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Ecological Risk Assessment of the Shark Bay Invertebrate Fisheries

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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 Shark Bay Prawn Managed Fishery (SBPMF), the Shark Bay Scallop Managed Fishery (SBSMF) and the Shark Bay Crab Managed Fishery (SBCMF) in 2019. The assessment focused on evaluating the ecological impact of these fisheries (i.e. prawn trawl, scallop trawl and crab trap) 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 on 11 September 2019.
- Except for the interaction of fishing with two of the target species, 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.
- Risks to the sustainability of stocks of two target species were ranked high and severe: brown tiger prawns in the SBPMF, and saucer scallops in the northern Shark Bay area of the SBSMF, respectively. Corrective management actions already adopted for the SBPMF and SBSMF are expected to reduce the risk to an acceptable level of medium risk over the assessment timeframe of five years.

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List of Abbreviations

BRD	Bycatch Reduction Device
CDR	Catch Disposal Record
CPL	Carnarvon Peron Line
CW	Carapace width
DPIRD	Department of Primary Industries and Regional Development (Western Australia, former Department of Fisheries)
EBFM	Ecosystem-Based Fisheries Management
EEZ	Exclusive Economic Zone
ERA	Ecological Risk Assessment
ESD	Ecologically Sustainable Development
ETP	Endangered, Threatened and Protected (species)
FHPA	Fish Habitat Protection Area
MSC	Marine Stewardship Council
MSY	Maximum Sustainable Yield
NPF	Northern Prawn Fishery
SBCMF	Shark Bay Crab Managed Fishery
SBPMF	Shark Bay Prawn Managed Fishery
SBSMF	Shark Bay Scallop Managed Fishery
TACC	Total Allowable Commercial Catch
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 Shark Bay Prawn Managed Fishery (SBPMF), the Shark Bay Scallop Managed Fishery (SBSMF) and the Shark Bay Crab Managed Fishery (SBCMF) in 2019. The assessment focused on evaluating the ecological impact of these fisheries (i.e. prawn trawl, scallop trawl and crab trap) on all retained species, bycatch, endangered, threatened and protected (ETP) species, habitats, and the broader ecosystem. The impact of any other fisheries that target Shark Bay Invertebrate Resource, including the recreational fishing sector, was only considered when assessing the overall impact of fishing on the target stocks (i.e. western king and brown tiger prawns, saucer scallops and blue swimmer crabs). As there have been several previous risk assessments undertaken for the SBPMF, SBSMF and SBCMF (Department of Fisheries 2002a, b; 2004; 2012), 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 these fisheries (Department of Fisheries 2002a, b; 2004; 2012; see Appendix A). These risk scores were then reviewed and updated during an external ERA workshop held on 11 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 fisheries and the ecosystem components that have the potential to be impacted by these fishing activities. 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 strategies for the Shark Bay Invertebrate Resources (Department of Fisheries 2014a; DPIRD 2020a, b in prep.).

PART 1

1 Aquatic Environment

Shark Bay is located within the Gascoyne Coast Bioregion of WA, near the northern limit of the transition region between temperate and tropical marine environments (Figure 1.1). It is Australia's largest marine embayment (~16,000 km^2) and is generally shallow, with a mean depth of 9 m and a maximum depth of ~30 m. Located in an arid area of WA, rainfall in the area is extremely low, however, the bay is subject to occasional turbid fresh water river floods from two ephemeral rivers that flow into it, the Wooramel River in the south east and the larger Gascoyne River to the north east.

The shallow waters of Shark Bay support a benthic invertebrate fauna of exceptional abundance, diversity and zoological significance. For example, Slack-Smith (1990) reported 218 species of bivalve molluscs in this region (75% with a tropical range, 10% from a southern range and 15% endemic to the Australian west coast), while Hutchins (1990) reported 323 fish species (83% with a tropical range, 11% warm temperate and 6% cool temperate species). The bay is also renowned for its marine fauna and supports large populations of dugongs, dolphins, marine turtles and, seasonally, humpback whales. Shark Bay became WA's first World Heritage listed area in 1991.

Figure 1.1. Location of Shark Bay in WA.

Shark Bay has an eastern and western gulf, to the south divided by the Peron Peninsula and semi enclosed to the north-west by Bernier, Dorre and Dirk Hartog Islands (Figure 1.2), which restricts water exchange between the bay and open ocean (Nahas et al. 2005; Kangas et al. 2015). Primary habitats of Shark Bay include seagrasses, microbial communities and algal mats, along with some areas of coral. Comprehensive habitat mapping for Shark Bay is limited despite its size, world heritage status and presence of highly productive fisheries. The majority of existing habitat information is focused on the shallow water inner gulfs, within the SBPMF nursery grounds or special purpose closed areas, including stomatolites to the extreme south (Hamelin Pool) and the southern algal mats (Environmental Protection Authority 2001).

Seagrass covers nearly 30% of Shark Bay, predominately in the southern and inshore areas around the Faure Sill and Wooramel Seagrass Bank; the largest known structure of its kind in the world. The 12 species of seagrass in the bay also make it one of the most diverse seagrass assemblages in the world (Kangas et al. 2015). The high biomass and productivity of seagrass, coupled with the large accumulation of nutrients present in seagrass meadows, make them of great significance to the trophic structure of Shark Bay (CALM 1996). They also provide important habitat and nursery areas for fish and invertebrates and have significantly contributed the physical, chemical, biological and geological environment through the development of major marine features such as the Faure Sill (CALM 1996).

The central northern and western regions of Shark Bay consist of mobile silty/sand, with varying levels of abundance and distribution of sponges, octocorals, invertebrates and infaunal species (Environmental Protection Authority 2001; Morrison et al. 2003). Many crustaceans prefer this substrate, especially prawns, Portunid crabs (e.g. blue swimmer and coral crabs), parthenopids, pebble crabs, slipper lobsters and grotesque crabs (Morrison et al. 2003). Molluscs can also be found in this region, including the saucer scallop that lives on the surface of soft sediments. The infaunal habitat is dominated by diverse and numerous bivalve species (Slack-Smith & Bryce 1995). Fieldnotes taken by Marsh in 1975 record several species of crinoids, asteroids, ophiuroids, holothurians and echinoids from the central northern regions of Shark Bay (Kangas et al. 2007). Few fish species have been found to live permanently in the soft, sandy substrates of Shark Bay (Morrison et al. 2003).

The aquatic environment of Shark Bay has extensive management protection through the Shark Bay Marine Park and its sanctuary and special purposes areas (Figure 1.2), DPIRD Fish Habitat Protection Areas (FHPAs) and permanently fishery legislated closures accounting for over 60% of Shark Bay.

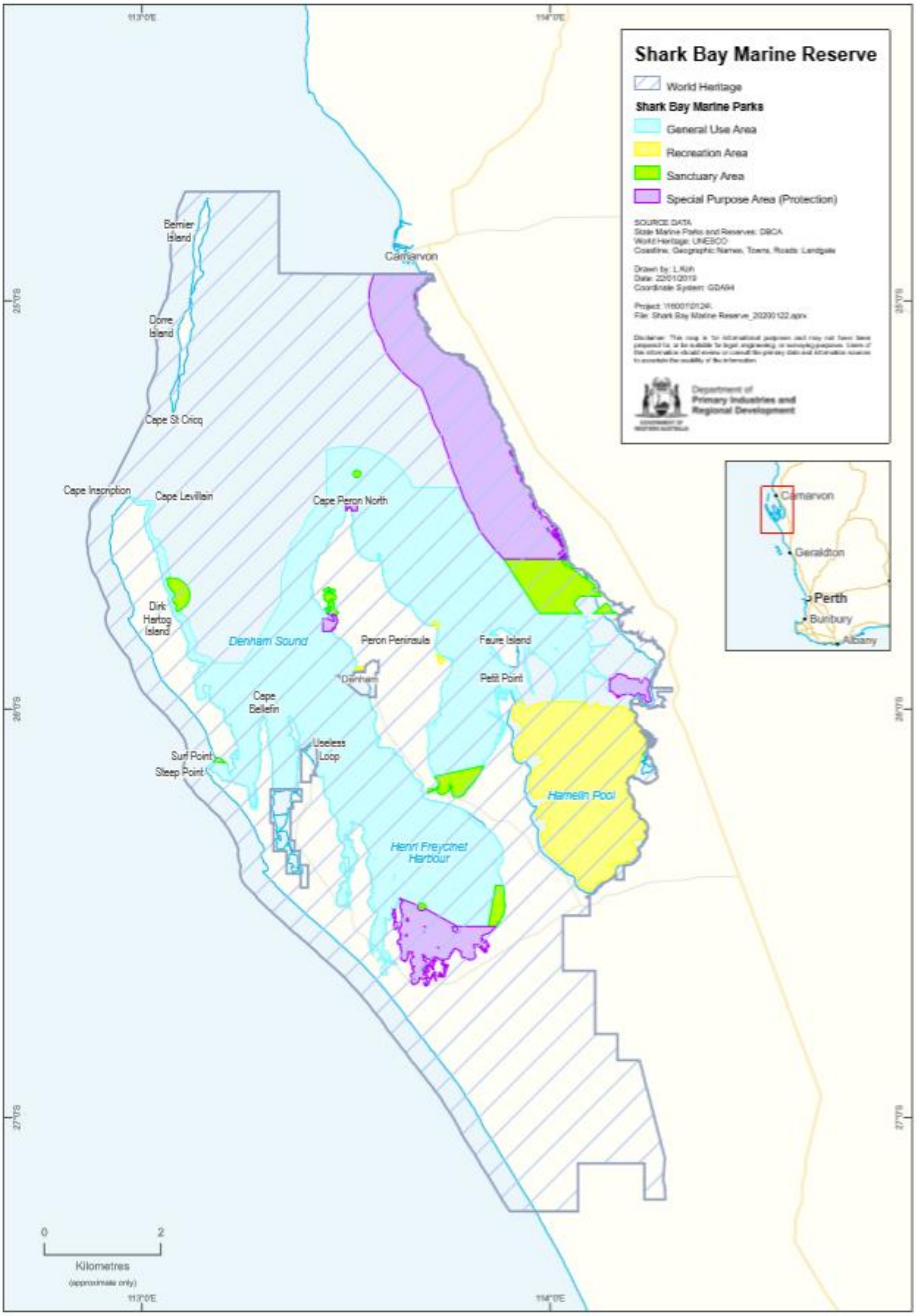

Figure 1.2. Boundaries of the Shark Bay World Heritage and Shark Bay Marine Park areas.

2 Shark Bay Prawn Managed Fishery

2.1 Current Fishing Activities

The commercial prawn fishery in Shark Bay has been operating since the early 1960s (Kangas et al. 2015). There are currently 18 vessels permitted to operate in the SBPMF, using low-opening demersal otter trawl nets to target prawns. The permitted trawl area within the Inner Shark Bay area is 6063 km^2 (i.e. excluding the closed areas; Figure 2.1), with prawn trawl fishing generally occurring in only 40-50% of this area each season.

Overall effort in the SBPMF 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 SBPMF 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 western king and brown tiger prawns in Shark Bay. The annual cycle of operation in the SBPMF is dynamic and depends on the strength and timing of prawn recruitment. 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 SBPMF fishing season is generally open from March through November each year, with specific opening and closing dates set according to the lunar phase. During the initial fishing period, there is a large area closure inside the Carnarvon Peron Line (CPL; Figure 2.1) to avoid the harvest of small-size prawns and to provide protection of brown tiger prawns prior to their spawning period. The remainder of the season consists of a series of rolling openings and closures of defined fishing areas within the fishery (Figure 2.1). Some of the areas within the CPL are closed at (approximately) the same times each year to protect brown tiger and western king prawn breeding stocks. Fishery-independent spawning stock surveys are conducted in June, August and September, collecting data that are used to inform the potential (re-)opening of fishery areas, as well as to assess annual fishery performance.

The SBPMF 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.

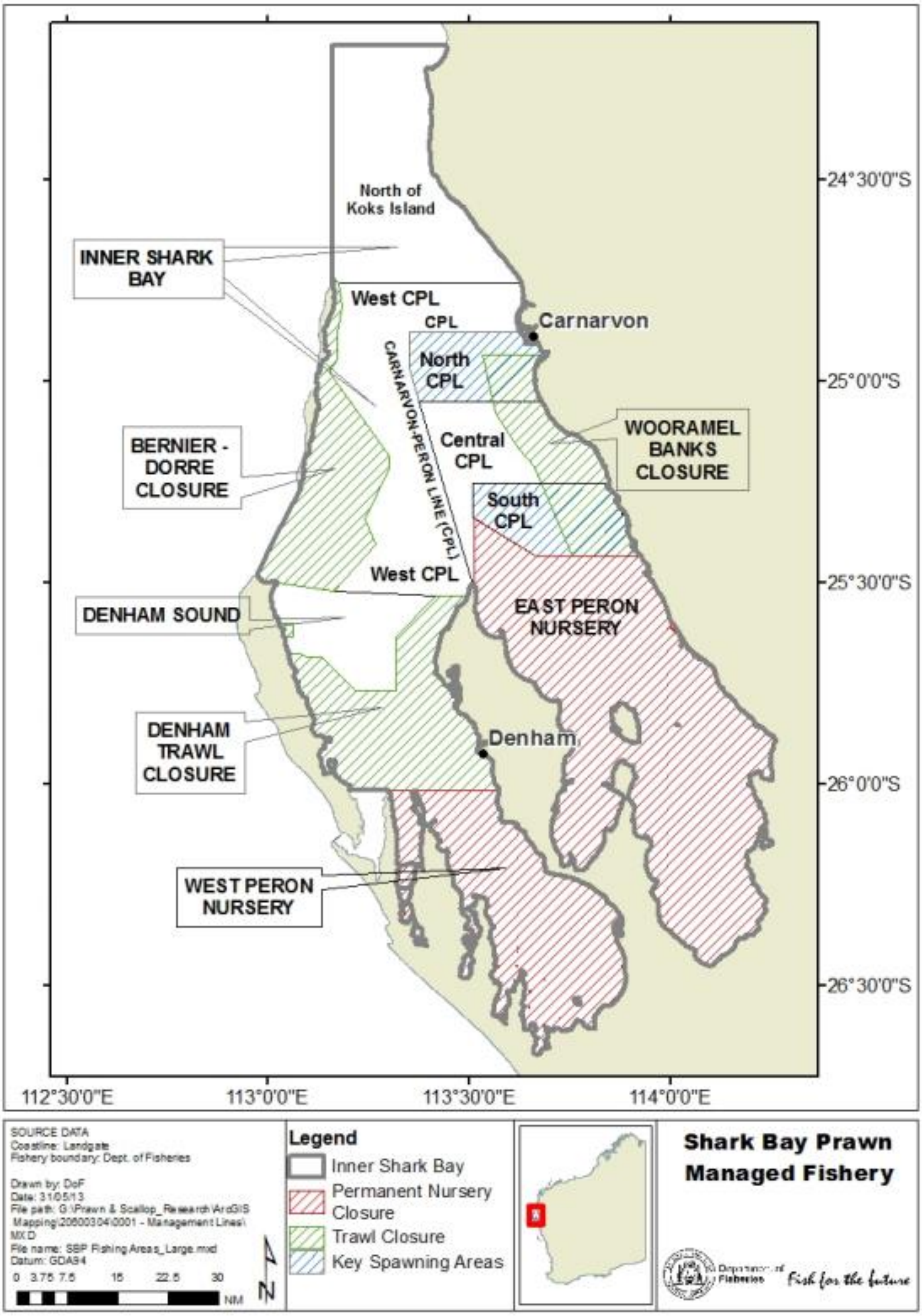

Figure 2.1. Boundaries, management areas and area closures (red and green) of the SBPMF, and extent of the Inner Shark Bay area.

2.2 Fishing Gear and Methods

Vessels in the SBPMF use low-opening demersal otter trawl nets in quad-rigged formation (Figure 2.2), with a current maximum headrope allocation of 724 m (396 fathom). The 18 boats operating in the fishery each tow four 10.1 m (5.5 fathom) nets. The fleet uses a 50 mm diamond mesh codend to select for prawns (Kangas et al. 2012). Otter boards are attached to the extremities of each trawl 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.

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 50 to 180 minutes in duration.

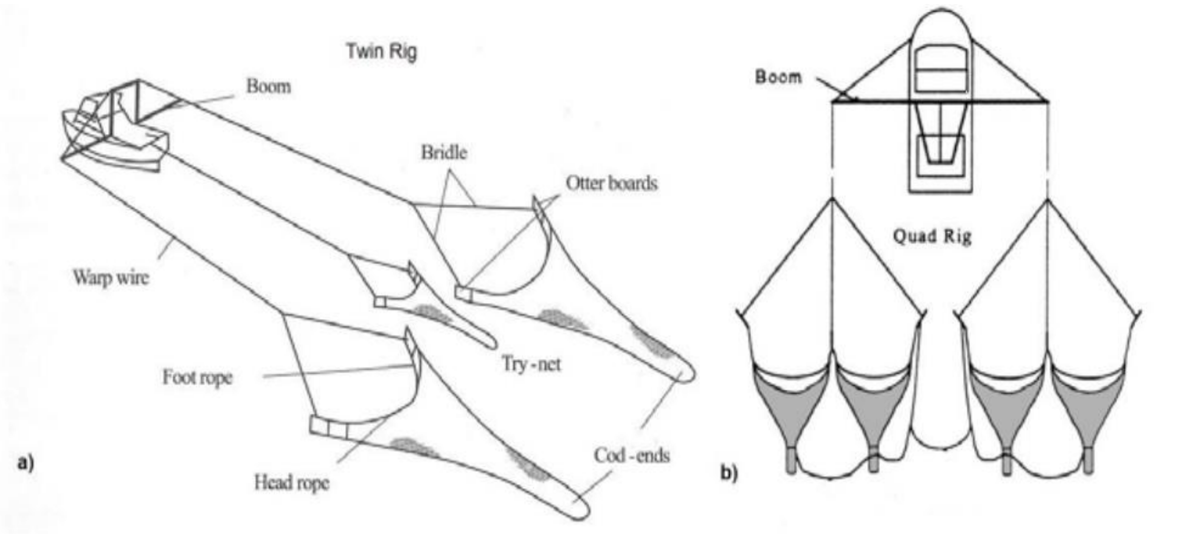

Figure 2.2. Standard (a) twin-rig and (b) quad-rig otter trawl (Adapted from Stirling 1998). The quad-rig configuration is currently used by all vessels in the SBPMF.

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 SBPMF industry has continued to develop, trial and implement fishery-specific BRDs for efficiency purposes. Since 2002, all vessels have used onboard ‘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 for 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 SBPMF is provided in Table 2.1.

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

Species	Catch (tonnes)						% of total retained
	2014	2015	2016	2017	2018	Average	
Western king prawns	1282.0	1633.2	1010.3	1184.2	651.5	1152.2	61.8%
Brown tiger prawns	625.2	433.9	514.1	421.5	438.3	486.6	26.1%
Coral prawns	100.5	125.9	119.5	106.1	90.4	108.5	5.8%
Cuttlefish	42.7	23.3	30.6	21.6	27.5	29.1	1.6%
Mantis shrimp	5.1	17.8	11.0	35.9	37.1	21.4	1.1%
Whiting	18.8	14.8	25.6	17.4	21.3	19.6	1.1%
Flatheads	10.4	16.1	16.7	5.9	7.7	11.4	0.6%
Squid	13.5	6.3	14.9	8.8	8.7	10.4	0.6%
Blue endeavour prawns	17.1	22.4	4.4	1.9	0.9	9.3	0.5%
Australian sardines	1.1	18.3	7.7	0.6	0.3	5.6	0.3%
Bugs	4.1	4.9	9.8	2.0	3.4	4.8	0.3%
Flounders	6.8	6.2	0.2	0.3	0.2	2.7	0.1%
Black jewfish (mulloway)	3.1	3.0	1.3	0.8	0	1.6	0.1%
Octopuses	1.5	0.8	1.3	1.4	0.7	1.1	0.1%
Other finfish	0	0	0.1	0	0.2	0	<0.1%

Note that saucer scallops and blue swimmer crabs are only retained by prawn trawl fishers that also hold licences and quota in the SBSMF and SBCMF (see Sections 3 and 4), respectively.

2.3.1 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, through WA, Northern Territory, Queensland, and down the east coast to northern New South Wales. 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 SBPMF retained 1152 tonnes of western king prawns annually between 2014 and 2018, which equates to 62% of the total retained catch (Table 2.1). There is very little recreational prawn fishing in Shark Bay. No prawn catches were reported by boat-based fishers in the Gascoyne Coast Bioregion in the most recent state-wide survey of boat-based recreational fishing 2015/16 (Ryan et al. 2017). Fishery-independent indices of abundance indicate that the Shark Bay stock of western king prawns is currently exploited at a sustainable level (Kangas et al. in prep.).

2.3.2 Brown tiger prawns

The brown tiger prawn (*Penaeus esculentus*) is a decapod crustacean of the family Penaeidae, which 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 Shark Bay in WA to central New South Wales in the east (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 SBPMF retained 486 tonnes of brown tiger prawn annually between 2014 and 2018, which equates to 26% of the total catch (Table 2.1). No prawn catches were reported by boat-based fishers in the Gascoyne Coast Bioregion in the most recent state-wide survey of boat-based recreational fishing in 2015/16 (Ryan et al. 2017). Fishery-independent indices of abundance indicate that the Shark Bay stock of brown tiger prawns is currently exploited at a sustainable level (Kangas et al. in prep.).

2.3.3 Other species

Operators in the SBPMF that also hold licences in the SBSMP and SBCMF are permitted to retain saucer scallops and blue swimmer crabs, respectively, caught in their prawn trawl gear. These catches are managed by quota for the SBSMP and SBCMF and are considered under Sections 3 and 4, respectively.

The SBPMF catches a variety of minor prawn species that are retained in much lower numbers compared to the targeted species. On average, over the last five years, coral prawns (*Metapenaeopsis* sp.) have represented around 6% of the total retained catch in the SBPMF (Table 2.1), less than 3% of the total catch (including discards). Catches of blue endeavour prawns (*Metapenaeus endeavouri*) are typically low in Shark Bay, which is at the southern end of its distribution in WA, historically increasing only after periods of increased water temperatures (e.g. the 2010/11 marine heatwave).

Although the retention of mantis shrimps has increased as markets for this species have developed, it represented less than 3% of the total retained catch in 2017 and 2018 (Table 2.1). Fishery-independent surveys sampling the full catch composition (i.e. retained and discarded species) in 2002-03 and 2014-17 indicate that the proportion comprising mantis shrimps has remained consistent over time (0.6% of total catch).

Cephalopods, including cuttlefish (*Sepia* spp.), squid and octopus, have been consistently retained in low numbers by the SBPMF (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. Fishery-independent bycatch surveys show that cephalopods represented 1.4 and 2.5% of the total catch sampled in 2002-03 and 2014-17, respectively.

Bugs (*Thenus* spp.) have a wide geographical range and, although marketable and retained, they are caught in low numbers in Shark Bay (Table 2.1). Less than 0.1% of the catch sampled in fishery-independent bycatch surveys in 2002-03 comprised bugs, with none caught during more recent sampling in 2014-17.

The SBPMF also retains minor catches of some finfish species (~2% of total retained catch annually), including whiting (*Sillago* spp.), flathead, sardines, flounder and black jewfish (*Protonibea diacanthus*; often incorrectly reported as mulloway) (Table 2.1). Other finfish are sometimes retained in very low numbers as new markets are explored but are primarily discarded (see Section 2.4).

2.4 Bycatch Species

As it is not mandatory for fishers in the SBPMF 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 2002-03 (Kangas et al. 2007; Kangas and Morrison 2013) and, more recently, between 2014 and 2017 as part of the SBPMF Bycatch Action Plan (Department of Fisheries 2014b).

The level of bycatch taken in Shark Bay prawn trawl nets is moderate relative to other subtropical trawl fisheries, with quantities ranging from 4–8 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 50% of the total catch (in weight) may be discarded (Table 2.2), however, this is possibly an underestimate as it is based on the assumption that the groups of species reported in Table 2.1 are consistently retained. Broadly, the catch composition in the two sampling periods has remained similar. The component of catches that are not typically retained by the SBPMF comprises a wide suite of several hundred small invertebrate and fish species (Table 2.2).

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

Common name	Species/Family name	% of total
Blue swimmer crabs	***Portunus armatus***	**13.6**
Western king prawns	***Penaeus latisculcatus***	**12.9**
Saucer scallops	***Ylistrum balloti***	**7.0**
Brown tiger prawns	***Penaeus esculentus***	**3.5**
Whiting	*Sillago* spp.	3.6
Coral prawns	*Metapenaeopsis* spp.	2.6
Flathead	Platycephalidae	2.2
Flounder	Bothidae	1.6
Endeavour prawns	*Metapenaeus endeavouri*	1.0
Black jewfish	*Protonibea diacanthus*	0.8
Mantis shrimp	Squillidae	0.6
Squid	*Photololigo edulis*	0.5
Sardines	*Sardinella* spp.	0.4
Cuttlefish	*Sepia* spp.	0.4
Octopus	*Octopus* sp.	0.1
Goatfish	*Upeneus* spp.	7.5
Lizardfish	Mostly *Saurida undosquamis*	7.1
Minor crabs	Mostly *Portunus* spp.	4.3
Ponyfish	Mostly *Leiognathus leuciscus*	3.8
Trumpeter	*Pelates* spp.	2.7
Leatherjacket	Mostly *Paramonacanthus choirocephalus*	2.5
Toadfish	Tetraodontidae	2.4
Threadfin bream	*Pentapodus* spp.	2.2
Emperors	*Lethrinus* spp.	1.9
Other finfish*		1.9
Dragonets	Callionymidae	1.8
Other invertebrates*		1.6
Roach	Mostly *Gerres subfasciatus*	1.0
Minor prawns	Penaeidae	1.1
Scorpionfish	Scorpaenidae	1.0
Trevallies	Carangidae	0.8
Herring	*Herklotsichthys* spp.	0.7
Red-barred grubfish	*Parapercis nebulosa*	0.7
Minor bivalve molluscs	*Annachlamys flabellata* and *Melo miltonis*	0.6
Slipper lobsters	Scyllaridae	0.6
Echinoderms	Mostly holothurians and urchins	0.5
Spinefoot	*Siganus canaliculatus*	0.5
Minor cephalopods	Mainly *Euprymna tasmanica*	0.4
Long-finned gurnard	*Lepidotrigla argus*	0.3
Slender seamoth	*Pegasus volitans*	0.3
Gulf damsel	*Pristotis obtusirostris*	0.3
Striped seapike	*Sphyraena obtusata*	0.3
Wrasses	Labridae	0.2
Rays		0.2

Invertebrate bycatch is dominated by a number of minor crab species (including *Portunus rubromarginatus*; 2%) but also include small prawns, cephalopods, bivalve molluscs and echinoderms (including holothurians, sea urchins, sea stars and brittle stars). More than half of the finfish bycatch in the prawn trawls comprised goatfish (Mullidae), lizardfish (mostly Harpodontidae) and ponyfish (Leiognathidae) (Table 2.2). The three most common species were the large-scaled lizardfish (*Saurida undosquamis*; 6% of total catch), the asymmetrical goatfish (*Upeneus asymmetricus*; 5%) and the whipfin ponyfish (*Leiognathus leuciscus*; 4%). 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 (~2%) and pink snapper (0.1%).

The implementation of BRDs has largely eliminated the catch of large sharks and rays (Kangas & Thomson 2004; Table 2.2). In the recent bycatch study, only 0.1% of the total catch comprised small rays such as the butterfly ray (*Gymnura australis*) and the coachwhip stingray (*Himantura* sp.). The use of hoppers on all SBPMF 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. Reporting by skippers in the SBPMF has improved in the most recent three years following the implementation of a fishery-led Crew Member Observer Program (CMOP) and targeted education. Interactions with protected species are also recorded during Departmental fishery-independent surveys.

While protected species, including whales, dolphins, dugongs, turtles, sea snakes and syngnathids (sea horses and pipefish) are abundant in Shark Bay (see Kangas et al. 2015), only syngnathids and sea snakes are captured in larger numbers in the SBPMF (Table 2.3). Most are returned to the water alive. Syngnathids are typically associated with seagrass and macroalgal habitats distributed across Shark Bay. Large components of these habitats represent prawn nurseries that are permanently protected from trawling.

Data from the fishery-dependant CMOP and fishery-independent survey sources of information have recently been used to verify the number and species composition of the sea snakes in the fishery's bycatch. Half (50%) of sea snake interactions in the SBPMF are with the elegant sea snake (*Hydrophis elegans*), 30% involve the leaf-scaled sea snake (*Aipysurus foliosquama*), and the remainder are with *A. pooleorum*, *H. major* and *Emydocephalus annulatus*. The leaf-scaled sea snake is currently listed as Critically Endangered due to its previously assumed limited distribution, which is now under review. Reported mortality rates of sea snakes are less than 15%.

Sawfish are captured in very low numbers in the SBPMF, mainly in the northern trawl grounds. The species of sawfish encountered as trawl bycatch in Shark Bay has not been confirmed, however, the green sawfish (*Pristis zijsron*) is known to be present in the area.

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

Species / Fate	2014	2015	2016	2017	2018
Sawfish					
Alive	0	3	1	2	0
Dead	0	2	0	0	0
Unknown	0	0	0	0	1
Sea snakes					
Alive	511	1133	4633	3579	2999
Dead	53	143	593	489	381
Unknown	0	0	0	1	0
Syngnathids					
Alive	30	17	276	419	166
Dead	0	3	1	15	8
Unknown	0	0	0	3	0
Turtles					
Alive	27	35	79	70	87
Dead	0	0	0	1	0
Unknown	0	0	1	1	0
Dolphins					
Alive	0	0	0	0	1
Dead	0	0	0	0	0

The full implementation of BRDs (grids) in the SBPMF since 2003 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.

2.6 Habitat and Ecosystem Impacts

The SBPMF only operates over a small proportion of the total area of Shark Bay and the SBMPF management area and therefore has a low potential to impact benthic habitats. The spatial extent of fishing (referred to as the trawl footprint) is monitored annually for the SBPMF using the fishery-dependent logbook data and 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 SBPMF interacted with 3078 km^2 or ~20% of Shark Bay (~16,000 km^2) and ~9% of the SBPMF management area (Figure 2.3).

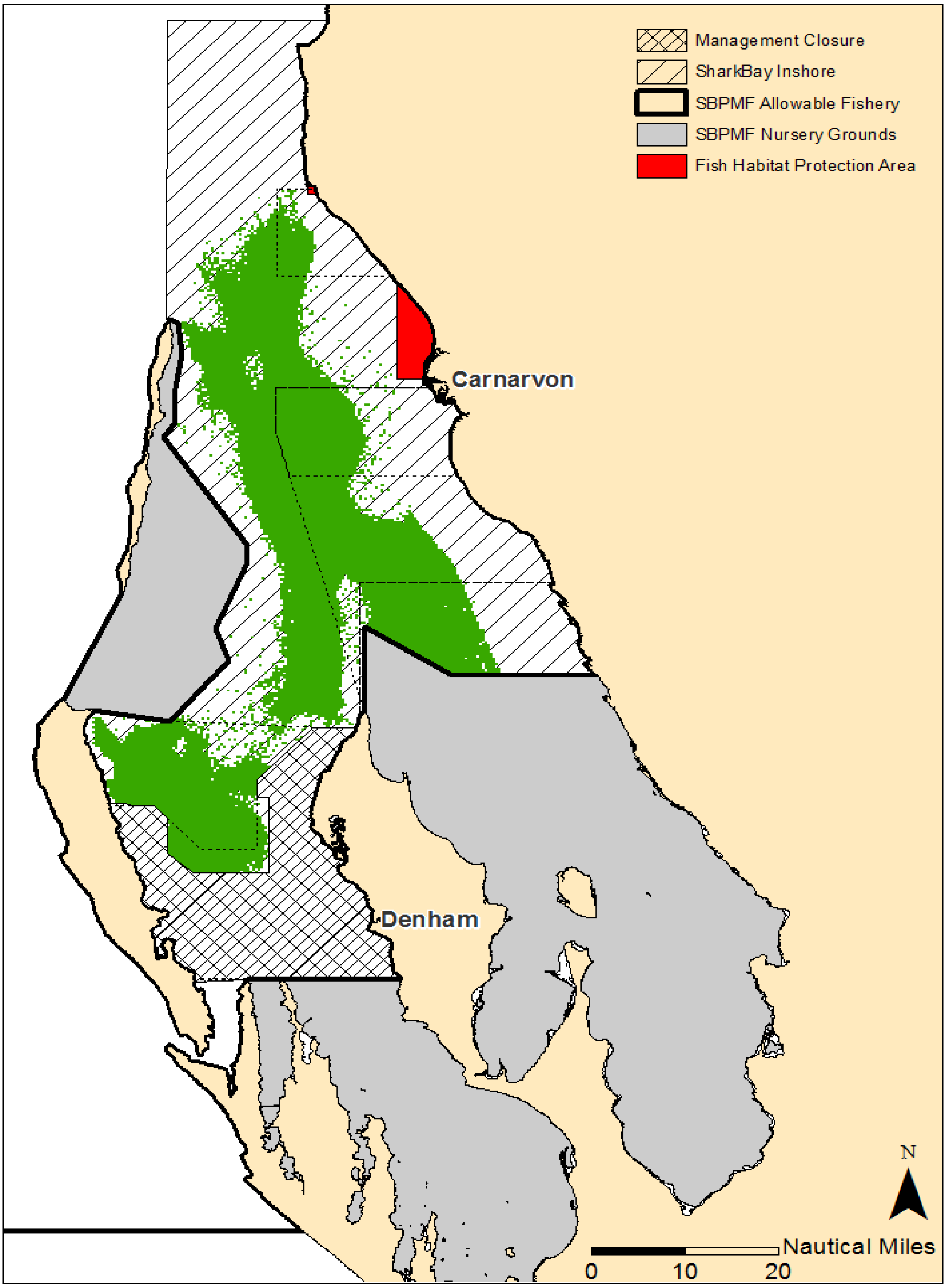

Figure 2.3. The cumulative trawl footprint (dark green shading) of the Shark Bay Prawn Managed Fishery between 2012 and 2016.

When overlaying this effort data (Figure 2.3) over the only published available habitat map for Shark Bay (Figure 2.4) for the five year period between 2012 to 2016, the majority (86%) of fishing is shown to occur on the central and northern areas of Shark Bay which is dominated by extensive areas of sand and silt (Kangas et al. 2015). The depth (mostly >=20 m) and central location in the bay also support that this undefined habitat that would be less likely to support significant sea grass or macroalgae beds. Quantitative studies of similar WA prawn fisheries (Pitcher et al. 2017) suggest that these types of sand and silt habitats are relatively resilient to fishing. The SBPMF has limited interactions with the remaining identified habitats within Shark Bay. For example, seagrass, the second most dominate habitat type the fishery interacts with, had just 8% interaction with the SBPMF in 2012 to 2016.

Effort is also categorised into level of fishing intensity; 0-None, 1-Low, 2-Moderate, 3-High. In relation to Shark Bay this data shows that the SBPMF has no interaction with over 80% of Shark Bay, including permanent closures and areas that are open to fishing but have had no effort between 2012 and 2016. Of the 20% of Shark Bay that has effort from the SBPMF 22% is what could be considered low intensity, 57% moderate and 20% high. This is consistent with a report by Mazor et al. (2017) which suggest that although the SBPMF has one of the higher trawl footprints (when compared to other trawl fisheries in the Australian Exclusive Economic Zone (EEZ) in relation to the spatial size of the allowable fishery) the protection provided by the permanent closures in this region was also comparatively high, offsetting the perceived higher exposure. This study also concluded that the exposure of effort intensity is typically moderate or low and even if impacts in trawled areas were high (which is not the case in the SBPMF between 2012-16) and recovery was slow, the large proportions of abundance protected outside trawled areas could sustain most benthos at regional scales (Mazor et al. 2017).

The ecosystem impacts of trawling are well-studied in Australia, including numerous studies in tropical and sub-tropical environments, in particular in the Northern Prawn Fishery (NPF), where research has found no evidence that the fishery affects this ecosystem in a significant way (MRAG Americas Inc. 2012). NPF studies have suggested that the effects of trawling at the current scale of the fishery do not affect overall biodiversity and cannot be distinguished from other sources of variation in community structure (MRAG Americas Inc. 2012). Similarly, the impacts of the SBPMF have been assessed by Kangas et al. (2007) and Kangas & Morrison (2013). Results indicate that latitudinal and seasonal effects appear to exert a stronger influence on community structure than the effects of trawling. For fish it was shown that the fishing impacts were detectable at moderate to high trawl intensities and that low trawl effort sites had the highest abundance, however, trawling did not affect diversity indices (Kangas & Morrison 2013).

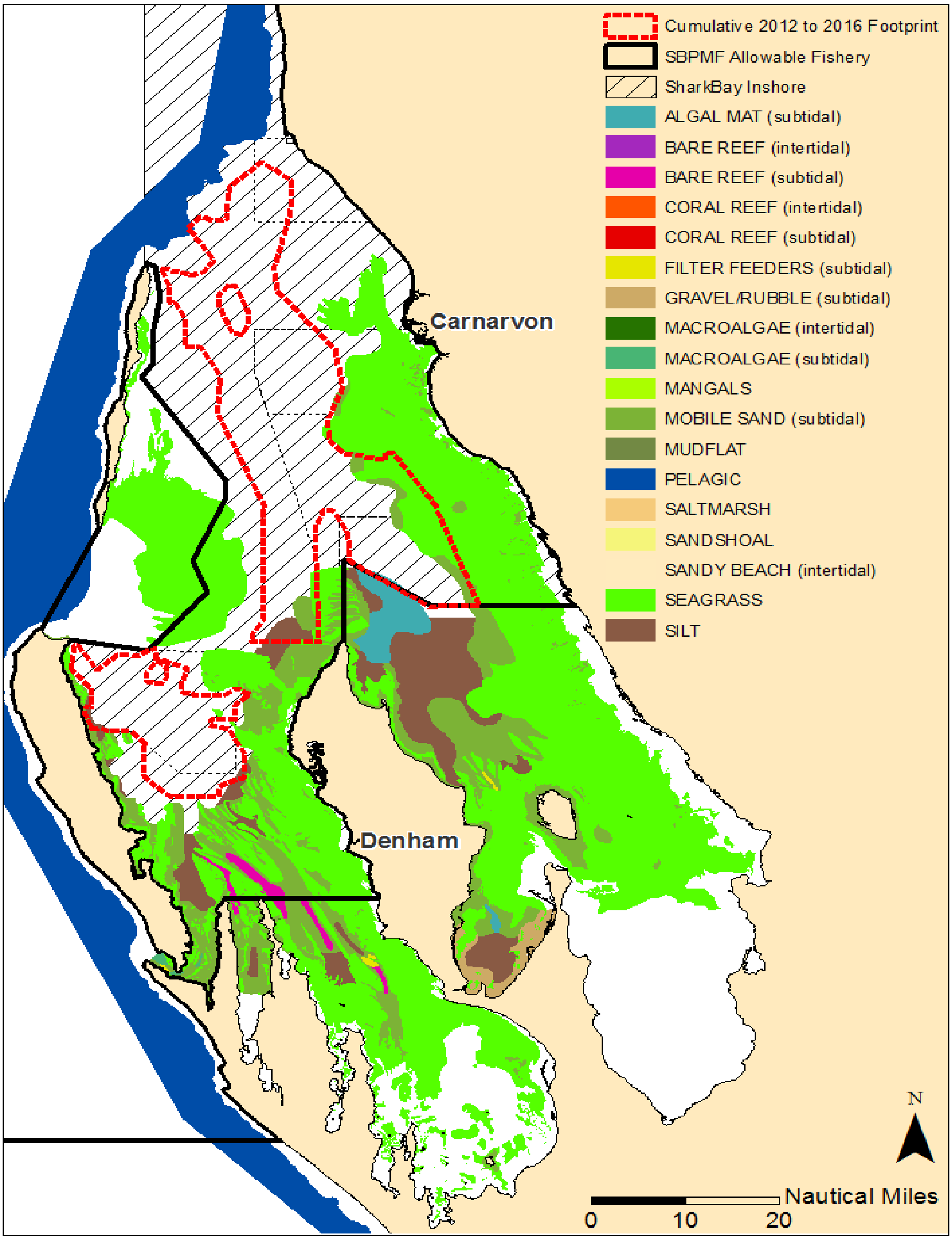

Figure 2.4. Habitats of Shark Bay (CALM 1996) overlapped with the cumulative SBPMF trawl foot print for 2012-16 (red outline).

3 Shark Bay Scallop Managed Fishery

3.1 Current Fishing Activities

The SBSMF targets scallops using low-opening otter trawls and is the most valuable scallop fishery in WA. The boundaries of the SBSMF and the two key fishing areas (Denham Sound and Northern Shark Bay) are outlined in Figure 3.1. Annual catches fluctuate widely in response to variable recruitment but have typically ranged between 200 t and 500 t (meat weight). Very high annual catches above 2000 t were observed in the early 1990s, following a period of favourable environmental conditions that led to exceptional recruitment.

The SBSMF is limited entry and consists of two classes of licence; A and B Class. There are 11 A Class boats licenced to take only scallops, while 18 B Class boats also target prawns in the SBPMF. A scallop catch share arrangement of 70:30% between the scallop and prawn fleets was implemented in 2011. The Shark Bay scallop resource is managed based on a constant escapement harvesting approach, where the TACC is set annually for scallops in each of the two key fishing areas (Denham Sound and Northern Shark Bay) and allocated to licence holders as Individual Transferable Quota (ITQ). The current harvest strategy (DPIRD 2020a in prep.) relies primarily on fishery-independent survey information for setting the TACC for each fishing season.

Management also includes a mix of input controls including gear restrictions and spatial and temporal closures. No retention of scallops is permitted in the fishery during the winter spawning closure, the exact timing of which is dependent on moon phases and is specified each year in the fishing season arrangements (e.g. 1 July to 31 August in 2018).

The SBSMF was closed to fishing for three years from 2012 to 2014 in response to low scallop abundance caused by adverse environmental conditions (marine heatwave). Since the fishery reopened to limited fishing in 2015, catches gradually increased to around 300 t. Scallop fishing in Northern Shark Bay ceased in 2019 after surveys indicated that the stock in this area had once again fallen below acceptable levels. The Northern Shark Bay stock is now considered to be in a recovery phase.

The SBSMF has been assessed and accredited under the provisions of the Environment Protection and Biodiversity Conservation Act 1999 and has export approval until 2025.

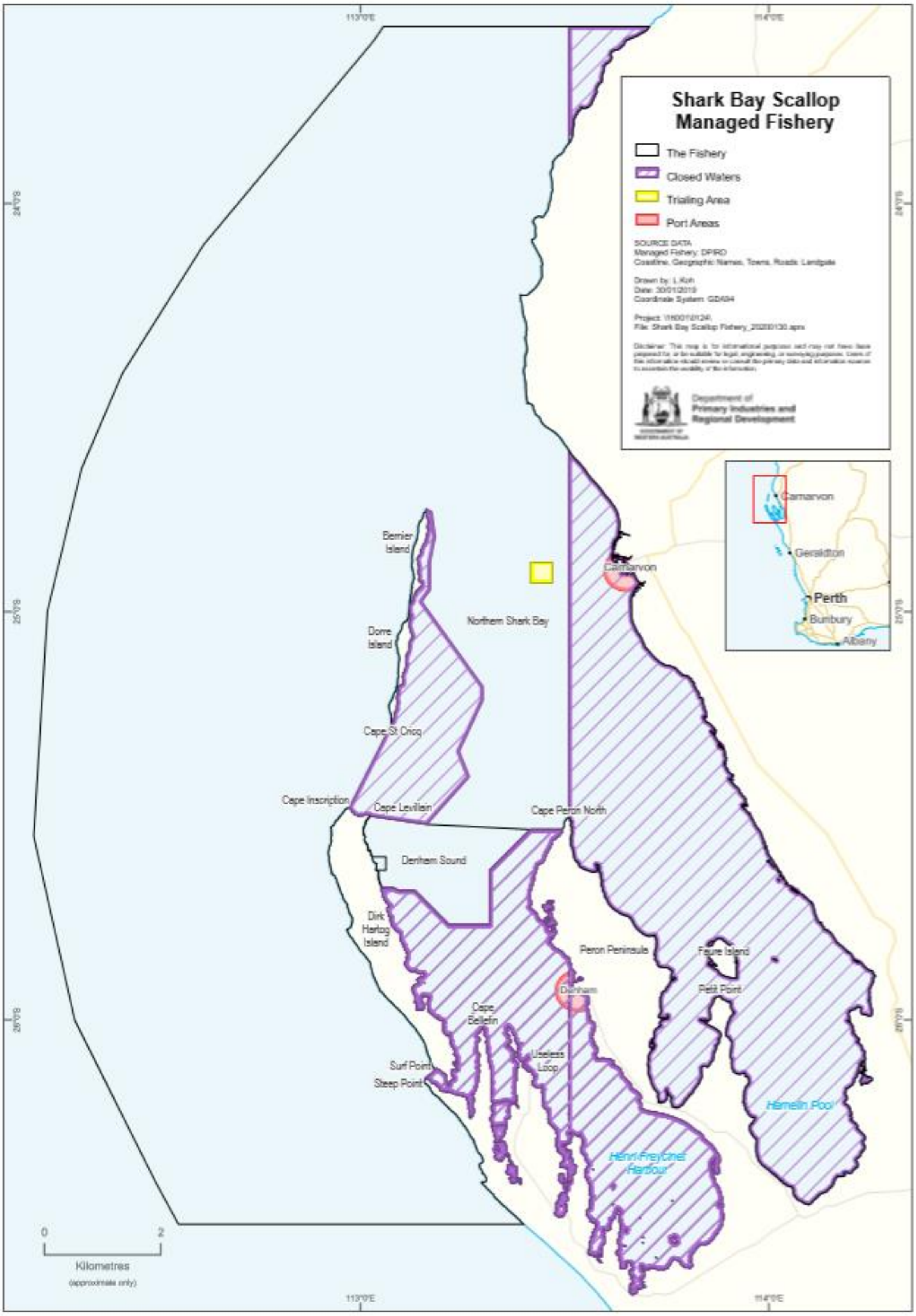

Figure 3.1. Boundaries, management areas (Denham Sound and Northern Shark Bay) and area closures of the SBSMF in WA.

3.2 Fishing Gear and Methods

Class A (scallop only) fishing vessels in the SBSMF use low-opening demersal otter trawl nets in twin-rigged formation (see Figure 2.2a), each towing two 12.8 m (7 fathoms) nets. The total net headrope capacity for the scallop fleet is 281.6 m (154 fathoms). The fleet uses a 100 mm diamond mesh codend to select for scallops greater than 85 mm shell height (Kangas et al. 2012). Trawl duration varies depending on scallop abundance but is typically no longer than 60 minutes. As with the prawn fleet, the scallop fleet use BRDs in the form of large object excluders (i.e. grids) but do not use finfish excluders due to the larger mesh used to select scallops. A detailed description of trawl nets used by the prawn trawl fleet (i.e. B Class vessels in the SBSMF) can be found in Section 2.2.

3.3 Retained Species

A summary of recent retained catches in the commercial SBSMF is provided in Table 3.1. The retained catch of prawns by B Class fishers is considered as part of the SBPMF (see Section 2). Similarly, the catch of blue swimmer crabs (by the trap and trawl sectors) in Shark Bay is managed through quota in the SBCMF (see Section 4). The risk to these species is based on weight-of-evidence assessments of these species, which considers the cumulative impacts of all fishing sectors.

Table 3.1. Retained catches (whole weight) in the SBSMF between 2011 and 2018, noting that the fishery was closed between 2012 and 2014.

Species	Catch (tonnes, whole weight)						% of total retained
	2011	2015	2016	2017	2018	Average	
Saucer scallop	295.1	287.9	319.1	1649.1	1531.5	816.5	99.97%
Bugs	0.01	0.3	0	0.5	0.2	0.2	0.03%
Cuttlefish	0	0.09	0	0.01	0.1	0.03	<0.01%
Squid	0.01	0	0	0.01	0.1	0.02	<0.01%

*Note that retained catches of blue swimmer crabs and prawns in the scallop trawl nets are reported under Sections 2 and 4 on the SBPMF and the SBCMF.

3.3.1 Saucer scallops

The saucer scallop (*Ylistrum balloti*, formerly *Amusium balloti*) is a bivalve mollusc that belongs to the family Pectinidae. It occurs on the east and west coast of Australia and in New Caledonia. In WA, it is found between Broome and east of Esperance (as far as Israelite Bay), occurring in greatest numbers in Shark Bay and the Abrolhos Islands. It inhabits sandy and is often found in sheltered environments, in bays or the lee of islands and reef systems.

Saucer scallops are short-lived (2-3 years) and has fast growth (water temperature depending), attaining a maximum size of around 115 mm (Heald 1978). Scallops are broadcast spawners, releasing their eggs and sperm into the surrounding waters for fertilisation to occur. Annual recruitment is naturally highly variable and primarily environmentally driven. As a result, catches in the SBSMF fluctuate widely between years.

On average, the SBSMF retained 817 tonnes (whole weight) of saucer scallops annually between 2011 and 2018 (excluding years when the fishery was closed), which comprises almost 100% of the total catch during those years (Table 3.1). No scallop catches were reported by boat-based fishers in the Gascoyne Coast Bioregion in the most recent state-wide survey of boat-based recreational fishing in 2015/16 (Ryan et al. 2017).

Indices of abundance from three fishery-independent surveys undertaken annually in February, June and November indicate that the scallop stock in Denham Sound is currently exploited at a sustainable level (Kangas et al. in prep.). There is currently no scallop fishing permitted in Northern Shark Bay as the stock in this area is still considered to be in a recovery phase.

3.3.2 Other species

In addition to prawns and blue swimmer crabs (see Sections 2.3 and 4.3, respectively), other species retained by fishers in the SBSMF include minor catches of small invertebrates species such as bugs (*Thenus* spp.) and cephalopods (Table 3.1). Other invertebrate and finfish species that are retained in low number in prawn trawl fishery, although not commonly reported, have the potential to be retained if caught.

3.4 Bycatch Species

In contrast to bycatch data for the prawn trawl fleet in Shark Bay (i.e. SBPMF and Class B fishers in the SBSMF; see Section 2.4), there is limited information on discarded catches by Class A fishers in the SBSMF. An observer program undertaken after the implementation of BRDs in the Shark Bay trawl fisheries in 2003 showed bycatch to retained catch ratios of 0.5:1 in the scallop trawl fishery (Kangas & Thomson 2004). This is substantially lower than the prawn trawl fishery, owing to the larger mesh size of scallop trawl nets (100 mm) that allows many of the smaller bycatch species to escape through the net mesh. Some of the larger invertebrate and finfish species that are caught and discarded in prawn trawl fishery (see Section 2.4), however, have the potential to also be caught as bycatch in scallop trawls. The post-release survival of the invertebrate species is likely to be greater than that of any discarded finfish.

3.5 ETP Species

Due to the lower fishing effort of Class A scallop fishers compared to the prawn fleet, they only occasionally capture turtles and sea snakes in their trawl nets (Table 3.2). Due to the relatively short duration of scallop trawls (up to 60 minutes, less when scallops are highly abundant), they are generally released alive. Protected species interactions of Class B (prawn trawl) vessels in the SBSMF are discussed in Section 2.5.

Table 3.2. Reported ETP species interactions in the SBSMF between 2014 and 2018.

Species / Fate	2014*	2015	2016	2017	2018
Turtles					
Alive	-	0	2	0	4
Dead	-	0	0	0	0
Sea snakes					
Alive	-	0	0	0	2
Dead	-	0	0	0	0

* Fishery closed in 2014

3.6 Habitat and Ecosystem Impacts

As with the SBPMF, the spatial extent of fishing (referred to as the trawl footprint) is monitored annually for the SBSMF using the fishery-dependent logbook data and VMS data (see Section 2.6 for a description of data). The allowable trawl area of the SBSMF fishery is smaller than that of SBPMF with similar nursery grounds and protections through the Shark Bay Marine Park, DPIRD FHPAs, and legislated fishery closures.

Less than 10% of the allowable trawl area of the SBSMF was fished in 2016, noting there was limited fishing in northern Shark Bay by the Class A fleet. As the fishery targets sandy habitats, trawling activity is considered to have a low impact on the substrate (Laurenson et al. 1993). As with the SBPMF, protection provided by the permanent closures in this region is high in relation to the trawled areas when compared to other trawl fisheries in the Australian EEZ, offsetting the perceived higher exposure (Mazor et al. 2017). In addition, even if impacts in trawled areas were high (which is not the case in SBSMF with an 8.7% interaction) and recovery was slow, the large proportions of abundance protected outside trawled areas could sustain most benthos at regional scales (Mazor et al. 2017).

The ecosystem impacts of scallop fisheries are considered to be low, with the total biomass taken by these operations being small. The natural high recruitment variability and resulting scallop stock abundance, and short life span also means that few predators are highly dependent on the species.

4 Shark Bay Crab Managed Fishery

4.1 Current Fishing Activities

The SBCMF targets the blue swimmer crab resource in Shark Bay. The resource is harvested by the commercial crab trap, prawn trawl and scallop trawl sectors, as well as a small recreational fishery (1-2 tonnes annually). Management of the commercial sector moved from an effort-controlled system to a quota management system in 2013/14. At the same time, a formal arrangement was adopted to share the annual blue swimmer crab resource across the commercial sectors (crab trap: 66.0%, prawn trawl: 33.8%, scallop trawl: 0.2%). The current overall capacity of the SBCMF is specified as 650 tonnes, based on estimates of long-term maximum sustainable yield (MSY).

There are 32 licences in the SBCMF, which are divided into Class A and B licences. The Class of licence is defined by the use of traps in Zone 1 or 2 of the fishery (Figure 4.1). There are five trap-only licences; three Class A and two Class B. The holding of a Class A licence allows for trap fishing in Zone 1 only, while a Class B licence allows for trap fishing in both Zone 1 and Zone 2. Collectively, the prawn and scallop trawl sectors hold the remaining 27 Class A licences, which allow them to fish for crabs in Zone 1 and Zone 2 using trawl gear in those areas permitted by their respective trawl arrangements. Alternatively, they may fish by trap in Zone 1 at any time, however, this has not occurred to date, given the efficiency of the trawl sectors to catch their quota during the trawl season.

The harvest strategy for the blue swimmer crab resource in Shark Bay is based on a constant exploitation approach where the catch varies in proportion to variations in stock abundance (DPIRD 2020b in prep.). Crabs are a fast-growing, short-lived species and stock abundance can change significantly from year to year depending on environmental conditions. As a result, the TACC for the resource is reviewed each year based on the state of the resource relative to specific reference levels. The fishers also have to comply with a number of input controls, including gear restrictions, spatial closures and a minimum size limit for crabs (127 mm CW, with a voluntary limit of 135 mm CW).

The SBCMF is open for 12 months of the year (1 November to 31 October). During the prawn trawl season (typically March to November), the trap operators move into the shallower grounds of the fishery to minimise gear interactions between the sectors. Although the scallop trawl season historically ran between April and November, a larger component of catches is now taken during the summer months. As this is the peak fishing period for trap operators, at-sea communications take place between the sectors to co-ordinate their fishing operations to avoid gear interactions.

The blue swimmer crab resource in Shark Bay was significantly impacted by the 2010/11 marine heatwave, which resulted in a closure of the SBCMF in April 2012. With evidence that the crab stock was rebuilding, the fishery re-opened in 2013 under a conservative TACC of 400 tonnes, which has increased as stock levels have continued to rebuild.

The SBCMF has been assessed and accredited under the provisions of the Environment Protection and Biodiversity Conservation Act 1999 and has export approval until 2025.

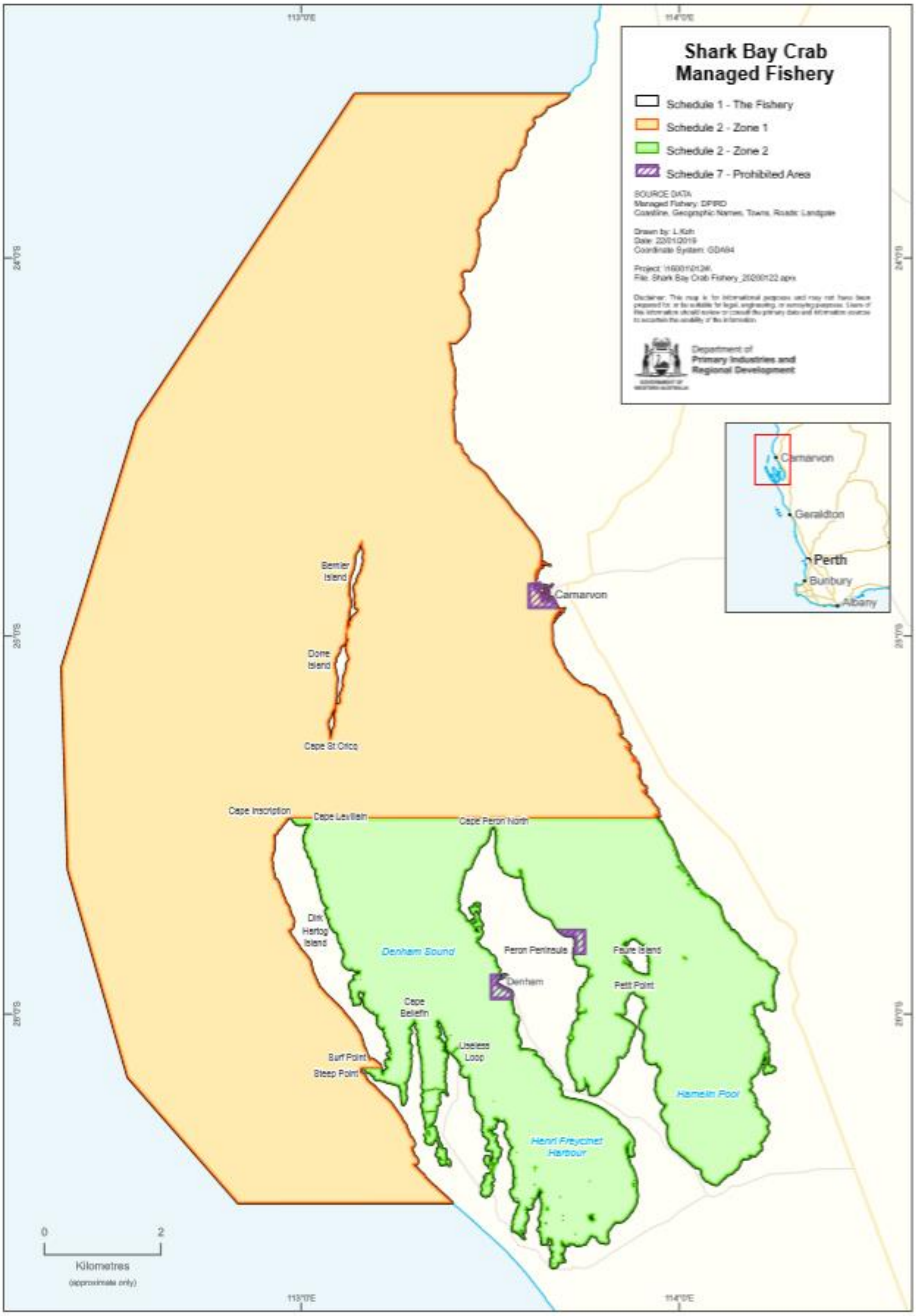

Figure 4.1. Boundaries and management zones of the SBCMF in WA.

4.2 Fishing Gear and Methods

Vessels in the SBCMF may only catch blue swimmer crabs using crab traps or trawl net configurations. The crab trap sector is permitted to use both collapsible (Figure 4.2) and non-collapsible crab traps to target blue swimmer crabs in Shark Bay. Crab traps are typically set in lines, joined together by negatively buoyant rope, attached to an identifiable surface float. The hourglass traps used in the commercial fishery are purpose-designed to minimise capture of undersized blue swimmer crabs and non-target species, the majority of which escape through the entrance gaps when the pot is soaking or being hauled.

Trawl nets may only be used by fishers in the SBCMF who also hold a licence in the SBPMF and/or the SBSMF, retaining crabs as part of their prawn and scallop fishing operations. Fishing gear and methods of the prawn and scallop trawl sectors are covered in Sections 2.2 and 3.2, respectively.

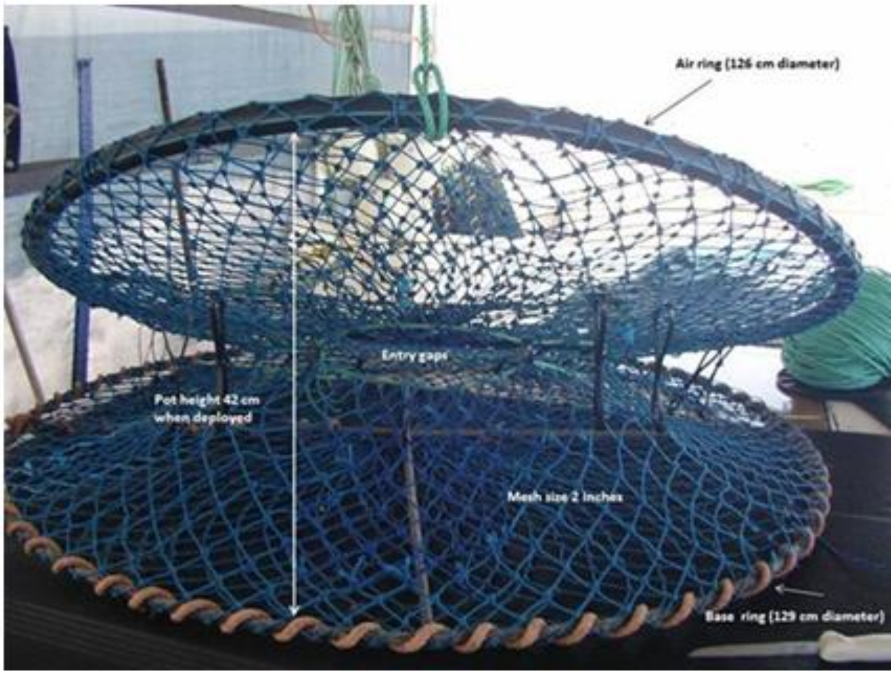

Figure 4.2. Example of a collapsible crab trap permitted for use in the SBCMF. Non-collapsible traps are also used.

4.3 Retained Species

A summary of recent retained catches of blue swimmer crabs by the trap and trawl sectors in the SBCMF is provided in Table 4.1. Although not frequently reported by fishers in their logbooks, a small proportion of the total crab catch may comprise other minor crab species (see Section 4.3.2). As the SBCMF quota currently refers to portunid crabs, the catches of these species are not currently required to be distinguished on Catch Disposal Records (CDRs) submitted by fishers when landing their catch.

Table 4.1. Retained catches of blue swimmer crabs in the SBCMF between 2013/14 and 2017/18.

Species	Catch (tonnes)						% of total retained
	2013/14	2014/15	2015/16	2016/17	2017/18	Average	
Blue swimmer crabs*							
Trap	175	153	153	274	317	214	52.3%
Prawn trawl	196	188	220	170	201	195	47.7%
Scallop trawl	0	0.14	0	0.064	0.05	0.214	<0.01%

*Note that a minor proportion of retained crab catch is likely comprised of coral crabs and three-spot sand crabs.

4.3.1 Blue swimmer crabs

The blue swimmer crab (*Portunus armatus*) is a tropical species widely distributed throughout the Indo-West Pacific, ranging from east Africa to Japan, Tahiti and northern New Zealand (Kailola et al. 1993). In Australia, the blue swimmer crab inhabits estuarine and coastal marine waters from the south coast of WA, around the north to the south coast of New South Wales. Southerly populations are also found in the warmer waters of the South Australian gulfs.

Blue swimmer crabs in Shark Bay exhibit protracted spawning year around with peak spawning activity higher during the cooler autumn/winter months. This coincides with low winds and more stable atmospheric conditions in the Bay, which is likely to be favourable for larval retention (Kangas et al. 2012). In Shark Bay, the growth rate of crabs is at its maximum during the coolest months of the year, and minimal in the warmest months of the year. Spring and early summer months are most suitable for fast growth which slows down during the warmer summer months. A 2011 extreme marine heatwave event was a major contributor to the 2012 stock decline as water temperatures rose 5°C above average, adversely impacting the survival and growth of juveniles over that summer period.

Female crabs reach maturity at around 110 mm CW and males at 105 mm CW (Chandrapavan et al. 2018) in Shark Bay, when they are ~10-12 months of age. Given the voluntary commercial minimum size limit is 135 mm CW (the legal minimum size limit is 127 mm CW), most females breed at least once before recruiting into the fishery. On average, the batch fecundities of legal-sized females are about twice those of sublegal-sized (mature) females which indicates that legal-sized females, depending on their abundance, may make an important contribution to overall egg production.

The crab resource in Shark Bay supports a small but regionally important recreational fishery that catches around 1-2 tonnes crabs annually (Ryan et al. 2017). Customary fishing for blue swimmer crabs is known to take place in Shark Bay, however, there is no quantitative information available on catches. Fishery-independent and dependent indices of abundance indicate that the blue swimmer crab stock in Shark Bay is currently exploited at a sustainable level (Chandrapavan et al. in prep.).

4.3.2 Other species

Logbook data indicate that the only species other than blue swimmer crabs that are retained in crab traps are coral crabs (*Charybdis cruciata*) and three-spot sand crabs (*Ovalipes australiensis*). Due to the lower market value of the two latter species compared to blue swimmer crabs, these are only retained occasionally in low numbers.

Coral crabs are generally found in marine coastal waters on a range of bottom types including mud, sand, rock and seagrasses in depths of up to 60 m (Jones & Morgan 2002). While they are not the primary targets of the blue swimmer crab fishery their abundance at certain times of the year, especially in the northern regions of the fishery. Sand crabs are distributed across southern Australia. They are common on surf beaches and in sandy bays and inlets, however, they also occur offshore to depths of 100 m (Jones & Morgan 2002).

4.4 Bycatch Species

The hourglass traps used in the commercial trap fishery are purpose-designed to minimise capture of bycatch species. The traps also minimise the amount of damage that bycatch species incur during setting and retrieval, which increases the survival rate of discards. Bycatch in the Shark Bay prawn and scallop trawl fisheries are described in the relevant sections of this report.

Although information on bycatch in the crab trap fishery is limited, the invertebrate, finfish and elasmobranch species that are caught by the trawl sectors have the potential to also be caught as bycatch in crab traps. Anecdotal evidence from fishers indicates that octopus is regularly caught in low numbers in shallow waters (Department of Fisheries 2004). The majority of octopus that enter the pots are able to escape through the entrance gaps in the side of the pots while still soaking or being hauled up. Various species of shallow-water crabs and starfish are also infrequently caught and discarded in small numbers (Department of Fisheries 2004). Discarded catches of finfish include low numbers of toadfish (*Lagocephalus sceleratus*), spangled emperor (*Lethrinus nebulosus*), leatherjackets and boxfish (Department of Fisheries 2004). The majority of fish that enter the pots are able to escape through the entrance gaps either when the pot is soaking or being hauled.

4.5 ETP Species

Although there have been no reported interactions of crab trap fishers with protected species in Shark Bay to date, there is the potential for the fishery to interact with species known to interact with the trawl fisheries in the region (e.g. sawfish, cetaceans, dugongs, sea snakes, turtles and syngnathids). As in other trap fisheries in WA, this is most likely to occur through entanglement in ropes and lines connected to the pots, rather than through direct capture.

4.6 Habitat and Ecosystem Impacts

Trap fishing effort in the SBCMF is primarily focused on the central and northern areas of Shark Bay, which are dominated by sand and silt habitats (Kangas et al. 2015). Some of the fishing in nearshore waters off Carnarvon, and within Denham Sound in the south, is likely occurring over seagrass and macroalgal habitats (Figure 2.4). Unlike the prawn and scallop trawl sectors, which are not permitted to operate in extensive areas of Shark Bay that are closed off to trawling, trap fishing is permitted in most of the embayment (apart from sanctuary zones and the Hamelin Pool Marine Reserve). A preliminary analysis of the spatial effort data from 2014-2017, based on assumptions of the distance between pots on the lines (~10 m, assumed to be set in a northwards direction from the reporting starting location) and adding a 5 m buffer either side of lines to allow for some movement of traps whilst set and retrieved, indicate that the annual areal footprint by crab traps is approximately 10-15 km^2, which is less than 1% of the Inner Shark Bay area.

Fishing with crab traps results in limited habitat disturbance as only minor dragging of traps on the sea bottom occurs during trap retrieval. Sand and associated biota does not get brought to the surface in commercial blue swimmer crab traps, as the mesh used on traps is sufficiently large to allow escape of any sand-dwelling macro benthos. Although seagrasses are occasionally uprooted and brought to the surface with the trap, the infrequent nature of this happening and the small amount of living seagrass removed results in minimal habitat damage.

Blue swimmer crabs are opportunistic, bottom-feeding carnivores and scavengers. Their diet primarily consists of a variety of sessile and slow moving invertebrates, including bivalve molluscs, crustaceans, polychaete worms and brittle stars (Edgar 1990). Predators of blue swimmer crabs in WA have not been identified. The smooth stingray, southern fiddler and gummy shark are known predators of adult crabs in South Australia. As the commercial take of crabs represents a relatively small portion of the biomass (i.e. no retention of crabs <135 mm CW), which is effectively renewed annually, secondary food chain effects are likely to be minimal in this fishery.

5 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 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 5.1.

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 5.1). Secondly, risk identification involves the process of recognising and describing the relevant sources of risk (Section 5.2). 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 5.3).

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.

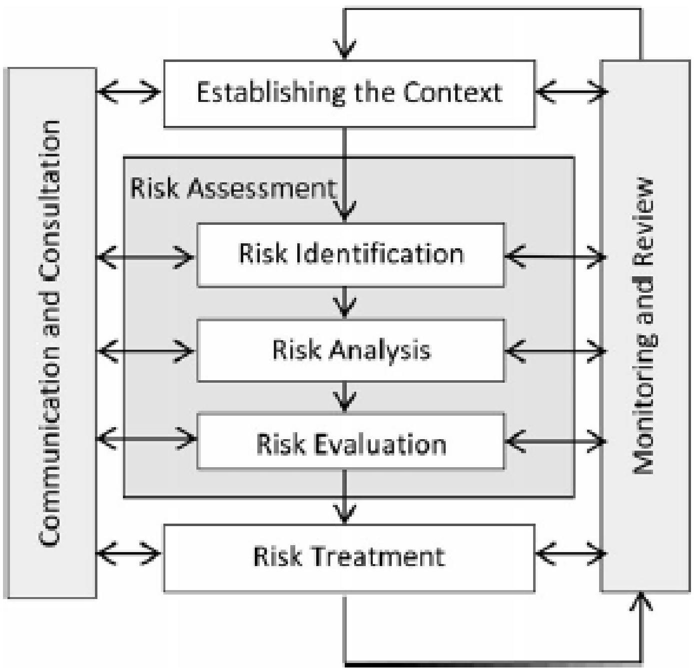

Figure 5.1. Position of risk assessment within the risk management process.

5.1 Scope

This risk assessment covers commercial trawl fishing by the SBPMF and SBSMF and commercial trap fishing by the SBCMF, within the management boundaries of these fisheries. The assessment considers only the ecological impacts of these fishing activities and, where relevant, the cumulative impact of all three fishing sectors is considered. The calculation of risk is usually determined within a specified period, which for this assessment is the next five years (i.e. until 2025).

5.2 Risk Identification

The first step in the risk assessment process was to identify the issues relevant to the fisheries being assessed. Issues were identified using a component tree approach (see Figure 5.2 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 Shark Bay invertebrate fisheries was based on:

- Previous risk assessments undertaken for the fisheries to achieve approval for Wildlife Trade Operations (Department of Fisheries 2002a, b; 2004; 2012);
- Gaps identified during pre-assessments of the Shark Bay Invertebrate Fisheries 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.

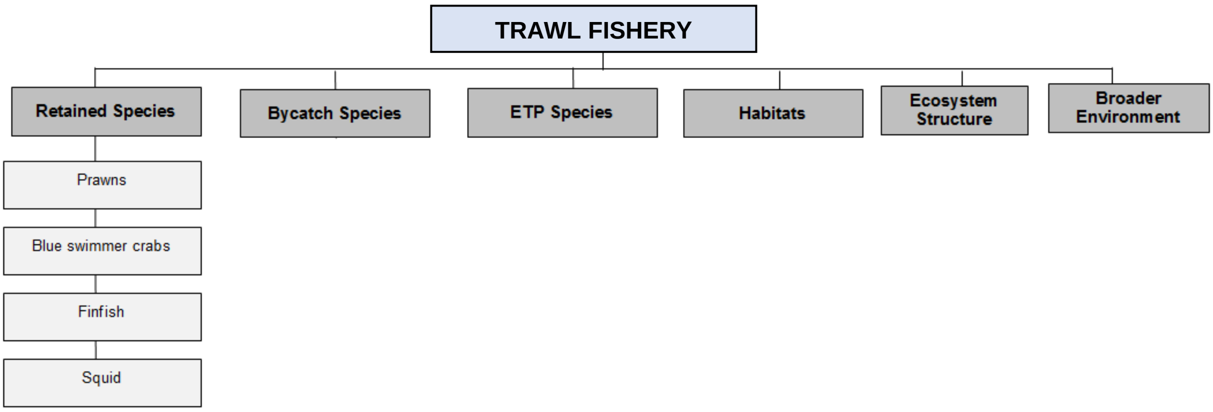

Figure 5.2. An example of a component tree for ecological sustainability, identifying the main components (dark grey boxes) and sub-components for retained species in a trawl fishery.

5.3 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 Shark Bay Invertebrate Fisheries 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 5.3). Each issue was thus assigned a risk level within one of five categories: Negligible, Low, Medium, High or Severe (Table 5.1).

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 will be reviewed in 5 years, or prior to the next review of the harvest strategies for these resources, 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 5.3. 4 × 4 Consequence – Likelihood Risk Matrix (based on AS 4360 / ISO 31000; adapted from Fletcher 2015).

Table 5.1. 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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7 Appendix A

Risk ratings in previous risk assessments for the Shark Bay prawn fishery

Component and Sub-component	2001	2008	2010
Retained Species (Primary)			
Western king prawns	MEDIUM	MEDIUM	MEDIUM
Brown tiger prawns	HIGH	HIGH	HIGH
Retained Species (Secondary)			
Coral prawns	MEDIUM	MEDIUM	MEDIUM
Endeavour prawns	MEDIUM	LOW	LOW
Squid & cuttlefish	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
Blue swimmer crabs	NEGLIGIBLE	LOW	MEDIUM
Finfish	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
Other	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
Bycatch Species			
Invertebrates	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
Finfish	MEDIUM	MEDIUM	MEDIUM
Sharks		NEGLIGIBLE	NEGLIGIBLE
ETP Species			
Sea snakes	LOW	LOW	LOW
Green turtles	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
Loggerhead turtles	LOW	LOW	LOW
Dugongs & cetaceans	LOW	LOW	LOW
Syngnathids	LOW	LOW	LOW
Habitats			
Sand	MEDIUM	MEDIUM	MEDIUM
Seagrass	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
Coral/sponge	MEDIUM	MEDIUM	MEDIUM
Ecosystem			
Taking retained species	LOW	LOW	LOW
Discarding/Provisioning	MEDIUM	MEDIUM	MEDIUM
Translocation (pests, disease)	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
Debris/Littering		LOW	LOW
Turbidity	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE

Risk ratings in previous risk assessments for the Shark Bay scallop fishery

Component and Sub-component	2001
Retained Species (Primary)	
Scallops	MEDIUM
Retained Species (Secondary)	
Cuttlefish	NEGLIGIBLE
Blue swimmer crabs	NEGLIGIBLE
Bugs	NEGLIGIBLE
Bycatch Species	
Invertebrates	NEGLIGIBLE
Finfish	NEGLIGIBLE
ETP Species	
Sea snakes	LOW
Green turtles	NEGLIGIBLE
Loggerhead turtles	LOW
Dugongs & cetaceans	LOW
Syngnathids	LOW
Habitats	
Sand	LOW
Coral/sponge	LOW
Ecosystem	
Taking retained species	LOW
Discarding/Provisioning	LOW
Discarding scallop shells	NEGLIGIBLE
Translocation (pests, disease)	NEGLIGIBLE
Turbidity	NEGLIGIBLE

Risk ratings in previous risk assessments for the Shark Bay crab fishery

Component and Sub-component	2002
Retained Species (Primary)	
Blue swimmer crabs	MEDIUM
Retained Species (Secondary)	
Coral crabs	NEGLIGIBLE
Sand crabs	NEGLIGIBLE
Bycatch Species	
Octopus	NEGLIGIBLE
Other crabs	NEGLIGIBLE
Starfish	NEGLIGIBLE
Finfish	NEGLIGIBLE
ETP Species	
Turtles	NEGLIGIBLE
Whales & dolphins	NEGLIGIBLE
Habitats	
Sand	NEGLIGIBLE
Seagrass	NEGLIGIBLE
Ecosystem	
Taking retained species	NEGLIGIBLE
Discarding/Provisioning	NEGLIGIBLE
Ghost fishing	NEGLIGIBLE
Debris	NEGLIGIBLE

PART 2

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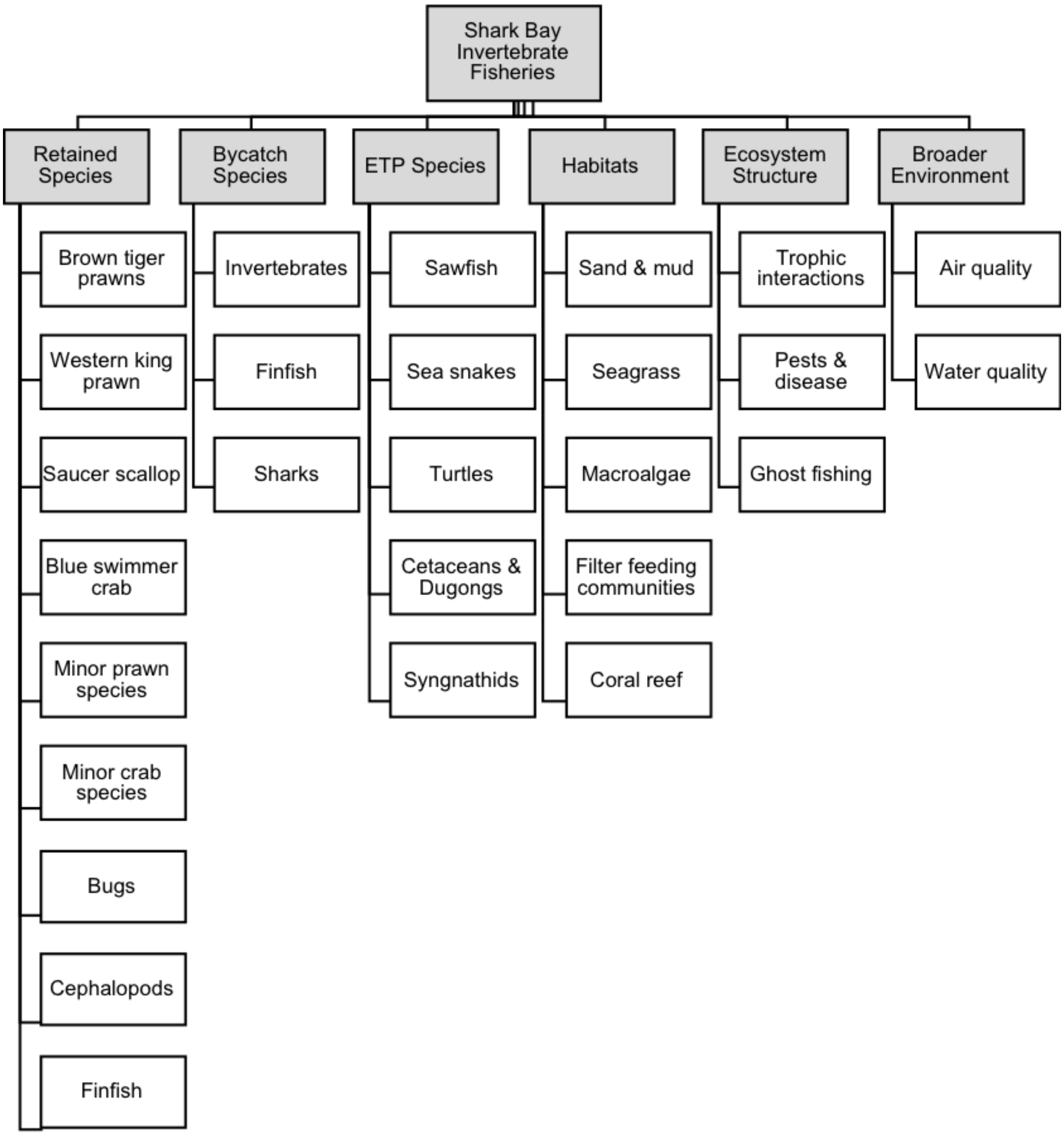
Department of Primary Industries and Regional Development
Western Australia

Ecosystem Based Fisheries Management

Ecological Risk Assessment of the Shark Bay Invertebrate Fisheries (Prawn, Scallop and Crab)



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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Attachments

Executive Summary

An ecological risk assessment (ERA) of the commercial Shark Bay Invertebrate Fisheries (Fisheries) was convened with industry experts and stakeholders on 11 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 framework and the outputs inform the development and review of harvest strategies. The Fisheries include the Shark Bay Prawn Managed Fishery (SBPMF), the Shark Bay Scallop Managed Fishery (SBSMF) and the Shark Bay Crab Managed Fishery (SBCMF).

The SBPMF 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 fisheries. This ERA will be used to inform the re-certification of the SBPMF.

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 Fisheries 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 a Technical Panel in this qualitative ERA.

Except for the interaction of fishing with two of the target species, the threats assessed for fishing interactions with ecological assessment components in the ERA were ranked medium, low or negligible for the Fisheries using the adopted methodology. The SBPMF generally represents more intensive effort than SBSMF or SBCMF and tends to dominate the cumulative risk rankings when considering all three Fisheries operating in Shark Bay. Risk rankings of medium or less are considered acceptable risks for well-managed fisheries, subject to ongoing performance monitoring.

Risks to the sustainability of stocks of two target species were ranked high and severe: brown tiger prawns in the SBPMF, and saucer scallops in the northern Shark Bay area of the SBSMF, respectively. Corrective management actions both already adopted and proposed for the SBPMF and SBSMF are expected to reduce the residual risk ranking to an acceptable level of medium risk over the assessment timeframe of five years.

Ongoing performance monitoring of the Fisheries should confirm that these risks remain acceptably low. In the event that circumstances of the Fisheries 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 Shark Bay Invertebrate Fisheries (Fisheries) was convened with industry experts and stakeholders on 11 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 Shark Bay Invertebrate Fisheries include the Shark Bay Prawn Managed Fishery (SBPMF), the Shark Bay Scallop Managed Fishery (SBSMF) and the Shark Bay Crab Managed Fishery (SBCMF).

The SBPMF 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 the SBPMF.

The Department completed an internal ERA of the Fisheries in July 2019 to evaluate the ecological impact of demersal trawling for the SBPMF and SBSMF and trapping and demersal trawling for SBCMF. The potential impacts were identified and assessed for all retained species, bycatch, endangered, threatened and protected (ETP) species, habitats and the broader ecosystem. The July 2019 ERA considered the cumulative impacts of the three fishing methods (i.e. prawn trawl, scallop trawl and crab traps) on retained and discarded species, and habitats when assessing risk. 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.

Shark Bay is Australia's largest marine embayment (~16,000 km^2), located in the Gascoyne Coast Bioregion of WA—near the southern limit of the transition between the tropical waters of the northern coast and the temperate waters of the southwest. It is relatively shallow (9-30 m), with an eastern and western gulf, to the south divided by the Peron Peninsula and semi-enclosed to the northwest by Bernier, Dorre and Dirk Hartog Islands which restrict water exchange between the bay on open ocean. The bay is subject to occasional turbid freshwater river floods.

Shark Bay is a highly productive ecosystem supporting benthic invertebrate fauna of exceptional abundance, diversity and zoological significance. The bay is also renowned for its marine fauna and supports large populations of dugongs, dolphins, marine turtles and seasonal residence of migrating humpback whales. Extensive management protection has been implemented through the Shark Bay Marine Park and its sanctuary and special purpose areas, Fish Habitat Protection Areas and permanently legislated trawl fishery closures accounting for over 60% of Shark Bay.

Habitat mapping of Shark Bay is limited, with existing information focused on the shallow water inner gulfs within the SBPMF nursery grounds and special purpose closed areas. Primary habitats of Shark Bay include seagrasses (~30% cover), microbial communities and algal mats, and some areas of coral. Seagrass around the Faure Sill and Wooramel Seagrass Bank is considered one of the most diverse assemblages in the world and is of great significance to the trophic structure of Shark Bay.

The central northern and western regions of Shark Bay consist of mobile silt/sand with varying levels of abundance and distribution of sponges, octocorals, invertebrates and infauna. Crustaceans including the target species of the Fisheries prefer this habitat, but few finfish species are permanently attracted to these soft, sandy substrates.

Shark Bay Prawn Managed Fishery

Eighteen boats operate in the SBPMF using low-opening demersal otter trawl nets on primarily sandy substrates in ab**out 40-50%** of the fishery area annually. The fishing season typically extends from March/April through November, and the harvest strategy is based on a constant escapement approach which aims to protect spawning stocks and allow prawns to reach optimal market size before fishing commences and implementing temporal closures of important spawning areas and areas of small prawns. Boats are equipped with hoppers to maximise the survival of discarded species in recirculating seawater.

The SBPMF 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 night-time fishing). Monthly moon closures of at least five days and significant spatial closures are also used to reduce effort and 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 western king prawns (*Penaeus latisulcatus*) and brown tiger prawns (*Penaeus esculentus*). Operators in the SBPMF that also hold licences in the SBSMF and SBCMF are permitted to retain saucer scallops (*Ylistrum balloti*) and blue swimmer crabs (*Portunus armatus*). These catches are managed by quota.

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.

Another notable species retained by the SMPMF is bugs (*Thenus* spp.). However, although commercially valuable they comprise about 0.1 % of the retained catch. Minor catches (~2%) of finfish may be retained, including whiting, flathead, sardines, flounder and black jewfish.

Bycatch taken in the SBPMF is moderate relative to other subtropical trawl fisheries. Invertebrate bycatch is dominated by minor crab species but also includes small prawns, cephalopods, bivalve molluscs and echinoderms. Finfish bycatch is dominated by goatfish, lizardfish and ponyfish. The majority of bycatch species are not targeted by other fisheries in the region, apart from minor catches of emperors (~2%) and pink snapper (~0.1%).

Bycatch reduction devices (BRDs) have largely eliminated the bycatch of large sharks and rays in the SBPMF. 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 survival of discarded finfish is likely to be low.

Under statutory requirements for reporting of ETP species captured by trawling, only syngnathids and sea snakes are captured in larger numbers. 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. Generally, the duration of trawls is between 30 and 60 minutes resulting in most turtles and seasnakes that are captured being released back into the water alive.

The SBPMF interacts with only a small portion of the total area of Shark Bay and the fishery management area, predominantly on soft sand habitat (~86% of effort) which is resilient to disturbance. Interaction with seagrasses, microbial communities, algal mats, and some areas of coral occurs to a much lesser extent in the southern and inshore areas of the bay (~8% of fishing effort occurs over seagrass).

The SBPMF does not interact with over 80% of Shark Bay, and large proportions of species abundance are protected outside trawled areas. Northern Prawn Fishery studies have suggested that the effects of trawling at the current scale of the fishery do not affect overall biodiversity and cannot be distinguished from other sources of variation in community structure.

Shark Bay Scallop Managed Fishery

The SBSMF targets saucer scallops (*Ylistrum balloti*) using low-opening otter trawl gear on primarily sandy substrates. The fishery is limited entry and consists of two classes of licence holders: eleven A-Class vessels to take only scallops, and eighteen B-Class vessels to take both scallops and prawns.

The fishing season is closed during the prescribed winter spawning period which varies dependent on moon phase, and the harvest strategy is based on a constant escapement approach which sets the total allowable commercial catch (TACC) in each of the two key fishing areas—Denham Sound and Northern Shark Bay. The SBSMF operates under an output control (Individually Transferable Quota) system, with restrictions on trawl gear size as well as seasonal closures and spatial closures.

The SBSMF was closed to fishing for three years from 2012 to 2014 in response to low scallop abundance during a period of high marine water temperatures. After re-commencing limited fishing effort in 2015 catches gradually increased; however, fishing was again closed in Northern Shark Bay in 2019 after stock levels were observed below acceptable abundance and currently remains in a recovery phase.

Saucer scallops, the target species, are short-lived (2-3 years) and fast growing depending on water temperature. The catch is highly variable, dependent on the recruitment success of scallop which is influenced by environmental conditions. Annual independent surveys indicate that the scallop stock in Denham Sound is currently exploited at a sustainable level. Since the SBSMF was closed from 2012 to 2014 in response to a marine heatwave, catches of the target species have been about 300 tonnes (t, whole weight) in 2015-2016, increasing to about 1,600 t (whole weight) in 2017-2018.

Scallop fishers may retain blue swimmer crabs (as per their quota allocation), and also may retain minor catches of small invertebrates (bugs and cephalopods). Other invertebrates and finfish species are retained in very low numbers.

Bycatch data is limited for Class-A fishers in the SBSMF. The larger mesh size of scallop trawl nets (100 mm) compared to prawn trawl nets allows many of the smaller potential bycatch species to escape. Bycatch reduction devices (BRDs) in the form of grids are mandatory in scallop nets but secondary BRDs have not been implemented due to the larger mesh size of Class-A scallop nets in the SBSMF. Some larger invertebrate and finfish species have the potential to be caught, with the post-release survival of invertebrates likely to be greater than discarded finfish.

ETP species interactions for the Class-B prawn and scallop trawl vessels are the same as for the SBPMF discussed above. Due to the lower fishing effort of the Class-A licence holders, they only occasionally capture turtles and sea snakes during trawl durations up to 60 minutes (less when scallops are highly abundant). The short duration of Class-A trawls generally results in turtles and sea snakes that are captured being released alive.

Only a small portion of the allowable trawl area for the SBSMF is fished primarily on sandy substrates, with low potential to impact benthic habitats of Shark Bay. Large proportions of species abundance are protected outside trawled areas. The ecosystem impacts of scallop fisheries are considered to be low. The total biomass harvested is highly variable. Few predators become dependent on scallop due to its high natural recruitment variability, short life span and consequent variations in stock abundance.

Shark Bay Crab Managed Fishery

The SBCMF targets blue swimmer crab (*Portunus armatus*) using commercial crab traps, although fishers in the SBPMF and SBSMF that also hold a crab licence retain this species caught in trawl gear. Bycatch, habitat and ETP interactions for the prawn and scallop trawl vessels is the same as for the discussed above, so below generally refers to the trap component of this fishery. Crabs are also harvested by a small recreational fishery (1-2 t annually). Crabs are a fast-growing, short-lived species.

The harvest strategy of the commercial fishery is a constant exploitation approach with quotas that change in response to stock abundance, which can vary significantly depending on environmental conditions. The fishery operates under an output control (ITQ) system across the trap and trawl sectors, with restrictions on gear, spatial closures and a minimum size carapace width (CW) limit of 127 mm (with a voluntary limit of 135 mm CW). The current overall capacity of the SBCMF is specified as 650 t based on estimates of long-term maximum sustainable yield (MSY), however the current TACC is 550 t.

The trap component of the SBCMF is open continuously in permitted areas. During the prawn trawl season (typically March to November) the trap operators move into shallower fishing grounds to avoid gear interactions with the trawl fishery, coordinated with at-sea communications between the fishing sectors.

The SBCMF was closed in 2012 after high marine water temperatures reduced stock, re-opening in 2013 with a conservative catch limit that has gradually increased.

Blue swimmer crab, the target species for the trap sector, is retained along with other minor crab species (coral crab, three-spot sand crab) under the catch quota that refers to *portunid* crabs. Blue swimmer crabs exhibit protracted spawning year-round, peaking during the cooler autumn/winter months. Female crabs reach maturity at around 110 mm CW and males at about 105 mm CW (~10-12 months of age).

Indices of abundance indicate that the blue swimmer crab stock in Shark Bay is currently exploited at a sustainable level.

Bycatch for the trap sector is very limited due to the design of crab traps, which also increases the survival rate of discards compared to trawl fisheries. Invertebrate, finfish and elasmobranch species have the potential to be caught as bycatch in traps; however, these species can escape through the entrance gaps of the traps when they are soaking or being hauled to the surface. Discarded finfish include low numbers of toadfish, spangled emperor, leatherjackets and boxfish.

There have been no reported interactions of crab trap fishers with ETP species in Shark Bay to date. The potential for future interactions, if they occur, is most likely through entanglement with ropes and lines connected to the traps rather than direct capture.

Trap fishing in the SBCMF is primarily focused on the central and northern areas of Shark Bay, dominated by sand and silt habitats. The annual areal footprint of crab traps is approximately 10-15 km^2, which is less than 1% of the Inner Shark Bay area available for the SBCMF. The use of crab traps results in limited habitat disturbance, as only minor dragging of traps on the sea floor occurs during trap retrieval. The mesh size of traps is sufficiently large to allow the escape of sand-dwelling macro benthos that may enter the trap while it is soaking or being hauled. Although seagrasses are occasionally uprooted and brought to the surface with the trap, the small amount of living seagrass being removed results in minimal habitat damage.

Blue swimmer crabs are opportunistic carnivores and scavengers, their diet consisting of a variety of sessile and slow-moving invertebrates. Predators of blue swimmer crab in WA have not been identified. As the commercial take of crabs represents a relatively small portion of the biomass, which is effectively renewed annually, secondary food chain impacts are likely to be minimal.

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 Fisheries 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 and a Technical Panel 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. The composition and roles of the Stakeholder Working Group and the Technical Panel are elaborated below.

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 Fisheries, 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 Fisheries 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
- Shark Bay fishing industry companies, licensees and fishers.

There were 25 people from a cross-section of these organisations who expressed an interest in attending the ERA workshop, and 18 people who actually attended.

Technical Panel

A Technical Panel was convened for the ERA with the support of a range of stakeholders, as a subset of the Stakeholder Working Group. The Technical Panel encompassed a range of scientific disciplines relevant to the fishery assessment.

Although there is no formula to obtain a 'perfect' mix of expert representation, the goal was to represent the range of stakeholder interests with persons who demonstrate recognised experience and qualifications in the subject matter, and have the capacity to provide high quality technical expertise for risk analysis.

The persons serving on the Technical Panel were:

Mr Geoff Diver	Manager, Policy and Environment Sea Harvest
Dr Matt Fraser	Postdoctoral Research Fellow—Benthic Habitats UWA, Western Australia
Mr Phil Scott	Vice Chair Shark Bay World Heritage Advisory Committee
Dr Mervi Kangas	Principal Scientist, Invertebrate Trawl DPIRD, Western Australia

The Technical Panel's role in the workshop was to participate in the discussion of the threats identified for each of the fishing interactions with ecological assessment components, and to assess the risk level for these hazards under existing circumstances and fisheries management controls. Assessment was based on full consideration of published technical information and the management actions formally adopted by the Fisheries or committed to by the Department. New threats to ecological components were considered and assessed as necessary.

The Technical Panel also re-assessed the residual, or treated risk level for new or alternative management actions that were suggested by the Stakeholder Working Group.

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 and decisions of the Technical Panel.

Consequence and likelihood ratings

For each assessment component of the Fisheries, 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 Technical Panel'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 Fisheries, 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. Only the Technical Panel contributed to the judgments made in the risk analysis, with input from the Stakeholder Working Group.

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.

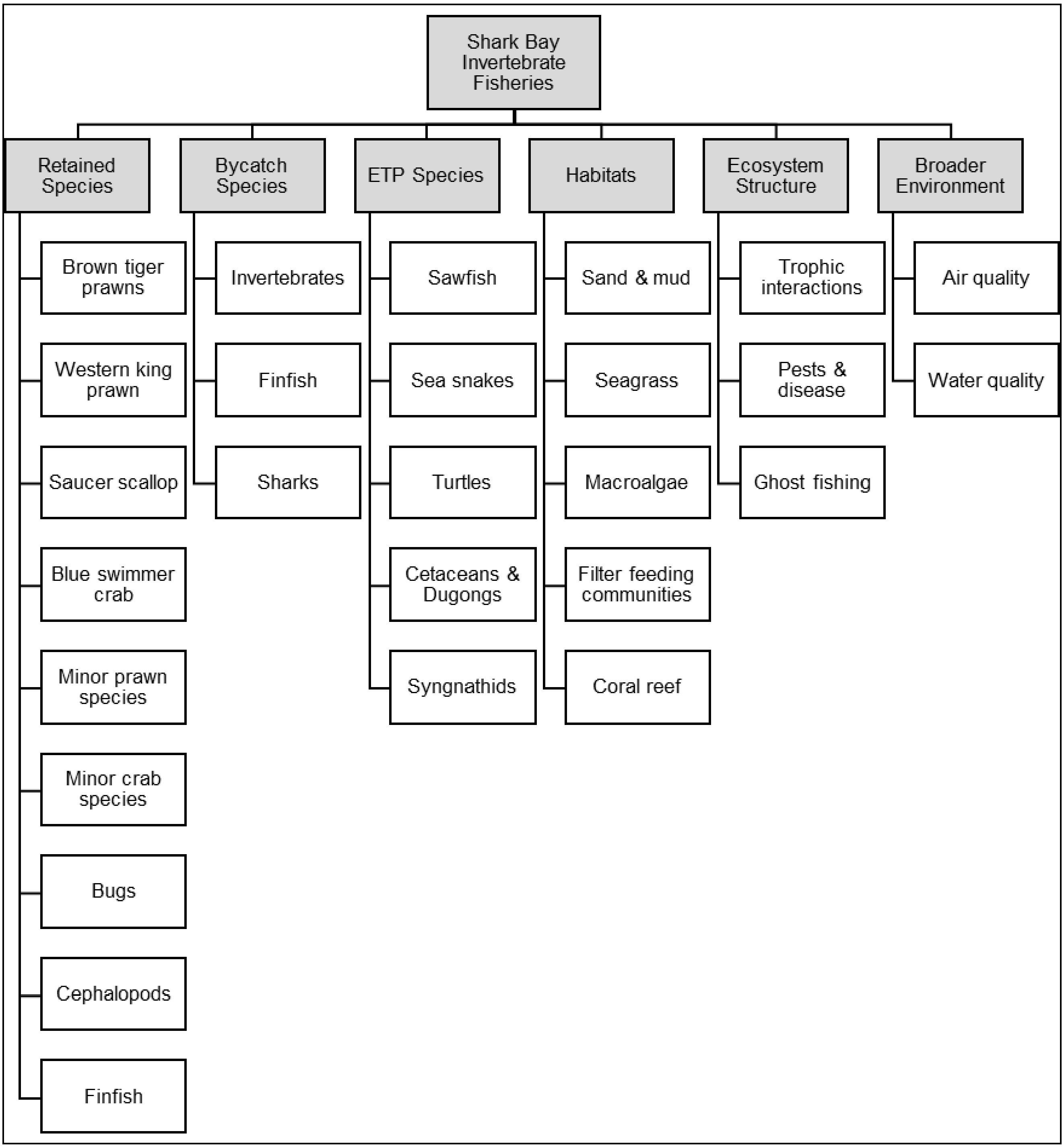

Figure 2. Shark Bay Invertebrate Fisheries ecological components for assessment.

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 Fisheries 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 for 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.

Severe risk

One severe risk was identified in the risk assessment. Spawning biomass stock of saucer scallops in the northern region of Shark Bay fishing grounds is considered to be below the minimum recovery limit (ERA Workshop Record Item no. 3). As a result, the northern Shark Bay fishing grounds are currently closed to the SBSMF and additional spatial closures in northern Shark Bay have been implemented by fisheries managers. A Recovery Strategy has been implemented, as required by the Department's risk management controls (Table 7).

The recommended corrective action, in addition to the spatial closures and Recovery Strategy, is to conduct three monitoring surveys of scallop stocks each year.

High risk

One high risk was identified in the risk assessment. Spawning biomass stock of brown tiger prawns, one of the primary target species of the SBPMF, have been observed to be possibly below the maximum sustainable yield (Item no. 2). This finding is based on the monitoring of catch rates, biomass dynamic modelling and independent spawning survey catch rates. Additional spatial closures have already been implemented to ensure breeding stock of brown tiger prawns is protected, as well as continued monitoring of recruitment.

The recommended corrective actions are: to commence long-term research to evaluate population dynamics; and to consider real time monitoring of catch size distribution using new technology such as electronic logbooks.

Medium risk

Five medium risks were identified in the risk assessment:

Item number	Nature of risk
1	Reduction of western king prawn stock, the most abundant target species in the prawn trawl fishery.
3	Reduction of saucer scallop stock in the Denham Sound fishing grounds (south of the northern area that is closed to scallop trawling), the target species of the scallop trawl fishery.
4	Reduction of blue swimmer crab stock, the target species of the crab trap fishery.
15	Capture of sea snakes in the prawn trawl fishery, with risk analysis based on the leaf scaled sea snake (most vulnerable ETP species of captured sea snake species).
26	Trophic interactions of discarding and provisioning in the prawn trawl fishery, with possible changes in trophic structure due to discarded prey.

Target species (1, 3 and 4)

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

Sea snakes (15)

Sea snakes are regularly captured in demersal trawl gear but mainly returned alive (mortality <15%). Risk is mitigated with recirculating seawater hoppers on prawn trawl and Class-B scallop trawl vessels, and crews are trained in sea snake handling and identification. It was noted that the conservation status of some species (e.g. the leaf scaled sea snake) is under review, with the prospect of downgrading the conservation status based on new evidence of abundance and distribution. No additional corrective actions were recommended by workshop participants.

The medium risk ranking of cumulative impacts (considering the combined effects of SBPMF, SBSMF and SBCMF) is attributed to the medium risk ranking of the SBPMF fishery. Much lower capture rates are observed in the less intensive SBSMF, and no interactions with sea snakes have been reported in the SBCMF.

Trophic interactions in the prawn trawl fishery (26)

The discarding of bycatch from vessel hoppers occurs over a large area of Shark Bay while the vessels are steaming. Sharks and dolphins are commonly observed as scavengers for discards. Top predators are not generally caught in trawl nets due to the use of bycatch reduction devices. Seabirds are observed to also scavenge for discards. There is the potential for certain species to become reliant on discards or to change behaviour, but fishing effort is seasonal and the trophic interactions of discarding and provisioning over the long term is thought to represent a steady state in ecosystem structure and function.

Workshop participants did suggest a corrective action for consideration—to conduct ecosystem modelling. It was noted that funds for such modelling are currently being sought by DPIRD.

The medium risk ranking of cumulative impacts is again attributed to the medium risk ranking of the SBPMF. Discarding of bycatch from SBSMF and SBCMF involves a much smaller quantity of biomass.

Low and negligible risk

Fourteen low risk rankings were recorded for the cumulative risk of fishing interactions of all Shark Bay Fisheries. Most of these low risk rankings are attributed to the low risk rankings of the SBPMF, where the relative intensity of fishing effort was greater than for the SBSMF and the SBCMF. The exceptions are noted in the ERA Workshop Record (Attachment 2).

Eleven low risk rankings and fifteen negligible risk rankings were recorded for SBPMF interactions with ecological assessment components.

Five low risk rankings and twenty-four negligible risk rankings were recorded for SBSMF interactions with ecological assessment components.

Four low risk rankings and twenty-four negligible risk rankings were recorded for SBCMF interactions with ecological assessment components.

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.

Risk treatment

Medium risk assessed for the target/retained species, sea snakes, and trophic interactions 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 Fisheries harvest strategies.

High risk assessed for brown tiger prawns requires a full performance report and regular monitoring by fisheries managers. Additional remedial action suggested by the participants for consideration included additional spatial closures (already implemented), long-term research to evaluate population dynamics and real-time monitoring of catch size distribution (electronic logbooks suggested). Adoption of these remedial actions was judged to reduce the consequences of fishing for this target species to moderate, with a likelihood of moderate consequences judged to be likely. This results in an acceptable treated risk level of medium over the assessment timeframe of five years.

Severe risk assessed for saucer scallop in the Northern Shark Bay area requires a Recovery Strategy and detailed monitoring. The northern Shark Bay area was closed to fishing in 2019. Additional remedial actions suggested by the participants for consideration included additional spatial closures (already implemented) and three monitoring surveys of scallop stocks each year. Adoption of these remedial actions was judged to reduce the consequences of fishing to moderate, with a likelihood of moderate consequences judged to be likely. This results in an acceptable treated risk level of medium over the assessment timeframe of five years.

For all medium risks, specific management and/or monitoring is required and is routinely implemented in these Fisheries. 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 Fisheries.

Risk management

Risk management of the Fisheries 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 SBPMF 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 Fisheries:

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.

Conclusion

The ERA undertaken on 11 September 2019 resulted in the outcomes documented in the 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 SMPMF and future certification of the SBSMF and SBCMF. Consensus was reached on the expert judgements of the Technical Panel in this qualitative ERA.

Except for the interaction of fishing with two of the target species, the threats assessed for fishing interactions with ecological assessment components in the ERA were ranked medium, low or negligible for the SBPMF, SBSMF and SBCMF using the adopted methodology. The SBPMF generally represents more intensive effort than SBSMF or SBCMF and tends to dominate the cumulative risk rankings when considering all invertebrate commercial fisheries operating in Shark Bay. Risk rankings of medium or less are considered acceptable risks for well-managed fisheries, subject to ongoing performance monitoring.

Risks to the sustainability of stocks of two target species were ranked high and severe: brown tiger prawns in the SBPMF, and saucer scallops in the northern Shark Bay area of the SBSMF, respectively. Corrective management actions both already adopted and proposed for the Fisheries are expected to reduce the residual risk ranking to an acceptable level of medium risk over the assessment timeframe of five years.

Ongoing performance monitoring of the Fisheries should confirm that these risks remain acceptably low. In the event that circumstances of the Fisheries 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 Fisheries Management (EBFM)—Risk assessment of the Shark Bay Invertebrate Fisheries*. Internal review, Department of Primary Industries and Regional Development, Western Australia.

Fletcher, W.J., J. Chesson, M Fisher, K.J. Sainsbury, T. Hundloe, A. Smith and B. Whitworth (2002). *National ESD reporting framework for Australian fisheries: The 'how to' guide for wild capture fisheries*. FRDC Project 2000/145, Canberra.

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

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

Attachment 1

Workshop Participants and Agenda

Ecological Risk Assessment
Shark Bay Invertebrate Fisheries

Workshop Participants
11 September 2019

Name	Company / Organisation	Position title / Area of expertise
Lynda Bellchambers	DPIRD OCD	Principal Sc EBFM
Nick Caputi	DPIRD FSRA	Supervising Scientist Invertebrates
Patrick Cavalli	DPIRD ARM	Principal Manager Trawl
Dean Clarke	DPIRD OCD	Supervising Fisheries Officer — Carnarvon
Geoff Diver	Sea Harvest	Manager — Policy and Environment
Scott Evans	DPIRD FSRA	Research Scientist EBFM/MSC
Emily Fisher	DPIRD FSRA	Research Scientist EBFM/MSC
Matt Fraser	UWA Oceans Institute	Postdoctoral Research Fellow — Benthic Habitats
Felicity Horn	EO SBPTOA	Executive Officer
Andrew Hosie	WA Museum	Curator, Crustacea
Mervi Kangas	DPIRD FSRA	Principal Scientist Invertebrate Trawl
Lisa Kirkendale (Attended by phone from 9:00am to 10:30am)	WA Museum	Head of Department and Curator, Molluscs
Natalie Moore	DPIRD ARM	Trawl Policy Management
Shane O'Donoghue	Crab Industry Consultant	Bayana Pty Ltd, 2 MFLs (Traps)
Matt Pember	WAFIC	Senior Resource Access Officer, Scientist and Fisheries Rep
Scott Ragza	Sea Harvest	General Manager

Name	Company / Organisation	Position title / Area of expertise
Phil Scott	Shark Bay World Heritage Advisory Committee	Community and Conservation
Brent Wise	DPIRD FSRA	
Richard Stoklosa	*e-systems*	Ecological Risk Assessment Facilitator

e-systems

Agenda

Date	Wednesday, 11 September 2019
Location	Meeting Room 3.34, Level 3 Department of Primary Industries and Regional Development — Fisheries Gordon Stephenson House 140 William Street Perth WA 6000 **NOTE: Please report to Reception on Level 2, accessed via Railway Lane, Murray St Mall**
Facilitator	Richard Stoklosa, E-Systems
Purpose	**Ecological Risk Assessment** **Shark Bay Invertebrate Fisheries — Prawn Trawl, Scallop Trawl and Crab Trap**

PLEASE ARRIVE BY 8:45am FOR COFFEE AND TEA

09:00	Welcome and introductions	Brent Wise / Richard Stoklosa
09:15	Adoption of workshop agenda and procedure	Richard Stoklosa
09:30	Introduction to fisheries and summary of current stock assessments	Mervi Kangas
09:45	Ecological risk assessment and cumulative risk	Group discussion
10:45	Morning tea	
11:00	Continue ecological risk assessment	Group discussion
13:00	Lunch break	
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
17:00	Adjourn	

Attachment 2

Ecological Risk Assessment Workshop Record

Shark Bay Invertebrate Fisheries 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	Western king prawns	Primary target species of SBPMF trawl.	Reduction in stock.	Weight-of-evidence stock assessment. Independent survey catch rates. Biomass dynamic modelling.	Moderate	Likely	Medium						
2	Brown tiger prawns	Primary target species of SBPMF trawl.	Reduction in stock. Possible that current spawning biomass is below B_{MSY}.	Monitoring of catch rates. Biomass dynamic modelling. Independent spawning survey catch rates. Grading of prawns to monitor size distribution Harvest strategy.	High	Possible	High	Addiitonal spatial closures to ensure breeding stock of brown tiger prawns is protected as well as monitoring of recruitment.	Commence long term research to evaluate population dynamics. Real time monitoring of catch size distribution (electronic logbooks).	Moderate	Likely	Medium	A response has been observed from long term monitoring from spatial closures, showing building of stock level.
3	Saucer scallops	Northern Shark Bay fishing grounds.	Spawning stock in Northern Shark Bay is below acceptable limits.	Northern Shark Bay area is currently CLOSED.	Major	Likely	Severe	Recovery strategy for Northern Shark Bay scallop stocks. Additional spatial closures in the northern area of Shark Bay.	Three monitoring surveys of scallop stocks each year.	Moderate	Likely	Medium	
		Denham Sound fishing grounds.			Moderate	Likely	Medium						
4	Blue swimmer crabs	Primary target species of SBCMF trap.	Reduction in stock.	Weight-of-evidence stock assessment.	Moderate	Likely	Medium						
5	Minor prawns	Secondary retained species of all fisheries.	Reduction in stock, mainly due to prawn trawl.	Monitoring of catch rates.	Moderate	Unlikely	Low						
		Prawn trawl.			Moderate	Unlikely	Low						Continue monitoring the ongoing harvest of mantis by the prawn trawl fishery.
		Scallop trawl (A Class only)			Moderate	Remote	Negligible						
		Crap trap.			Moderate	Remote	Negligible						
6	Cephalopods	Secondary retained species of all fisheries.	Reduction in stock, mainly due to prawn trawl.	Monitoring of catch rates. Nearshore waters closed to trawling.	Minor	Possible	Low						
		Prawn trawl.			Minor	Possible	Low						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						
7	Bugs	Secondary retained species of all fisheries.	Reduction in stock, mainly due to prawn trawl.	Monitoring of catch rates. Nearshore waters closed to trawling.	Minor	Possible	Low						
		Prawn trawl.			Minor	Possible	Low						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						
8	Minor crabs	Secondary retained species of all fisheries.	Reduction in stock, mainly due to crab trap.	Monitoring of catch rates.	Minor	Possible	Low						Opportunistic variability of secondary species when testing markets for marketability.
		Prawn trawl.			Minor	Remote	Negligible						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Possible	Low						
9	Whiting & flathead	Secondary retained species of all fisheries.	Reduction in stock, mainly due to prawn trawl.	Monitoring of catch rates. Nearshore waters closed to trawling.	Minor	Possible	Low						
		Prawn trawl.		Fishery size limit for flathead as well as processing size limit.	Minor	Possible	Low						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						
10	Other finfish species	Secondary retained species of all fisheries.	Reduction in stock (very low numbers captured and retained).	Monitoring of catch rates. Nearshore waters closed to trawling.	Minor	Remote	Negligible						Some finfish species (eg. sardines, flounders, black jewfish) are exposed to significant impacts to stocks if they were retained in large numbers.
		Prawn trawl.			Minor	Remote	Negligible						
		Scallop trawl.			Minor	Remote	Negligible						

Shark Bay Invertebrate Fisheries Ecological Risk Assessment

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		Crap trap.			Minor	Remote	Negligible						
Bycatch species													
11	Invertebrates	Capture and discarded to sea in SBPMF trawl, SBSMF trawl and SBCMF trap.	Typically returned alive.	Selective gear (mesh size, trap design). Hoppers on prawn trawl and Class B scallop trawl vessels. Spatial closures for all assessment components.	Minor	Remote	Negligible						Comparison of bycatch across two time periods show similar trend. More comparisons are planned. Expression of weight percent indication of abundance is a limitation in understanding of population impact.
		Prawn trawl.			Minor	Remote	Negligible						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						
12	Finfish	Capture and discarded to sea in SBPMF trawl, SBSMF trawl and SBCMF trap.	Reduction in stock, mainly due to prawn trawl. Trawl bycatch mortality is likely to be high.	Nearshore waters closed to trawling. Crab traps are selective and bycatch mostly returned alive.	Minor	Possible	Low						Bycatch in the scallop trawl fishery is less than that in the prawn trawl fishery, as a result of the larger mesh of nets and lower fishing effort.
		Prawn trawl.			Minor	Possible	Low						Lizardfish and goatfish represent approximately seven percent of catch by weight. The large scale lizardfish is the only individual species caught at rates above five percent of catch by weight.
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						
13	Sharks & rays	Capture and discarded to sea in SBPMF trawl, SBSMF trawl and SBCMF trap.	Reduction in stock (very low numbers of small animals captured and released).	Bycatch reduction devices on trawl gear. Crab traps are selective and bycatch mostly returned alive.	Minor	Remote	Negligible						
		Prawn trawl.			Minor	Remote	Negligible						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						
Endangered, threatened and protected (ETP) species													
14	Sawfish	Capture and returned to sea in SBPMF trawl, SBSMF trawl and SBCMF trap.	Capture mainly in prawn trawl gear (very low numbers). Post-release survival is likely to be low.	Statutory reporting of all ETP species. National sawfish recovery strategy, mainly concerned with other regions of Australia.	Minor	Possible	Low						No reported interactions in the scallop trawl or crab trap fisheries.
		Prawn trawl.			Minor	Possible	Low						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						
15	Sea snakes	Capture and returned to sea in SBPMF trawl, SBSMF trawl and SBCMF trap.	Regularly captured in prawn trawl gear but returned alive (mortality <15%). Risk is judged on the leaf scaled sea snake (most vulnerable of the ETP species in this group). Other species are regarded as lower consequence ranking.	Hoppers on prawn trawl and Class B scallop trawl vessels. Crews trained in sea snake handling and identification when being returned to sea (last three years).	Moderate	Likely	Medium						Low capture rates in the scallop trawl fishery. No reported interactions in the crab trap fishery. Conservation status of some species is under review with prospect of downgrading the conservation status (add citation reference).
		Prawn trawl.			Moderate	Likely	Medium						Highly scrunitised for Marine Stewardship Council assessment of the fishery for certification.
		Scallop trawl.	Larger mesh size, smaller nets and smaller fleet with smaller effort than prawn trawl.		Moderate	Unlikely	Low						Some uncertainty in reporting in the small scallop trawl fleet.
		Crap trap.			Minor	Remote	Negligible						
16	Turtles	Capture and returned to sea in SBPMF trawl, SBSMF trawl and SBCMF trap.	Low numbers mostly captured in prawn and scallop try gear, but almost all returned alive. Public concern.		Moderate	Unlikely	Low						The risk score of low is the result of the consideration of potential public concern rather than ecological consequences. A reduction in the sightings of green turtles was noted after marine heat wave in 2011.

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					Consequences	Likelihood	Risk ranking			Consequences	Likelihood	Risk ranking	
		Prawn trawl.	Low numbers mostly captured in prawn and scallop try gear, but almost all returned alive. Public concern.	BRDs. Short trawl duration of exploratory net shots.	Moderate	Unlikely	Low						The risk score of low is the result of the consideration of potential public concern rather than ecological consequences (insert citation reference).
		Scallop trawl.	Low numbers mostly captured in prawn and scallop try gear, but almost all returned alive.	BRDs. Short trawl duration of exploratory net shots.	Minor	Unlikely	Negligible						Low capture rates in the scallop trawl fishery.
		Crap trap.	Entanglement in ropes and mortality.		Minor	Remote	Negligible						No reported interactions in the crab trap fishery.
17	Cetaceans & dugongs	Capture and returned to sea in SBPMF trawl, SBSMF trawl and SBCMF trap.	Potential injury or mortality to dolphins and/or dugongs.		Minor	Remote	Negligible						No reported interactions with dugongs to date.
		Prawn trawl.	Capture in trawl nets--direct capture or entanglement.	Low trawl speed, noise and low-opening otter boards.	Minor	Remote	Negligible						Direct capture of dolphins has not been recorded to date.
		Scallop trawl.	Capture in trawl nets.	Low trawl speed, noise and low-opening otter boards.	Minor	Remote	Negligible						
		Crap trap.	Entanglement in ropes and mortality.		Minor	Remote	Negligible						No reported interactions in the crab trap fishery.
18	Cetaceans & dugongs	Vessel strikes with dugongs and cetaceans.	Potential injury or mortality.	Spatial separation of dugong feeding areas in seagrass habitats.	Minor	Remote	Negligible						No reported strikes reported to date from slow moving fishing vessels.
		Prawn trawl.		Low trawl speed, noise.	Minor	Remote	Negligible						
		Scallop trawl.		Low trawl speed, noise.	Minor	Remote	Negligible						
		Crap trap.	Entanglement in ropes.		Minor	Remote	Negligible						No reported interactions in the crab trap fishery.
19	Syngnathids	Capture and returned to sea in SBPMF trawl, SBSMF trawl and SBCMF trap.	Capture in trawl nets and crab traps.		Minor	Possible	Low						
		Prawn trawl.	Frequently reported capture but majority returned alive.	Distribution is primarily segregated from trawl grounds (eg seagrass beds).	Minor	Possible	Low						
		Scallop trawl.	Potential for capture.		Minor	Possible	Low						No reported capture in scallop trawl fishery.
		Crap trap.	Potential for capture.		Minor	Possible	Low						No reported capture in crap trap fishery.
Habitats													
20	Sand & mud	Interaction of trawl gear with benthic habitat in SBPMF trawl, SBSMF trawl and SBCMF trap.	Damage and loss of habitat sustaining associated benthos.		Moderate	Unlikely	Low	Further research is planned to study habitat dynamics in Shark Bay. FRDC project to study habitats in closed nursery areas of Shark Bay.					Risk based on large trawl footprint of fisheries. Uncertainty due to dated habitat mapping with limited information.
		Prawn trawl, predominantly on sand and silt.	Large trawl footprint over sand habitat is fished less intensely than localised areas (eg CPL line during part of the fishing season).		Moderate	Unlikely	Low						Sand habitats are resilient to trawling interaction (citation reference needed). Question of intensive trawling on the CPL resulting in localised loss of sand habitat to harder substrate. Size of fishery has a large proportion of closures. Entire SBPMF extends well beyond Shark Bay for MSC assessment purposes (trawl footprint covers only 9% of the entire fishery area).
		Prawn trawl, predominantly on sand and silt.	Trawl footprint covers 19% of the Shark Bay portion of the fishery, and the area on the Carnarvon Perron Line has loss of sand habitat from intensive effort.		Minor	Likely	Low						
		Scallop trawl, predominantly on sand and silt.	Less intensive fishing effort than prawn trawl.		Minor	Possible	Low						The footprint is smaller than prawn trawl with less fishing effort compared to prawn trawl.
		Crap trap setting and retrieval.			Minor	Remote	Negligible						

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					Consequences	Likelihood	Risk ranking			Consequences	Likelihood	Risk ranking	
21	Seagrasses	Interaction of trawl gear with benthic habitat in SBPMF trawl, SBSMF trawl and SBCMF trap.	Damage and loss of habitat sustaining associated benthos.		Minor	Likely	Low						
		Prawn trawl.	Incidental damage to seagrass habitats.	Only 8% of seagrass habitats are targeted by trawl gear (1996 data). Large areas of seagrass habitats are located in areas closed to fishing.	Minor	Unlikely	Negligible						There is potential public concern over the loss of any part of the seagrass habitat in Shark Bay. Uncertainty around genetic diversity of seagrass meadows in Shark Bay and how that impacts the resilience of habitat. The impacts of the marine heat wave, for example, resulted in a loss of 30% of the seagrass habitat, far outweighing the impacts of fishing.
		Scallop trawl.	Incidental damage to seagrass habitats.		Minor	Unlikely	Negligible						Scallop trawl does not generally encroach on seagrass habitats.
		Crap trap setting and retrieval.	Removal of seagrass during hauling of traps.		Minor	Likely	Low						Traps are often set on seagrass locations based on current habitat information (generic knowledge of distribution).
22	Macroalgae	Interaction of trawl gear with benthic habitat in SBPMF trawl, SBSMF trawl and SBCMF trap.	Damage and loss of habitat sustaining associated benthos.		Minor	Unlikely	Negligible						Very limited mapping of macroalgae distribution in Shark Bay.
		Prawn trawl.			Minor	Unlikely	Negligible						
		Scallop trawl.			Minor	Unlikely	Negligible						
		Crap trap setting and retrieval.	Removal of macroalgae during hauling of traps.		Minor	Unlikely	Negligible						
23	Filter feeding communities	Interaction of trawl gear with benthic habitat in SBPMF trawl, SBSMF trawl and SBCMF trap.	Damage and loss of habitat sustaining associated benthos.		Minor	Possible	Low						Uncertainty due to dated habitat mapping with limited information.
		Prawn trawl.			Minor	Possible	Low						
		Scallop trawl.			Minor	Unlikely	Negligible						
		Crap trap setting and retrieval.			Minor	Remote	Negligible						
24	Coral reefs	Interaction of trawl gear with benthic habitat in SBPMF trawl, SBSMF trawl and SBCMF trap.	Damage and loss of habitat sustaining associated benthos.		Minor	Remote	Negligible						Lack of overlap between fishery footprints and coral distribution.
		Prawn trawl.			Minor	Remote	Negligible						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap setting and retrieval.			Minor	Remote	Negligible						
Ecosystem structure													
25	Trophic interactions — Removal of retained species	Removal of biomass in SBPMF trawl, SBSMF trawl and SBCMF trap.	Reduction of prey that predators rely on as food source.		Moderate	Unlikely	Low						
		Prawn trawl, removing 1,200 to 1,500 tonnes of prawns during fishing season.	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 is closed to trawling. Regulation of target species is designed to prevent collapse of stocks.	Moderate	Unlikely	Low		Conduct ecosystem modelling (funds currently being sought by DPIRD).				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). Mitigation of brown tiger prawn and scallop stock risk in Shark Bay is considered likely to reduce risk to those target species to acceptable recovery levels.
		Scallop trawl.		Significant portion of nearshore waters is closed to trawling.	Moderate	Unlikely	Low						Naturally high recruitment variability of scallops leads to few predators being dependent on them as a food source.
		Crap trap.		Relatively small commercial take of biomass.	Moderate	Unlikely	Low						

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26	Trophic interactions — Discarding & provisioning	Discard of bycatch biomass in SBPMF trawl, SBSMF trawl and SBCMF trap.	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.	Moderate	Possible	Medium		Conduct ecosystem modelling (funds currently being sought by DPIRD).				Fishing effort is seasonal and subject to closures (spatial and full moon). Interaction of discarding and provisioning over the long term probably represents a steady-state in ecosystem structure and function.
		Prawn trawl.		Invertebrate bycatch likely to be returned alive with the use of hoppers on vessels.	Moderate	Possible	Medium						
		Scallop trawl.		Invertebrate bycatch likely to be returned alive with the use of hoppers on Class B vessels.	Moderate	Unlikely	Low						
		Crap trap.		Traps are highly selective and bycatch is likely to be returned alive.	Minor	Remote	Negligible						
27	Translocation (pests & disease)	Translocation of pests and diseases in SBPMF trawl, SBSMF trawl and SBCMF trap.	Introduction of marine pests or diseases to Shark Bay from port visits (Carnarvon to Fremantle and Geraldton), with the potential to alter ecosystem structure.	Slipping and cleaning of vessels in port. Port monitoring for introduced species in Fremantle, Port Hedland and Geraldton.	Minor	Remote	Negligible						Salt works in Shark Bay is another source of translocation by foreign vessels.
		Prawn trawl.			Minor	Remote	Negligible						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						
28	Ghost fishing	Loss of trawl and trap gear at sea in SBPMF trawl, SBSMF trawl and SBCMF trap.	Mortality of marine animals indiscriminately caught in lost nets and traps.	The high cost of trawl and trap gear incentivises fishers to retrieve it without any major losses (fisherman use a grapple to recover expensive trawl gear).	Minor	Remote	Negligible						
		Prawn trawl.			Minor	Remote	Negligible						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.	Strong currents have potential to move traps with potential loss.		Minor	Remote	Negligible						
Broader environment													
29	Air quality — Fuel exhaust	SBPMF trawl, SBSMF trawl and SBCMF trap.	Air pollution affecting air-breathing marine mammals and humans	Small number of vessels allowed to operate in the fishery.	Minor	Remote	Negligible						High wind speed disperses emissions.
		Prawn trawl.			Minor	Remote	Negligible						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						
30	Air quality — Greenhouse gas emissions	SBPMF trawl, SBSMF trawl and SBCMF trap.	Contribution to global warming.	Small number of vessels allowed to operate in the fishery.	Minor	Remote	Negligible						
		Prawn trawl.			Minor	Remote	Negligible						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						

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31	Water quality — Debris / litter	SBPMF trawl, SBSMF trawl and SBCMF trap.	Discarding of waste and bait from crab traps at sea, adversely impacting water quality. Galley waste discarded at sea.	Waste stored on board vessels.	Minor	Unlikely	Negligible						
		Prawn trawl.			Minor	Unlikely	Negligible						
		Scallop trawl.			Minor	Unlikely	Negligible						
		Crap trap.	Bait.		Minor	Unlikely	Negligible						
32	Water quality — Oil / fuel discharge	SBPMF trawl, SBSMF trawl and SBCMF trap.	Accidental oil or fuel spill at sea.	Small number of vessels allowed to operate in the fishery. Most vessels have inboard four stroke diesel engines and oil discharge is minimal. No fuel bunkering (transfer) at sea.	Minor	Remote	Negligible						
		Prawn trawl.			Minor	Remote	Negligible						
		Scallop trawl.			Minor	Remote	Negligible						
		Crap trap.			Minor	Remote	Negligible						
33	Water quality — Turbidity	SBPMF trawl, SBSMF trawl and SBCMF trap.			Minor	Possible	Low						Strong currents in Shark Bay dominate water flow and dispersion of sediments—the changes in turbidity from trawling are unlikely to be measurable. The major source of turbidity in Shark Bay is from river outflows following cyclonic rain events.
		Prawn trawl.	Disturbance of sediments likely from trawling. Short lived phenomenon.		Minor	Possible	Low						
		Scallop trawl.	Disturbance of sediments likely from trawling. Short lived phenomenon.		Minor	Unlikely	Negligible						
		Crap trap.	Limited disturbance of sediments from setting and retrieving traps.		Minor	Remote	Negligible						