 2015).

Although consequence and likelihood analyses can range in complexity, this assessment utilised a 4×4 matrix, where the consequence levels ranged from 1 (e.g. minor impact to fish stocks) to 4 (e.g. major impact to fish stocks) and likelihood levels ranged from 1 (Remote; i.e. < 5 % probability) to 4 (Likely; i.e. ≥ 50 % probability). Scoring involved an assessment of the likelihood that each level of consequence is occurring, or is likely to occur within the 5-year period specified for this assessment. If an issue is not considered to have any detectable impact, it can be considered to be a 0 consequence; however, it is preferable to score such components as there being a remote (1) likelihood of a minor (1) consequence.

This ecological risk assessment used a set of pre-defined likelihood and consequence levels. In total five consequence tables were used in the risk analysis to accommodate for the variety of issues and potential outcomes:

1. Target (Primary) fish stocks – measured at a stock level;
2. Non-Target (Secondary, retained/bycatch) fish stocks – measured at a stock level;
3. ETP species – measured at a population or regional level;
4. Habitats – measured at a regional level; and
5. Ecosystem/Environment – measured at a regional level.

For each issue, the consequence and likelihood scores were evaluated to determine the highest risk score using the risk matrix (Figure 3.3). Each issue was thus assigned a risk level within one of five categories: Negligible, Low, Medium, High or Severe (Table 3.1).

Different levels of risk have different levels of acceptability, with different requirements for monitoring and reporting, and management actions. Risks identified as negligible or low are considered acceptable, requiring either no or periodic monitoring, and no specific management actions. Issues identified as medium risk are considered acceptable providing there is specific monitoring, reporting, and management measures are implemented. Risks identified as high are considered ‘not desirable’, requiring strong management actions or new control measures to be introduced in the near future. Severe risks are considered ‘unacceptable’ with major changes to management required in the immediate future (Fletcher et al. 2002).

The risks be reviewed in 5 years, or prior to the next review of the EGPMF harvest strategy, where the risk scores are used as the performance indicator for the non-target ecological assets. Monitoring and assessment of the key target species will be ongoing, with the performance indicators for those stocks evaluated on an annual basis.

		Likelihood			
		Remote (1)	Unlikely (2)	Possible (3)	Likely (4)
Consequence	Minor (1)	Negligible	Negligible	Low	Low
	Moderate (2)	Negligible	Low	Medium	Medium
	High (3)	Low	Medium	High	High
	Major (4)	Low	Medium	Severe	Severe

Figure 3.3. 4×4 Consequence – Likelihood Risk Matrix (based on AS 4360 / ISO 31000; adapted from Fletcher 2015).

Table 3.1. Risk levels applied to evaluate individual risk issues (modified from Fletcher 2005).

Risk Levels	Description	Likely Reporting & Monitoring Requirements	Likely Management Action
Negligible	Acceptable; Not an issue	Brief Notes – no monitoring	Nil
Low	Acceptable; No specific control measures needed	Full Notes needed – periodic monitoring	None specific
Medium	Acceptable; With current risk control measures in place (no new management required)	Full Performance Report – regular monitoring	Specific management and/or monitoring required
High	Not desirable; Continue strong management actions OR new / further risk control measures to be introduced in the near future	Full Performance Report – regular monitoring	Increased management activities needed
Severe	Unacceptable; Major changes required to management in immediate future	Recovery strategy and detailed monitoring	Increased management activities needed urgently

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5 Appendix A

Risk ratings in previous risk assessments for the EGPMF

Component and Sub-component	2001	2008
Retained Species (Primary)		
Brown tiger prawns	MEDIUM	MEDIUM
Western king prawns	LOW	LOW
Retained Species (Secondary)		
Endeavour prawns	LOW	LOW
Coral prawns	LOW	LOW
Banana prawns	LOW	LOW
Blue swimmer crabs	NEGLIGIBLE	NEGLIGIBLE
Squid & cuttlefish	NEGLIGIBLE	NEGLIGIBLE
Sharks	NEGLIGIBLE	NEGLIGIBLE
Bugs	NEGLIGIBLE	NEGLIGIBLE
Finfish	NEGLIGIBLE	NEGLIGIBLE
Other	NEGLIGIBLE	NEGLIGIBLE
Bycatch Species		
Invertebrates	NEGLIGIBLE	NEGLIGIBLE
Finfish	LOW	LOW
Sharks	NEGLIGIBLE	NEGLIGIBLE
ETP Species		
Sea snakes	NEGLIGIBLE	NEGLIGIBLE
Green turtles	NEGLIGIBLE	NEGLIGIBLE
Loggerhead turtles	LOW	LOW
Leatherback turtles	NEGLIGIBLE	NEGLIGIBLE
Flatback turtles	NEGLIGIBLE	NEGLIGIBLE
Hawksbill turtles	NEGLIGIBLE	NEGLIGIBLE
Dugongs & cetaceans	LOW	LOW
Whales		LOW
Syngnathids	LOW	LOW
Habitats		
Sand	LOW	LOW
Seagrass & macroalgae	NEGLIGIBLE	NEGLIGIBLE
Coral/sponge	LOW	LOW
Ecosystem		
Taking retained species	LOW	LOW
Discarding/Provisioning	LOW	LOW
Translocation (pests, disease)	NEGLIGIBLE	NEGLIGIBLE
Turbidity	NEGLIGIBLE	NEGLIGIBLE

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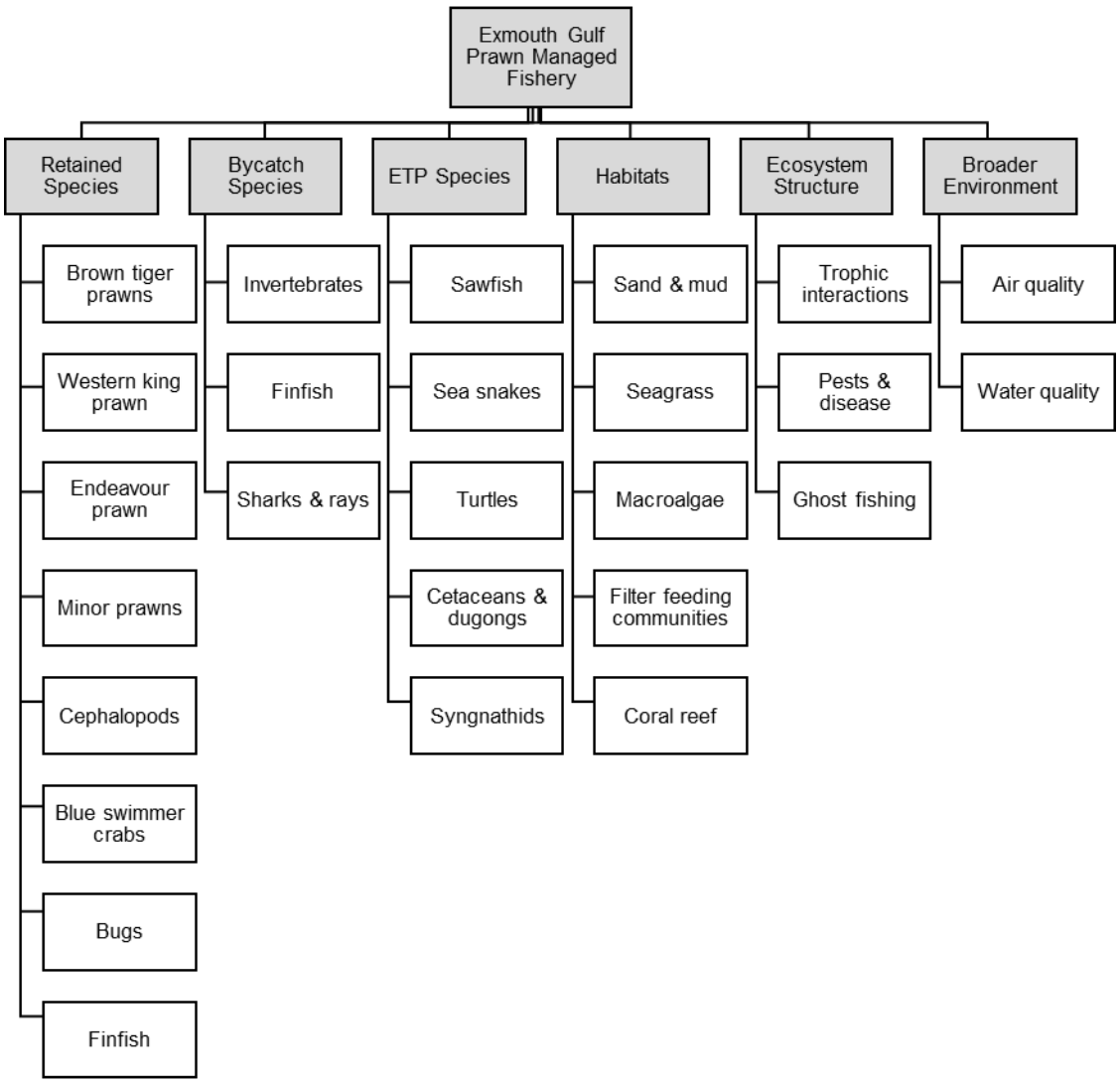
Department of Primary Industries and Regional Development
Western Australia

Ecosystem Based Fishery Management

Ecological Risk Assessment of the Exmouth Gulf Prawn Managed Fishery



September 2019

e-systems

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Revision History:

Revision 0	8 October 2019	For DPIRD review with stakeholders.
Revision 1	6 November 2019	Incorporated comments and issued for distribution.

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Table of Contents

Attachments

Executive Summary

An ecological risk assessment (ERA) of the Exmouth Gulf Prawn Managed Fishery (Fishery) was convened with industry experts and stakeholders on 12 September 2019 by the Department of Primary Industries and Regional Development (DPIRD, Department) in Western Australia. ERAs are conducted by the Department as part of its Ecosystem Based Fishery Management framework and the outputs inform the development and review of harvest strategies.

The Fishery received Marine Stewardship Council (MSC) accreditation in October 2015 and remains certified through October 2020 under the WA Government's 2012 commitment to support independent certification of the State's commercial fisheries. This ERA will be used to inform the re-certification of this Fishery.

The ERA Workshop Procedure (Stoklosa 2019) was developed in consultation with the Department, based on the methodology published by Fletcher et al. (2002) and recently refined (Fletcher 2015). Consequence and likelihood ratings for ecological components were adopted from Department standards being applied to all fisheries in Western Australia (Dr Lynda Bellchambers, personal communication). These standards are consistent with the Australian Standard for risk management (AS ISO 31000:2018).

The ERA Workshop Procedure and an executive summary of the Department's internal ERA undertaken in July 2019 (DPIRD 2019) were distributed to all stakeholders that confirmed their intention to attend this subject ERA.

Using the risk assessment methodology adopted by the Department and recognised for MSC certification, the ERA identified potential impacts on sustainability objectives for the Fishery and assessed the risks. All of the threats on the agenda were assessed using a consultative and structured workshop procedure. Consensus was reached in the expert judgements of the Stakeholder Working Group in this qualitative ERA, with the exception of the risk level for the interaction of trawl gear with filter feeding communities (medium vs. low risk).

The threats assessed for fishing interactions with ecological assessment components in the ERA were ranked medium, low or negligible using the adopted methodology. Risk rankings of medium or less are considered acceptable risks for a well-managed fishery, subject to ongoing management practices and performance monitoring.

Ongoing performance monitoring of the Fishery should confirm that these risks remain acceptably low. In the event that circumstances of the Fishery change, or performance monitoring detects an unexpected change, the relevant threats assessed in this ERA should be reviewed.

Introduction

An ecological risk assessment (ERA) of the Exmouth Gulf Prawn Managed Fishery (EGPMF, Fishery) was convened with industry experts and stakeholders on 12 September 2019 by the Department of Primary Industries and Regional Development (DPIRD, Department) in Western Australia (WA). ERAs are conducted by the Department as part of its Ecosystem Based Fisheries Management (EBFM) framework and the outputs inform the development and review of harvest strategies.

The Fishery previously received MSC accreditation in October 2015 and remains certified through October 2020 under the WA Government's 2012 commitment to support independent certification of the State's commercial fisheries. The target species of the subject Fishery are primarily brown tiger prawn (*Penaeus esculentus*), western king prawn (*Penaeus latisulcatus*) and blue endeavour prawn (*Metapenaeus endeavouri*).

The Department completed an internal ERA of the Fishery in July 2019 to evaluate the ecological impact of demersal trawling. The potential impacts were identified and assessed for all retained species, bycatch, endangered, threatened and protected (ETP) species, habitats and the broader ecosystem. An executive summary of the Department's internal ERA (DPIRD 2019) was made available to industry and stakeholders and was referenced without prejudicing the outcomes of this subject ERA.

Exmouth Gulf is a large (~4,000 km^2) and shallow (predominantly <20 m) tropical gulf in the Gascoyne Coast Bioregion of WA—in a transition between the tropical waters of the northern coast and the temperate waters of the southwest. The Gulf is open to the north and enclosed by the Cape Range and large sand beaches to the west, and a narrow band of mangroves bordering extensive salt flats to the east and south.

The Leeuwin Current affects the inshore and offshore waters of Exmouth Gulf, particularly during strong winter flows, introducing elevated water temperatures, depressed levels of dissolved nutrients and particle concentrations which inhibit the growth of macro algae. Consequently, fisheries production relies on nutrient sources from benthic habitats in nearshore waters, rather than from oceanic ecosystems.

Habitat information for Exmouth Gulf is limited, focussed around the shallow inshore areas within the nursery grounds with attention to seagrass species that are found in very low abundance. There are known to be small areas of coral reefs, primarily at the northern end of the Gulf (Bundegi Reef, Muiron Islands), and at the southern end (Point Lefroy to Roberts Island). 'Hotspots' of dense sponge communities have also been identified. Despite relative low abundance of vegetation Exmouth Gulf is considered a highly productive ecosystem, with macroalgae, phytoplankton and salt-flat cyanobacteria the main primary producers.

Two habitat maps are currently available to describe the extent of broad habitat types of the Gulf. The first map developed in 2006 describes six biophysical habitats from work completed as part of the North West Shelf Joint Environmental Management Study (NWSJEMS). The second map was developed from over a hundred validation survey sites by the Department in 2018 and is considered a more accurate estimate of the spatial distribution of benthic habitats within the area of Fishery operations (and validated much of the 2006 NWSJEMS map). The 2018 map identifies four major habitat types: mixed assemblage (~48% macro algae, seagrass, anemones, ascidians, bryozoans, soft coral), sand (~44%), filter feeder communities (~7.5%) and coral reef communities (~0.5%).

Thirty percent of the Exmouth Gulf area is permanently closed to trawling (excluding Ningaloo Marine Park, Muiron Marine Management Zone and the nursery grounds to the south and east of the Gulf). Six boats operate in the Fishery using low-opening otter trawl systems on primarily sandy substrates in only about 20-40% of the remaining Fishery area annually. The fishing season typically extends from April through early December, and the harvest strategy is based on a constant escapement approach which aims

to allow prawns to reach optimal market size before fishing commences and to protect spawning stocks to temporal closures of important spawning areas of the Gulf. Boats are equipped with hoppers to maximise the survival of discarded species in recirculating seawater.

The Fishery operates under an input control system, with restrictions on boat numbers and trawl gear size, as well as seasonal closures and restricted trawl hours (mostly nighttime fishing). Monthly moon closures of at least five days and significant spatial closures are also used to reduce effort. The Fishery is monitored by a vessel monitoring system (VMS) and daily logbooks, allowing fishery managers to monitor activities in relation to sensitive habitats and to track changes in fishing locations and intensity over time.

Retained species are dominated by Brown tiger prawns, Western king prawns and Blue endeavour prawns. In addition to minor prawn species, cephalopods (including cuttlefish, squid and octopus) have been consistently retained in low numbers. Given the short life span, high fecundity and wide distributions of most cephalopods they are considered highly productive and resilient to fishing.

The Fishery also retains a low number of Blue swimmer crabs (~0.4% of the total catch) captured in a small area of Exmouth Gulf, with extensive refuge areas provided within the permanently closed nursery areas and in the deeper waters of the continental shelf adjacent to the Gulf. The only other notable species retained by prawn trawlers is bugs (*Thenus* spp.). However, although commercially valuable they comprise about 0.4 % of the retained catch.

Bycatch is variable, dominated by mixed finfish and invertebrates. Bycatch reduction devices (BRDs) have largely eliminated the bycatch of large sharks and rays in the Fishery. The use of hoppers on all vessels reduces the time the catch spends out of water to enable more efficient sorting and to return discarded species to the sea more quickly. The majority of invertebrate bycatch is likely to be returned to the water alive, whilst the post-release mortality of discarded finfish is likely to be low.

Improved reporting as a result of the commitment of commercial fishers under statutory requirements for ETP species has indicated an increase in interactions, particularly sea snakes and sawfish. The sea snakes captured by trawling are mostly returned to the water alive. Very small numbers of sawfish are captured but not reliably reported to species level, with many returned alive. Try nets periodically capture turtles during exploratory trawls, but due to the smaller size of these nets and short duration of trawls the turtles are usually returned alive. The implementation of BRDs in demersal trawl gear used for commercial fishing has greatly reduced turtle capture.

The Fishery interacts with only a small portion of the total area of Exmouth Gulf and the EGPMF management area, predominantly on sand habitats, and therefore has a low potential to impact more sensitive benthic habitats. Although target prawn species are managed at relatively high levels of annual harvest, the impact of the catch on local food chains is unlikely to be significant—given the high natural mortality, extent of the non-trawled areas and the variable biomass of prawns resulting from changing environmental conditions such as cyclones.

Selection of the assessment method

The Department has adopted the risk analysis methodology of Fletcher et al. (2002), with some recent refinement (Fletcher 2015). It is the policy of the Department that the adopted risk analysis methodology is consistently used across all fishery assessments in Western Australia. E-Systems developed an ERA Workshop Procedure (Stoklosa 2019) incorporating the adopted Department risk analysis methodology. The Department's risk analysis methodology is consistent with the Australian Standard for risk management (AS ISO 31000:2018).

The ERA Workshop Procedure and an executive summary of the Department's internal ERA undertaken in July 2019 (DPIRD 2019) were distributed to all stakeholders that confirmed their intention to attend this subject ERA.

Using the risk assessment methodology adopted by the Department and recognised for MSC certification, the ERA identified potential impacts on sustainability objectives for the Fishery and assessed the risks. The threats for each assessment component were assessed using a consultative and structured workshop procedure, recording the circumstances of each interaction and risk analysis for all participants to view and clarify as necessary during the workshop.

Consultation and workshop participants

A consultative and inclusive process was developed for this ERA, to ensure that all stakeholders were provided with the ERA Workshop Procedure (Stoklosa 2019) and the technical documents that were assembled to underpin the assessment of the threats that were assessed. Substantial effort was made to seek the participation of a cross-section of experts who could provide high quality analysis of technical documentation, engage with stakeholders in discussion of each particular threat, and perform a qualitative risk analysis.

A Stakeholder Working Group of subject matter experts were proposed for the ERA workshop. The Stakeholder Working Group comprised a wide range of stakeholders.

The workshop facilitator was Richard Stoklosa of E-Systems, engaged by the Department. Preparation and conduct of the workshop was strictly guided by the ERA Workshop Procedure.

Stakeholder Working Group

A Stakeholder Working Group was invited by the Department to participate in the ERA workshop, including those involved in previous ERAs and others identified as having an interest in the proceedings. Stakeholders included individuals, organisations, companies, government agencies and research scientists having an interest and/or technical expertise. The Department identified a list of stakeholders who have expressed an interest in the MSC certification process for the Fishery, so that nominated participants could be informed of preparations for the workshop and be invited to attend.

The Stakeholder Working Group received ERA Workshop Procedure (Stoklosa 2019) and executive summary of the Department's internal ERA from July 2019 (DPIRD 2019).

Numerous stakeholders were invited to attend, including persons from (in no particular order):

- Department of Primary Industries and Regional Development;
- Department of Biodiversity, Conservation and Attractions;
- Marine Stewardship Council;
- Australian Fishery Management Authority;
- Western Australian Fishing Industry Council;
- Western Australian Museum;
- Conservation Council;
- Conservation Commission;
- University of Western Australia;
- Curtin University;
- Murdoch University;
- Flinders University;

- Edith Cowan University;
- Western Australian Marine Science Institution;
- Australian Institute of Marine Sciences;
- Greenpeace;
- World Wildlife Fund for Nature;
- Wilderness Society;
- Pew Charitable Trusts;
- Yamatji Marlpa Aboriginal Corporation;
- Recfishwest;
- Shark Bay World Heritage Advisory Committee;
- Ningaloo Coast World Heritage Advisory Committee;
- Gascoyne Development Commission;
- Aquaculture Council of Western Australia;
- marine science consulting firms;
- local Shire representatives; and
- MG Kailis Group, sole Exmouth Gulf prawn licensee.

There were 20 people from a cross-section of these organisations who expressed an interest in attending the ERA workshop, and 15 people who actually attended.

Workshop proceedings

A workshop agenda was distributed to all participants. All persons attending the workshop were invited to introduce themselves and area of expertise or interest. The agenda and ERA Workshop Procedure (Stoklosa 2019) were adopted by all participants, noting that the agenda would be flexible to accommodate the time availability of participants with specific expertise. The workshop agenda and list of participants is presented in Attachment 1.

During the workshop, the recording of workshop proceedings in a structured risk assessment template was digitally projected, to enable all workshop participants to observe the information that was captured from the discussions. All participants had the opportunity to clarify the technical record during the workshop to ensure accuracy and eliminate post-workshop wordsmithing or revisions.

Risk assessment

Identification of potential threats

The starting point for the workshop was the information contained in the Department's internal ERA from July 2019, which identifies the assessment components for the target species, secondary retained species, bycatch species, ETP species, habitats and ecological communities and broader ecosystem. The participants chose to proceed on this basis, with the understanding that additional threats could be identified and assessed, and that any of the Department's previous ERA findings could be debated and changed as necessary to reflect the views of the participants.

Consequence and likelihood ratings

For each assessment component of the Fishery, the consequences of the interaction of fishing activities with ecological components was described, and the existing management and operational measures to control or reduce the consequences or the likelihood of each threat were identified. The consequence ratings are reproduced here in Tables 1 through 5, and the likelihood ratings are reproduced in Table 6.

Table 1. Consequence ratings for primary target (retained) species.

Category	Rating	Description of consequences
Minor	1	Fishing impacts either not detectable against background variability for this population; or if detectable, minimal impact on population size and none on dynamics. Spawning biomass > Target level
Moderate	2	Fishery operating at maximum acceptable level of depletion. Spawning biomass < Target level but > Threshold level (BMSY)
High	3	Level of depletion unacceptable but still not affecting recruitment levels of stock. Spawning biomass < Threshold level (BMSY) but > Limit level
Major	4	Level of depletion is already affecting (or will definitely affect) future recruitment potential of the stock. Spawning biomass < Limit level

Table 2. Consequence ratings for non-target, secondary (retained and bycatch) species.

Category	Rating	Description of consequences
Minor	1	Measurable but minor levels of depletion of fish stock.
Moderate	2	Maximum acceptable level of depletion of stock.
High	3	Level of depletion of stock unacceptable but still not affecting recruitment level of the stock.
Major	4	Level of depletion of stock are already affecting (or will definitely affect) future recruitment potential of the stock.

Table 3. Consequence ratings for endangered, threatened and protected (ETP) species.

Category	Rating	Description of consequences
Minor	1	Few individuals directly but will not further impact on stock. Level of capture/interaction is well below that which will generate public concern.
Moderate	2	Level of capture is the maximum that will not impact on recovery or cause unacceptable public concern.
High	3	Recovery may be affected and/or some clear, but short-term public concern will be generated.
Major	4	Recovery times are clearly being impacted and/or public concern is widespread.

Table 4. Consequence ratings for habitats.

Category	Rating	Description of consequences
Minor	1	Measurable impacts to habitat but still not considered to impact on habitat dynamics or system. Area directly affected well below maximum accepted.
Moderate	2	Maximum acceptable level of impact to habitat with no long-term impacts on region-wide habitat dynamics.
High	3	Above acceptable level of loss/impact with region-wide dynamics or related systems may begin to be impacted.
Major	4	Level of habitat loss clearly generating region-wide effects on dynamics and related systems.

Table 5. Consequence ratings for ecosystem/communities.

Category	Rating	Description of consequences
Minor	1	Measurable but minor changes to the environment or ecosystem structure but no measurable change to function.
Moderate	2	Maximum acceptable level of change to the environment or ecosystem structure with no material change in function.
High	3	Ecosystem function altered to an unacceptable level with some function or major components now missing and/or new species are prevalent.
Major	4	Long-term, significant impact with an extreme change to both ecosystem structure and function; different dynamics now occur with different species/groups now the major targets of capture or surveys.

Table 6. Likelihood levels.

Category	Rating	Description of likelihood
Remote	1	The consequence has never been heard of in these circumstances, but it is not impossible within the timeframe* (probability <5%).
Unlikely	2	The consequence is not expected to occur in the timeframe, but it has been known to occur elsewhere under special circumstances (probability 5 to <20%).
Possible	3	Evidence to suggest this consequence level is possible and may occur in some circumstances within the timeframe (probability 20 to <50%).
Likely	4	A particular consequence level is expected to occur in the timeframe (probability ≥50%).

* The 'timeframe' is defined as the management period for the ERA, normally a five-year timeframe.

Risk ranking criteria

Using the Stakeholder Working Group's judgments of consequence and likelihood ratings, the risk is ranked as the product of the two ratings, as illustrated in the risk matrix in Figure 1. The risk matrix is used to rank risk in one of five levels, consistent with the adopted ESD Reporting Framework (Fletcher et al. 2002, Fletcher 2015).

		Likelihood rating			
		Remote (1)	**Unlikely (2)**	**Possible (3)**	**Likely (4)**
Consequence rating	**Minor (1)**	1	2	3	4
	Moderate (2)	2	4	6	8
	High (3)	3	6	9	12
	Major (4)	4	8	12	16

Figure 1. Risk ranking matrix.

Although the risk matrix depicts a 'risk score' of 1 to 16, it is based on a strictly qualitative risk analysis. The risk scores are used as a convenient means of classifying risk in five levels (negligible to severe) but should not be interpreted in quantitative terms. An explanation of the required management response and reporting requirements for each risk level is summarized in Table 7.

Table 7. Risk rankings and expected action.

Risk ranking	Risk outcome	Likely reporting and monitoring requirements	Likely management action
Negligible	Acceptable. Not an issue.	Brief justification – no monitoring.	Nil.
Low	Acceptable. No specific control measures needed.	Full justification required – periodic monitoring.	No specific response.
Medium	Acceptable. Continue with current risk control measures in place (no new management required).	Full performance report – regular monitoring.	Specific management and/or monitoring required.
High	Not desirable. Continue strong management actions OR new/further risk control measures to be introduced in near future.	Full performance report – regular monitoring.	Increases to management activities needed.
Severe	Unacceptable. If not already introduced, major changes are required to management in immediate future.	Full performance report – recovery strategy and detailed monitoring.	Increases to management activity needed urgently.

Assessment of ecological components

The Department has developed an 'assessment tree' of the ecological components to be assessed in the Exmouth Gulf Prawn Managed Fishery, presented in Figure 2 for reference. Workshop participants were invited to suggest any additional ecological components to assess in the workshop, but no new components were identified.

Following the introduction of each threat to the assessment components and clarification of the causes and effects of the interaction, an 'interaction scenario' was discussed by workshop participants and recorded in the risk assessment record. Existing risk management controls were identified for each threat to assist with the risk analysis part of the assessment. The completed risk assessment record for all threats considered in the ERA is presented in Attachment 2.

Some of the assessment components were assessed multiple times for different types of threats. These distinctions were made to ensure that the risk analysis focused on very specific interactions rather than attempting to make judgments about broad scenario descriptions that could be interpreted in different ways.

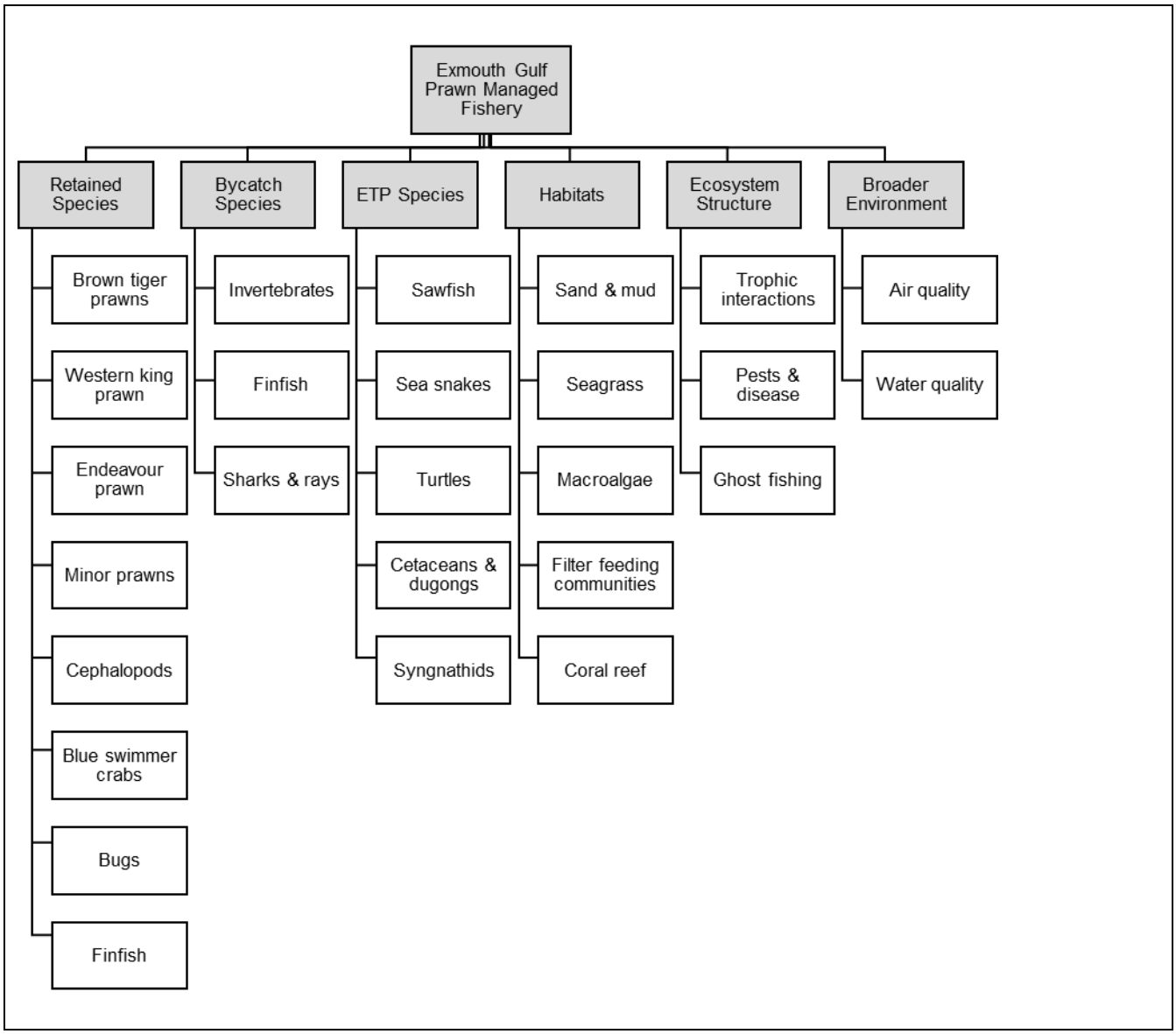

Figure 2. Exmouth Gulf Prawn Managed Fishery ecological components for assessment.

Risk ranking

Risk ranking is used to set priorities for risk management actions, as explained in Table 7.

Using the adopted risk assessment methodology, this ERA identified potential impacts on sustainability objectives for the Fishery and assessed the risks. The risk analysis revealed a number of potential threats to marine ecosystem components to be managed. Each of these is discussed below form the most significant threats assessed in the workshop. The threats for assessment components are numbered for reference to the ERA Workshop Record presented in Attachment 2.

No severe or high risk rankings were recorded in the ERA workshop.

Medium risk

Six medium risks were identified in the risk assessment:

Item number	Nature of risk
1	Reduction of brown tiger prawn stock, one of the target species in the prawn trawl fishery.
2	Reduction of western king prawn stock, one of the target species in the prawn trawl fishery.
3	Reduction of blue endeavour prawn stock, one of the target species in the prawn trawl fishery.
5	Reduction of banana prawn stock, one of the secondary retained species in the prawn trawl fishery.
15	Capture and release of sawfish species.
25	Trawl gear interaction with filter feeding communities.

Target prawn species (1, 2 and 3)

Medium risk is considered the appropriate level of risk for exploitation of target prawn species at acceptable levels. No additional corrective actions were suggested for these prawn species.

Secondary retained banana prawns (5)

Medium risk is considered the appropriate level of risk for exploitation of for secondary retained species at acceptable levels. Banana prawns are retained only when abundant, after consecutive years of high rainfall. Exmouth Gulf is the southernmost limit of the distribution of the species. No additional corrective actions were suggested for this species.

Capture and release of sawfish species (15)

Although captured in very low numbers on vessels with recirculating seawater hoppers, post-release survival is likely to be low. A significant portion of nearshore waters are closed to trawling and the Fishery complies with the national recovery plan for sawfish species. The risk ranking of medium reflects the uncertainty in the recovery of the species and the potential for public concern for ETP species. No additional corrective actions were suggested for sawfish species.

Trawl gear interaction with filter feeding communities (25)

Between 2012 and 2016 about five to eight percent of fishing occurred on mapped filter feeder communities within the managed fishery area of Exmouth Gulf. Benthic trawling has the potential for damage and loss to filter feeding community habitat sustaining associated benthos (e.g. sponges). A significant portion of nearshore waters are closed for trawling, largely protecting the distribution and abundance of filter feeding communities in Exmouth Gulf.

The Stakeholder Working Group could not agree on the likelihood of filter feeding communities exposed to moderate consequences. The rationale for scoring the likelihood varied from unlikely to possible and the likelihood of possible was recorded in the ERA Workshop Record (Attachment 2), subject to the review of existing data.

No additional corrective actions were suggested for trawling activities.

Low and negligible risk

Eleven low risk rankings and eighteen negligible risk rankings were recorded for fishery interactions with ecological assessment components. No additional corrective actions were suggested to mitigate these low and negligible risks.

Other observations

Some of the interactions of fishing activities with ecological assessment components were regarded as having the lowest consequence rating (minor) and the lowest likelihood rating (remote). In some cases, these interactions were regarded as having no credible threat to ecological values but were retained by workshop participants in the ERA Workshop Record (Attachment 2) as negligible risk. Retaining these interactions as negligible risk was decided to acknowledge the possibility that these interactions might become relevant in the future, or to demonstrate that the interactions were given genuinely considered in view of potential stakeholder or public concern.

It was noted by a stakeholder (Chair) of the Ningaloo Coast World Heritage Advisory Committee that the connectivity of Exmouth Gulf environmental values with the Ningaloo Reef World Heritage Area should be considered in fisheries management and potential impacts to ecological components as a result of commercial fishing activities.

Risk treatment

Medium risk assessed for the target/retained species, sawfish species and trawl gear interactions with filter feeding communities are considered acceptable if specific monitoring, reporting and management measures are implemented effectively and performance indicators are evaluated annually. No additional recommendations were suggested for managing these risks; however, a review should be undertaken in five years—or prior to the next review of the Fishery harvest strategies.

For all medium risks, specific management and/or monitoring is required and is routinely implemented in the managed Fishery. Risk treatment is not strictly required for low and negligible risk (refer to Table 7). However, participants were encouraged to suggest practical and cost-effective risk treatment measures which might further reduce the consequences and/or likelihood rating. These measures were recorded in the ERA Workshop Record (Attachment 2) for the threats where risk treatment was suggested.

Suggested risk treatment measures (beyond those already planned) are recorded as important advice to the Department for consideration, but they are subject to feasibility and cost/benefit analyses by the fishing industry and/or the Department to manage risk in the Exmouth Gulf Prawn Managed Fishery.

Risk management

Risk management of the Exmouth Gulf Prawn Managed Fishery involves standardised fishing practices and fishing gear, industry standards and codes of practice, legislation, and research and monitoring of management effectiveness. In addition, the WA government supports independent certification of the State's commercial fisheries, and the EGPMF is currently certified by the MSC.

MSC Principle 2 (Version 2.0) for sustainable fishing states:

> *Fishing operations need to be managed to maintain the structure, productivity, function and diversity of the ecosystem on which the fishery depends, including other species and habitats.*

There are five performance indicators for information under MSC Principle 2 that have been addressed by this ERA for managing risk, subject to specific assessment criteria for the EGPMF:

2.1.3 *Information on the nature and amount of primary species taken is adequate to determine the risk posed by the unit of assessment (UoA) and the effectiveness of the strategy to manage primary species.*

2.2.3 *Information on the nature and amount of secondary species taken is adequate to determine the risk posed by the UoA and the effectiveness of the strategy to manage secondary species.*

2.3.3 *Relevant information is collected to support the management of UoA impacts on ETP species, including:*

— information for the development of the management strategy;
— information to assess the effectiveness of the management strategy; and
— information to determine the outcome status of ETP species.

2.4.3 *Information is adequate to determine the risk posed to the habitat by the UoA and the effectiveness of the strategy to manage impacts on the habitat.*

2.5.3 *There is adequate knowledge of the impacts of the UoA on the ecosystem.*

The performance indicators, particularly with respect to understanding potential impacts and risk have been addressed through the process of conducting the subject ERA and the results of the assessment, as documented in this report.

The ERA Workshop Record (Attachment 2) functions as a risk register for fishery managers and provides input to the harvest strategy for the Fishery. A change in Fishery operations or adverse change from the ongoing performance monitoring of ecological components requires review of the risk rankings and recommendations of the ERA.

Conclusion

The ERA undertaken on 12 September 2019 resulted in the outcomes documented in the Ecological Risk Assessment Workshop Record presented as Attachment 2. All of the assessment components on the agenda were assessed using a consultative and structured workshop procedure, addressing the requirements of the MSC for continued certification of the EGPMF. Consensus was reached on the expert judgements of the Stakeholder Working Group in this qualitative ERA, with the exception of the risk ranking for trawl gear interactions with filter feeding communities (medium vs. low risk).

The threats assessed for fishing interactions with ecological assessment components.in the ERA were ranked medium, low or negligible using the adopted methodology. Risk rankings of medium or less are considered acceptable risks for a well-managed fishery, subject to ongoing performance monitoring. No additional risk management measures were recommended for consideration.

Ongoing performance monitoring of the Fishery should confirm that these risks remain acceptably low. In the event that circumstances of the Fishery change, or performance monitoring detects an unexpected change, the relevant threats assessed in this ERA should be reviewed.

References

AS ISO 31000:2018. *Risk management—Guidelines*. Standards Australia, Sydney.

DPIRD 2019. *Executive Summary: Ecosystem Based Fishery Management (EBFM)—Risk assessment of the Exmouth Gulf Prawn Managed Fishery*. Internal review, Department of Primary Industries and Regional Development, Western Australia.

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Fletcher, W.J. (2015). *Review and refinement of an existing qualitative risk assessment method for application within an ecosystem-based Fishery management framework*. ICES Journal of Marine Science 72: 1043-1056.

Stoklosa, R 2019. *Ecological Risk Assessment, Western Australian Fishery—Workshop Procedure*. Prepared for the Department of Primary Industries and Regional Development Western Australia.

Attachment 1

Workshop Participants and Agenda

Ecological Risk Assessment
Exmouth Gulf Prawn Managed Fishery

Workshop Participants
12 September 2019

Name	Company / Organisation	Position title / Area of expertise
Lynda Bellchambers	DPIRD OCD	Principal Res Sc EBFM
Patrick Cavalli	DPIRD ARM	Principal Management Officer
Scott Evans	DPIRD FSRA	Research Scientist EBFM
Emily Fisher	DPIRD FSRA	Research Scientist EBFM/MSC
Daniel Gorman	CSIRO	Research Sci Benthic Ecology
Mathew Hourston	DPIRD	Research Scientist Bycatch
George Kailis	MG Kailis	Management
Mervi Kangas	DPIRD FSRA	Principal Scientist Invertebrate Trawl
Kathryn McMahon	Edith Cowan University	A/Prof Seagrass Ecosystems
Matt Pember	WAFIC	Fisheries Rep, Resource Access Officer, Fisheries Scientist
Darren Schofield	DPIRD OCD	Fisheries Officer Exmouth
Mat Vanderklift	CSIRO	Research Scientist / Ecologist
Sharon Wilkin	DPIRD FSRA	Senior Technical Officer
Brent Wise	DPIRD FSRA	SPRS
Simon Woodley	Ningaloo Coast World Heritage	Marine Conservation
Richard Stoklosa	*e-systems*	Ecological Risk Assessment Facilitator

e-systems

Agenda

Date	Thursday, 12 September 2019
Location	Department of Primary Industry and Resource Development – Fisheries Western Australian Fisheries and Marine Research Laboratories Conference Rooms, 1st Floor 39 Northside Drive Hillarys, Western Australia
Facilitator	Richard Stoklosa, E-Systems
Purpose	**Ecological Risk Assessment** **Exmouth Gulf Prawn Managed Fishery — Prawn Trawl**

11:00	Welcome and introductions	Brent Wise / Richard Stoklosa
11:15	Adoption of workshop agenda and procedure	Richard Stoklosa
11:30	Introduction to fisheries and summary of current stock assessment	Mervi Kangas
11:45	Ecological risk assessment and cumulative risk	Group discussion
13:00	Lunch	
13:30	Continue ecological risk assessment	Group discussion
15:30	Afternoon tea	
15:45	Continue ecological risk assessment	Group discussion
16:30	Review progress and next steps	Richard Stoklosa / Brent Wise
17:00	Adjourn	

Attachment 2

Ecological Risk Assessment Workshop Record

Exmouth Gulf Prawn Managed Fishery Ecological Risk Assessment

Ref No.	Assessment component	Interaction threat	Consequences	Existing management and operational safeguards	Risk analysis			Planned commitments for remedial action (date to be implemented)	Suggested remedial action for consideration	Treated risk			Remarks
					Consequences	Likelihood	Risk ranking			Consequences	Likelihood	Risk ranking	
Target / retained species													
1	Brown tiger prawns	Primary target species.	Reduction in stock.	Weight-of-evidence stock assessment.	Moderate	Likely	Medium						
2	Western king prawns	Primary target species.	Reduction in stock.	Weight-of-evidence stock assessment.	Moderate	Likely	Medium						
3	Blue endeavour prawns	Primary target species.	Reduction in stock.	Weight-of-evidence stock assessment.	Moderate	Likely	Medium						
4	Coral prawns	Secondary retained species.	Reduction in stock.	Significant trawl closures in Exmouth Gulf.	Minor	Possible	Low						
5	Banana prawns	Secondary retained species.	Reduction in stock.	Daylight fishing ban when species is aggregating during daylight hours. Significant trawl closures in Exmouth Gulf.	Moderate	Possible	Medium						Targeted when abundant, after consecutive years of high rainfall. Exmouth Gulf is the southernmost limit of the distribution of the species.
6	Mantis shrimp	Secondary retained species.	Reduction in stock.	Independent stock surveys. Significant trawl closures in Exmouth Gulf.	Minor	Possible	Low						DPIRD would require review if any of the secondary retained species exceeded 5% of catch.
7	Blue swimmer crabs	Secondary retained species.	Reduction in stock (captured in very low numbers).	Extensive refuge in the permanently closed nursery areas. Minimum legal size (127mm carapace length) is larger than size at maturity.	Minor	Possible	Low						
8	Cephalopods	Secondary retained species.	Reduction in stock.	Monitoring of catch rates.	Minor	Possible	Low						Short life span, high fecundity and wide distribution of most cephalopods make these animals highly productive and resilient to fishing.
9	Bugs	Secondary retained species.	Reduction in stock (captured in very low numbers).	Monitoring of catch rates. Significant trawl closures in Exmouth Gulf.	Minor	Possible	Low						Generally caught in the central and northern portion of Exmouth Gulf.
10	Finfish	Secondary retained species.	Reduction in stock (captured in very low numbers). Incidental marketing.	Monitoring of catch rates. Significant trawl closures in Exmouth Gulf.	Minor	Unlikely	Negligible						Vessels have changed design to make retention of finfish impractical.
Bycatch species													
11	Invertebrates	Capture in trawl gear and discarded back to sea.	Typically returned alive.	Significant portion of nearshore waters are closed to trawling. Hoppers on prawn trawl vessels.	Minor	Remote	Negligible						
12	Lizardfish	Capture in trawl gear and discarded back to sea.	Reduction in stock. Trawl bycatch mortality is likely to be high.	Independent stock surveys. Nearshore waters closed to trawling.	Minor	Possible	Low						Lizardfish is most common bycatch species.
13	Other finfish	Capture in trawl gear and discarded back to sea.	Reduction in stock. Trawl bycatch mortality is likely to be high.	Independent stock surveys. Nearshore waters closed to trawling.	Minor	Remote	Negligible						The majority of bycatch species are not targeted by other fisheries in the region, with the exception of minor catches of demersal finfish such as emperors (~0.6%).
14	Sharks & rays	Capture in trawl gear and discarded back to sea.	Reduction in stock (very low numbers of small animals captured and released).	Significant portion of nearshore waters are closed to trawling. Bycatch reduction devices (BRDs) on trawl gear.	Minor	Remote	Negligible						

Exmouth Gulf Prawn Managed Fishery Ecological Risk Assessment

Ref No.	Assessment component	Interaction threat	Consequences	Existing management and operational safeguards	Risk analysis			Planned commitments for remedial action (date to be implemented)	Suggested remedial action for consideration	Treated risk			Remarks
					Consequences	Likelihood	Risk ranking			Consequences	Likelihood	Risk ranking	
Endangered, threatened and protected (ETP) species													
15	Sawfish	Capture in trawl gear and returned back to sea.	Captured in very low numbers. Post-release survival is likely to be low.	Statutory reporting of all ETP species. Significant portion of nearshore waters are closed to trawling. Compliance with national recovery plan.	Moderate	Possible	Medium						Numbers are so low that species identification is not made because it is impractical for crew to do so. Medium risk represents uncertainty in recovery of species. Medium risk level for potential public concern.
16	Short-nose sea snake	Capture in trawl gear and returned back to sea.	Regularly captured in prawn trawl gear but majority are returned alive.	Hoppers on prawn trawl vessels.	Moderate	Unlikely	Low						Listed conservation status of short-nose sea snake is a source of public concern, and is under review to relax status based on abundance and distribution. Trawl fishery observes about 25% of this species being caught in trawl gear and released. Further research in progress to determine current conservation status. Noted that the fishery must meet the requirements of the conservation status of the
17	Sea snakes	Capture in trawl gear and returned back to sea.	Public concern regarding the large number of sea snake interactions with trawl gear.	Hoppers on prawn trawl vessels.	Moderate	Unlikely	Low						Increasing public interest may occur based on public perception. Review risk if capture trends change significantly or if a public campaign eventuates to generate interest in perceived risk.
18	Turtles	Capture in trawl gear and returned back to sea.	Low numbers mostly captured in prawn try gear, but almost all returned alive.	BRDs.	Minor	Unlikely	Negligible						
19	Cetaceans & dugongs	Capture in trawl gear and returned back to sea.	Potential injury or mortality to dolphins.	Likelihood of dolphin entry into trawl nets is low due to low-opening otter boards. No known interactions with dugongs.	Minor	Remote	Negligible						Only one reported interaction of the capture of a diseased dolphin to date.
20	Cetaceans & dugongs	Vessel strikes with dugongs and cetaceans.	Potential injury or mortality.	Low speed of trawl vessels and significant noise when under way.	Minor	Remote	Negligible						
21	Syngnathids	Capture in trawl gear and returned back to sea.	Potential mortality to very low numbers of captured species, usually attached to substrate that affords some level of protection to animals.		Minor	Unlikely	Negligible						Difficult in practice to account for every syngnathid that is captured. Review statistics from 2017 season to explore reason for number of captured species.
Habitats													
22	Sand & mud	Interaction of trawl gear with benthic habitat.	Damage and loss of habitat sustaining associated benthos.	Quantitative studies suggest that sand and silt habitats are relatively resilient to trawl fishing.	Minor	Likely	Low						Between 2012 and 2016, the majority (~72%) of fishing occurred on mapped sand habitats (but actual fishing ground targets higher level of sand). Recognition of World Heritage Area boundary should be included in habitat mapping.
23	Seagrasses	Interaction of trawl gear with benthic habitat.	Damage and loss of habitat sustaining associated benthos.	Significant portion of nearshore waters are closed to trawling.	Minor	Remote	Negligible						Between 2012 and 2016, less than 5% of fishing occurred on seagrass habitat. Suggestion of high abundance of seagrass in depths <6m on high tide, where trawling occurs at depths >7m (confirmation subject to review of recent research).
24	Macroalgae	Interaction of trawl gear with benthic habitat.	Damage and loss of habitat sustaining associated benthos.	Significant portion of nearshore waters are closed to trawling.	Minor	Unlikely	Negligible						Between 2012 and 2016, very small overlap of fishing on mixed habitat assemblages.

Exmouth Gulf Prawn Managed Fishery Ecological Risk Assessment

Ref No.	Assessment component	Interaction threat	Consequences	Existing management and operational safeguards	Risk analysis			Planned commitments for remedial action (date to be implemented)	Suggested remedial action for consideration	Treated risk			Remarks
					Consequences	Likelihood	Risk ranking			Consequences	Likelihood	Risk ranking	
25	Filter feeding communities	Interaction of trawl gear with benthic habitat.	Damage and loss of habitat sustaining associated benthos.	Significant portion of nearshore waters are closed to trawling.	Moderate	Possible	Medium						Between 2012 and 2016, about 5-8% of fishing occurred on mapped filter feeder communities within the managed fishery area of Exmouth Gulf. The extent of damage to filter feeding communities depends on the frequency of trawling. Rationale for scoring likelihood could not be agreed by the participants between unlikely and possible, and the likelihood of 'possible' was recorded, subject to further review of existing data.
26	Coral reefs	Interaction of trawl gear with benthic habitat.	Damage and loss of habitat sustaining associated benthos.	Significant portion of nearshore waters are closed to trawling.	Minor	Remote	Negligible						Between 2012 and 2016, only about 0.1% of fishing occurred on coral reefs. Evidence shows that trawler fleet avoids coral to prevent damage to trawl gear.
Ecosystem structure													
27	Trophic interactions — Removal of retained species	Removal of prawn biomass.	Reduction of prey that predators rely on as food source. Removal of prawns as predators of other species. No perceived material change to ecosystem structure or function.	Significant portion of nearshore waters are closed to trawling. Trawlers target maximum size of prawns.	Moderate	Unlikely	Low						Naturally high recruitment variability of prawns leads to few predators being dependent on them as a food source. Diversity of predators. Total volume of on-target species is not considered a significant portion of biomass. Anecdotal evidence does not support significant change in animal distributions or abundance (with natural variability common for species trends). Uncertainty exists in the effects of the removal of a large biomass to ecosystem structure or function, particularly when region is exposed to other threats (eg future marine heat wave). High natural variability of biomass in Exmouth Gulf was noted, with productivity shifting in response to wider environmental triggers.
28	Trophic interactions — Discarding & provisioning	Discarding of bycatch biomass.	Potential changes in trophic structure due to discarded prey. Commonly observe sharks and dolphins scavenging for discards. Top predators are not generally captured in trawl nets due to BRDs. Seabirds observed to scavenge. Potential for certain species become reliant on fishing industry discards, or change in animal behaviours (eg dolphins).	Area over which discarded animals occurs is large. Hoppers discharge bycatch over a large area while vessel is steaming. Only six vessels operating in Exmouth Gulf Prawn Managed Fishery.	Minor	Possible	Low						
29	Translocation (pests & disease)	Translocation of pests and diseases from Port of Fremantle, where vessels call for annual maintenance.	Introduction of marine pests or diseases to Exmouth Gulf, with the potential to alter ecosystem structure.	Surveillance of marine pests and diseases in Port of Fremantle. Passive surveillance throughout WA with emergency response capability. Diagnostic laboratories for pest and pathogen identification.	Minor	Remote	Negligible						Higher pressure from international vessels calling into the region.

Exmouth Gulf Prawn Managed Fishery Ecological Risk Assessment

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					Consequences	Likelihood	Risk ranking			Consequences	Likelihood	Risk ranking	
30	Ghost fishing	Loss of trawl gear at sea.	Mortality of marine animals indiscriminately caught in lost nets.	The high cost of trawl gear incentivises fishers to retrieve it without any major losses. GPS and grapple to recover gear if lost.	Minor	Remote	Negligible						No reported loss of gear known to occur in the last couple of decades.
Broader environment													
31	Air quality — Fuel exhaust	Operation of six trawl vessels.	Air pollution affecting air-breathing marine mammals and humans.	Small number of vessels allowed to operate in the fishery.	Minor	Remote	Negligible						The fishery is only one of many industrial and recreational users of Exmouth Gulf. Industrial developments in Exmouth Gulf are increasing.
32	Air quality — Greenhouse gas emissions	Operation of six trawl vessels.	Contribution to global warming.	Small number of vessels allowed to operate in the fishery.	Minor	Remote	Negligible						The fishery may operate up to 15 vessels (only 6 in operation at present). An increase to 15 vessels would not change the risk ranking.
33	Water quality — Debris / litter	Discarding of waste and bait at sea.	Adverse impact to water quality.	MARPOL regulations to store waste aboard vessels.	Minor	Remote	Negligible						
34	Water quality — Oil / fuel discharge	Operation of six trawl vessels.	Accidental oil or fuel spill at sea.	Small number of vessels allowed to operate in the fishery. All vessels have inboard four stroke engines and oil	Minor	Remote	Negligible						Grease on trawl wires appears to remain after recovery.
35	Water quality — Turbidity	Deployment of benthic trawl gear from six vessels.	Disturbance of sediments likely from trawling. Short lived phenomenon.	Tides and currents disperse turbidity rapidly.	Minor	Unlikely	Negligible						Strong currents and tides in Exmouth Gulf dominate potential sources of turbidity. The contribution from trawling would unlikely be measurable.