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No. 2, 2015

Shark Bay Prawn Managed Fishery

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Fish for the future

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Overview

This report provides a comprehensive description of the Shark Bay Prawn Managed Fishery (SBPMF) and contains information relevant to assist the assessment of this fishery against the Marine Stewardship Council (MSC) standard (v1.3) for sustainable fishing. The SBPMF is located in Shark Bay, Western Australia and uses demersal otter trawl gear to predominantly target brown tiger prawns (*Penaeus esculentus*) and western king prawns (*Penaeus latisulcatus*).

The first part of this report (Sections 1 – 5) provides an overview of the SBPMF and the aquatic environment in which it operates, including information on the development of the fishery, fishing methods and gear used, the management system in place, an overview of the biology of the target species and external factors that may influence fishery operations and / or target species populations. The remainder of document provides more-detailed information for assessing the fishery against the performance indicators under MSC Principles 1, 2 and 3.

MSC Principle 1 (Sections 6 – 8) provides information to assess the condition of the target species' stocks. These sections provide information on the current stock status of brown tiger and western king prawns in Shark Bay and includes a detailed description of the stock assessment approaches and a summary of the harvest strategy employed for ensuring the sustainability of these stocks.

MSC Principle 2 (Sections 9 – 14) relates to the impact of the fishery on the marine environment in which it operates. These sections include, or point to, all currently-available information on the catch of retained non-target species, bycatch, interactions with endangered, threatened or protected (ETP) species, as well as a detailed description of the habitats and ecosystem within Shark Bay and all fishery-related impacts on habitat and ecosystem structure and function. Where detailed quantitative data are not available, a risk assessment approach has been used to assess the level of risk associated with any identified fishery-specific issues. The issues identified and their associated risk ratings are provided throughout the Principle 2 sections, where relevant.

MSC Principle 3 (Sections 15 – 16) provides information to assess the governance and management in place for the fishery. Governance information provided includes an overview of the local, national and international legal frameworks relevant to the management of the fishery, a description of the roles, responsibilities and consultation processes undertaken with fishery stakeholders, the long-term objectives and the incentives in place for sustainable fishing. These sections also include information on the fishery-specific management system, including fishery-specific objectives, the decision-making process, compliance and enforcement, ongoing research and an evaluation of the performance of this management system in recent years.

Although this document has been divided into MSC Principle-specific sections, it should be considered in its entirety as many sections provide supporting and complementary information. While this document is intended to provide a comprehensive account of the fishery, it is by no means meant to be the only source of information for assessing the fishery. If there is uncertainty regarding any parts of the descriptions and information herein, stakeholders should contact the Department so that any such issues can be addressed in subsequent updates of this document. This document should also be read in conjunction with the *SBPMF Harvest Strategy 2014 – 2019* and the *SBPMF Bycatch Action Plan 2014 – 2019*.

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Acronyms and Abbreviations

ALC	Automatic Location Communicator
AMM	Annual Management Meeting
AFMA	Australian Fisheries Management Authority
ARMA	Aquatic Resources Management Act
BAP	Bycatch Action Plan
BRD	Bycatch Reduction Devices
CALM	Conservation and Land Management
CAMBA	China-Australia Migratory Bird Agreement
CITES	Convention on International Trade in Endangered Species
CoA	Commonwealth of Australia
COAG	Council of Australian Governments
CPL	Carnarvon-Peron Line
CL	Carapace Length
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSMPA	Composite Square Mesh Panels (Aft)
CSMPF	Composite Square Mesh Panels (Forward)
CSWA	Circular, Straight-Vertical-Bars, Wide-Bar-Spacing, and Accelerator
CW	Carapace Width
DEC	Department of Environment and Conservation (Western Australia)
DoF	Department of Fisheries (Western Australia)
DotE	(Commonwealth) Department of the Environment
DPaW	Department of Parks and Wildlife (Western Australia)
EBFM	Ecosystem Based Fisheries Management
EEZ	Exclusive Economic Zone
ENA	Extended Nursery Area
ENSO	El Niño/La Niña Southern Oscillation
EOI	Expression of Interest
EPBC	Environment Protection and Biodiversity Conservation (Act)

ESD	Ecologically Sustainable Development
ETP	Endangered, Threatened and Protected
FAS	Fisheries Adjustment Scheme (Act)
FED	Fish Exclusion Devices
FHPA	Fish Habitat Protection Areas
FMO	Fisheries and Marine Officer
FRDC	Fisheries Research and Development Corporation
FRMA	Fish Resources Management Act
FRMR	Fish Resources Management Regulations
GDSF	Gascoyne Demersal Scalefish Fishery
GDC	Gascoyne Development Commission
GIS	Geographical Information Systems
GVP	Gross Value of Production
ICU	Industry Consultation Unit
IFAAC	Independent Allocation Advisory Comittee
IFM	Integrated Fisheries Management
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMS	Introduced Marine Species
IOD	Indian Ocean Dipole
ITQ	Individual Transferable Quota
JAMBA	Japan-Australia Migratory Bird Agreement
KPI	Key Performance Indicator
LOW	Letters of Warning
LENS	List of Exempt Native Species
MAC	Management Advisory Committee
MDS	Multi-dimensional Scaling
MFL	Managed Fishery Licence
MSC	Marine Stewardship Council
OCP	Operational Compliance Plan

OCS	Offshore Constitutional Settlement
NPF	Northern Prawn Fishery
NTA	Native Title Act
PSA	Productivity-Susceptibility Analysis
PSM	Public Sector Management Act
RMAD	Research, Monitoring, Assessment and Development (Plan)
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RRAMF	Risk Ranked Assessment for Multiple Fisheries
RSNA	Rectangular, Straight-Vertical-Bars, Narrow-Bar-Spacing and Accelerator
SAT	State Administrative Tribunal
SBBSMNMF	Shark Bay Beach Seine Mesh Net Managed Fishery
SBCIMF	Shark Bay Crab Interim Managed Fishery
SBPMF	Shark Bay Prawn Managed Fishery
SBPTOA	Shark Bay Prawn Trawler Operators' Association
SBSMF	Shark Bay Scallop Managed Fishery
SKM	Sinclair Knight Merz
SLA	Service Level Agreement
SRE	Short Recovery Experimental (site)
SRR	Stock-Recruitment Relationship
TACC	Total Allowable Commercial Catch
TPSA	Tiger Prawn Spawning Area
UoC	Unit of Certification
UWA	University of Western Australia
VFAS	Voluntary Fisheries Adjustment Scheme
VMS	Vessel Monitoring System
WAFIC	WA Fishing Industry Council
WAMSI	Western Australian Marine Science Institution
WC	Wildlife Conservation (Act)

1. Aquatic Environment

The Shark Bay Prawn Managed Fishery (SBPMF) operates in the waters of Shark Bay, a major tropical embayment within the Gascoyne Coast Bioregion of Western Australia (WA) (Figure 1.1). The Gascoyne Coast Bioregion represents a transition between the fully tropical waters of the northern coast and the temperate waters of the southwest region. The waters off the Gascoyne Coast are strongly influenced by the southward-flowing Leeuwin Current, generated by flow from the equatorial Pacific south through the Indonesian archipelago. This tropical current becomes evident in the North West Cape area around Exmouth Gulf and flows south along the continental shelf (Fletcher & Santoro 2013).

Shark Bay is Australia's largest enclosed marine embayment (approx. 13 000 km^2) and stretches approximately 250 km from the northern point of Bernier Island to the southern end of Freycinet Harbour. The Bay is enclosed in the north by Bernier, Dorre and Dirk Hartog Islands, which restrict water exchange between the bay and the open ocean (Burling et al. 1999; Nahas et al. 2005). Its unusual geomorphology has produced a diverse range of marine communities, including corals, seagrasses, mangroves and hypersaline communities. Shark Bay is an area of high biodiversity, with over 320 fish species (Hutchins 1990) and 218 species of bivalves recorded (Slack-Smith 1990). Shark Bay is also an important habitat for large and small cetaceans and supports large dugong and turtle populations. Other endangered, threatened or protected (ETP) species that utilise the bay include sea snakes, seahorses and pipefish, sharks and seabirds.

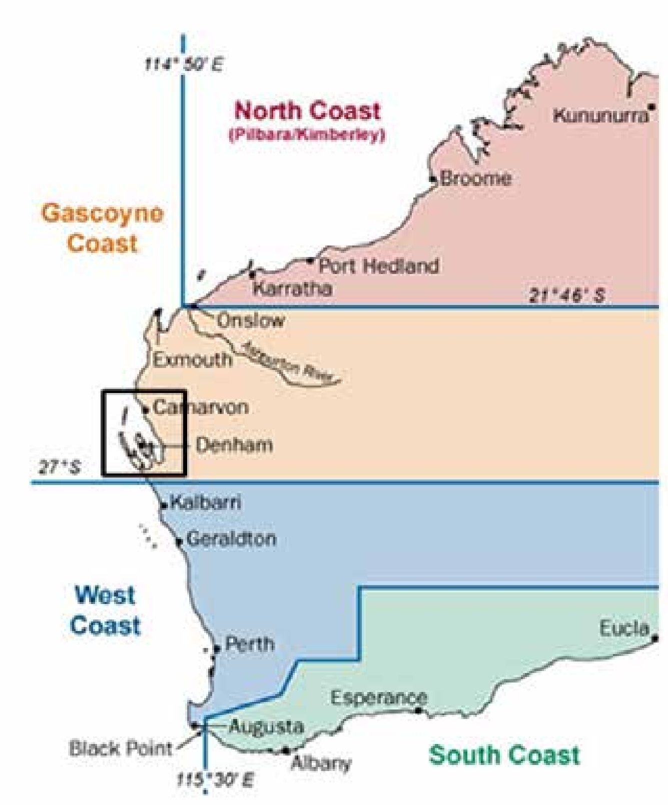

Figure 1.1. Locality of Shark Bay (black box) within the Gascoyne Coast Bioregion of Western Australia

In 1991, Shark Bay was inscribed on the World Heritage list on the basis of its 'natural heritage values', particularly its vast seagrass beds, its dugong population and its stromatolites (McCluskey 2008).

Shark Bay is generally shallow, with an average depth of nine metres and a maximum depth of 29 m. The southern half of the bay is divided by the Peron Peninsula into eastern and western gulfs. The bay is partly cut off from the Indian Ocean, with the influx of oceanic water limited to the northern Geographe Channel, the Naturaliste Channel and South Passage (Nahas et al. 2005).

Tides in the Bay are mixed diurnal with a mean tidal range of 0.6 m on a neap tide to a high of 1.7 m on a spring tide at Carnarvon and 1.2 m at Denham. Southerly winds generate substantial seas that mainly affect the southeast or southwest facing coats. Wave size is limited, however, by the relatively short fetch across the Bay. Sediments on the sublittoral platforms are frequently mixed by wave action, but sediments in the deeper embayment plain are rarely disturbed under average conditions (Logan & Cebulski 1970). The pattern of water circulation in the Bay is complex, due to the imbalance of flood and ebb tides, plus restrictions on water movement due to physical barriers of shallow banks and different salinities (Morrison et al. 2003).

Shark Bay receives very little freshwater input and is subject to high evaporation rates, resulting in steep environmental gradients based on salinity and water temperature (Logan & Cebulski 1970; Nahas et al. 2005). Major salinoclines in the bay have been divided into three categories: oceanic (36 – 40 ‰) in the northern embayment, metahaline (40 – 56 ‰) in Hopeless Reach, Denham Sound and Freycinet Basin and hypersaline (56 – 70 ‰) in Hamelin Pool, L'hardion Bight and small pockets at the southern ends of the Edel Land inlets (Logan & Cebulski 1970; Figure 1.2). The spacing of these salinoclines throughout the bay is irregular and is affected by shallow shoals and water movements, the latter changing seasonally. The steep environmental gradients have produced genetic variability among populations of marine species, and the bay is considered a focal point for genetic divergence (Johnson & Black 1990; Department of Conservation and Land Management [CALM] 1996).

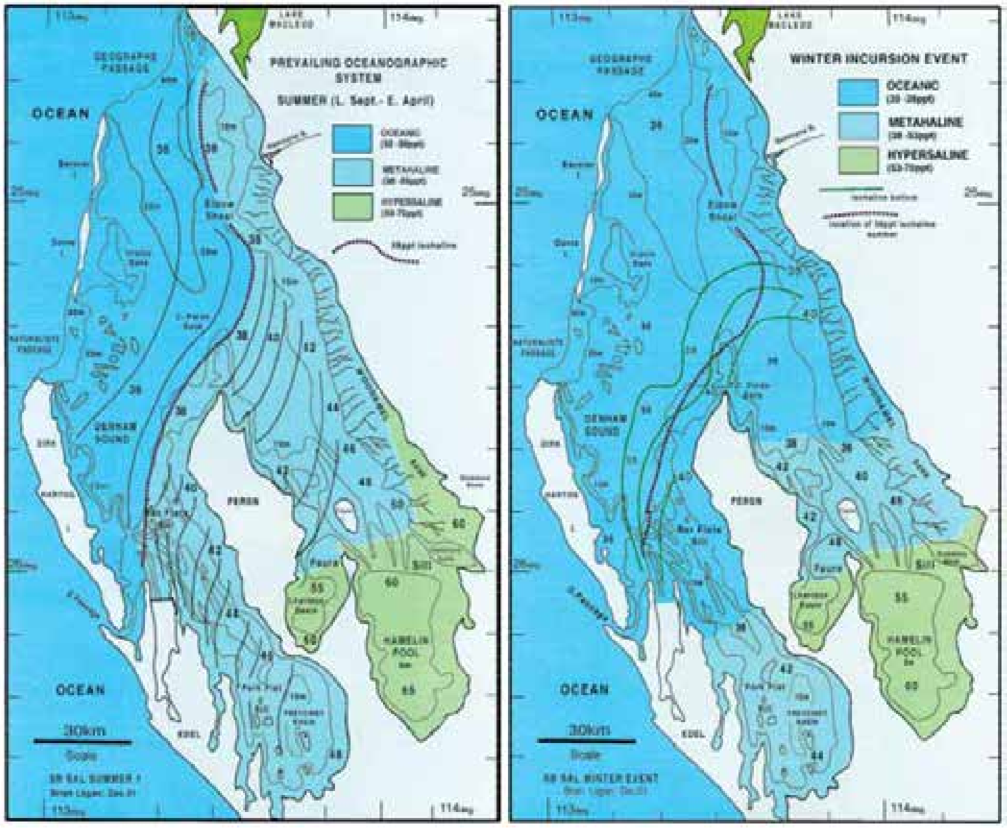

Figure 1.2. Salinity profiles of Shark Bay during (a) summer and (b) winter (Source: Logan & Cebulski 1970).

2. Target Species / Stock Description

2.1 Brown Tiger Prawn

Figure 2.1. The brown tiger prawn. Illustration © R. Swainston (www.anima.net.au).

2.1.1 Taxonomy and Distribution

The brown tiger prawn (*Penaeus esculentus*) is a decapod crustacean of the family Penaeidae. The species is easily identified by its pattern of distinctive pale brown and darker bands (Figure 2.1).

Brown tiger prawns are generally regarded as endemic to Australian and are distributed around the northern coast, from central New South Wales in the east to Shark Bay in WA (Ward et al. 2006; Figure 2.2). 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.

Figure 2.2. Distribution of brown tiger prawns in Australia.

2.1.2 Stock Structure

A number of genetic studies have explored the stock structure of brown tiger prawns in Australia. Mulley and Latter (1981) first examined four polymorphic allozyme loci in populations of this species from Exmouth Gulf in WA, the Gulf of Carpentaria, and northern and southern Queensland, finding no differences in gene frequency between these regions. In contrast to these findings, which have since been considered not to be statistically robust (Ward et al. 2006), Lavery and Keenan (1995) revealed significant spatial heterogeneity in a mitochondrial region of brown tiger prawns from Shark Bay in WA and the east coast of Queensland.

More recently, Ward et al. (2006) analysed eight polymorphic microsatellite loci of brown tiger prawns and demonstrated a small differentiation between the functionally independent populations of this species in Shark Bay and Exmouth Gulf, and a larger differentiation of these stocks from those in the Gulf of Carpentaria and Moreton Bay in Queensland.

The independent management and monitoring of brown tiger prawn fisheries in WA is a conservative management approach that ensures that there is no serial depletion of prawns in different fishing areas. If there is a sustainability issue with this species in any area, management actions will be taken to maintain spawning stocks in each area.

2.1.3 Life History

Although tiger prawns can live for 2 – 3 years, individuals older than two years of age are rarely caught under current harvest practices. Brown tiger prawns mature at six to seven months of age, at which time they undertake a migration into more offshore waters to spawn (Penn & Stalker 1979; Penn & Caputi 1986). Approximately one month after mating (see below), female prawns will release the fertilised eggs, which float and typically hatch within 24 hours (Dall et al. 1990).

Penaeid prawns have a comparable larval development (see Figure 2.3), hatching from the egg as freely-swimming nauplii. During the nauplii stages the larvae do not feed but utilise stored food from the egg, completing a series of six moults before developing to the next larval stage (Penn & Stalker 1979). As the larval development continues through the protozoea, mysis and postlarvae stages, predators are responsible for high mortality rates of the larvae. If by this time the larvae have drifted to a suitable nursery area, they will settle, as postlarvae, on beds of seagrass and algae two to four weeks after eggs are released from the females (Dall et al. 1990; Haywood et al. 1995; Liu & Loneragan 1997). If settlement occurs in unsuitable habitats, they are likely to perish (Penn & Stalker 1979).

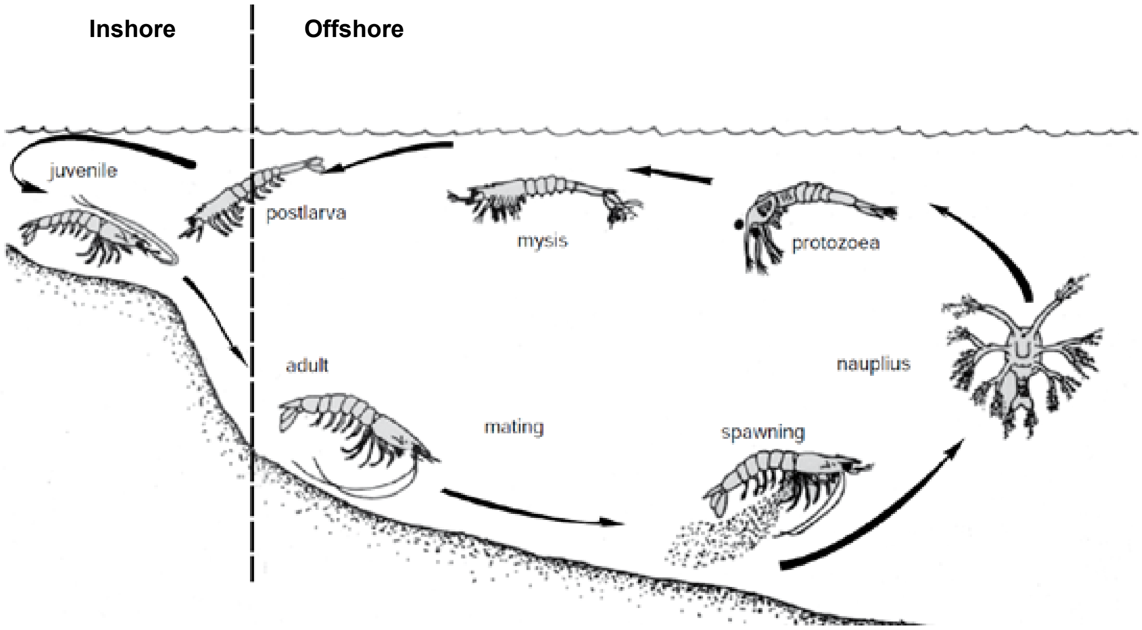

Figure 2.3. Life cycle of a penaeid prawn (modified from NSW Department of Industry and Investment 2010).

2.1.3.1 Movements and Important Habitats

Penaeid prawns need to move between different habitats to complete their lifecycle. Dall et al. (1990) describes these migrations as a larval and postlarval migration from the spawning ground to the nursery ground; a juvenile migration out of the nursery area; and an adult migration to deeper offshore water to spawn (Figure 2.3).

Juvenile brown tiger prawns occupy shallow waters with seagrass and algal communities, which form the main juvenile habitat for this species (Kenyon et al. 1995, 1997). Despite a strong association of this species with structured habitats, however, tiger prawn larvae do not discriminate between different types of seagrass when they settle (Loneragan et al. 1998). In Shark Bay, a main migration of juvenile prawns into deeper, more offshore waters occurs during late summer and autumn of each year, after approximately three to six months spent in the nursery areas (Penn & Stalker 1979). This migration can commence in February and extends to May (Penn & Caputi 1986). Prawns move by either walking or swimming, however, the speeds recorded during migration are unlikely to be achieved by walking (Dall et al. 1990).

As pre-adults, brown tiger prawns migrate out of the nursery areas into deeper waters to spawn. Adult brown tiger prawns are generally found over mud or sandy mud substrates in coastal waters less than 30 m depth, however, have been recorded as deep as 200 m (Grey et al. 1983). Most spawning females are found in water 13 – 20 m deep (Penn 1988; Penn et al. 1995).

Active vertical migration during the pelagic larval stage, in combination with water currents, is the most probable method transporting postlarvae to the inshore nursery areas (Penn 1975; Dall et al. 1990).

2.1.3.2 Reproduction

Brown tiger prawns first reach maturity at a size of 25 mm carapace length (CL), with 50 % of the population mature at 32 mm CL (Crocos 1987).

When prawns mate, the male needs to be hard-shelled and the female soft-shelled (i.e. newly moulted; Dall et al. 1990). The male inserts into the female reproductive organ (thelycum) a sperm capsule (spermatophore), which remains there until the female is ready to spawn her eggs. Eggs are released into the water before the female moults again, which is typically after approximately one month (Penn & Stalker 1979; Crocos & Kerr 1986). Spawning occurs at night with the eggs released from the female through small pores at the base of the third walking legs (Walker 1975).

Spawning female brown tiger prawns are found in WA between July and the end of summer. In Exmouth Gulf the main spawning season is between August and October (White 1975; Penn & Caputi 1986). North-eastern Shark Bay is a main spawning area for brown tiger prawns (Figure 3.1).

2.1.3.3 Size-Fecundity Relationships

The relationship between the fecundity (F) and carapace length (CL, mm) of brown tiger prawns can be described as:

$F = 22573 \times CL - 536291$ ($n = 131$) (Crocos 1987).

According to this relationship, mean fecundity in this species varies from around 96 000 to 615 000 for females between 32 mm and 51 mm CL (Crocos 1987). As retained ripe ova were rarely observed in spent ovaries, these values are considered to represent the numbers of eggs released at a single spawning. Females are capable to spawning more than once during a spawning season.

2.1.3.4 Factors Affecting Recruitment of Juveniles

Environmental factors such as rainfall, temperature and salinity have been identified as major causes of variation in penaeid recruitment (Garcia & Le Reste 1981; Jackson & Burford 2003). The recruitment of brown tiger prawns is negatively correlated with salinity and positively correlated with temperature (Penn & Caputi 1986; Courtney et al. 1995; Penn et al. 1995). Although juvenile tiger prawns can withstand a range of temperatures and salinities, exposure to extreme temperatures (15 and 35 ° C) and salinities (5 ‰ and 55 ‰) results in high mortality rates (O'Brien 1994). In Exmouth Gulf, cyclones can have both a negative and positive effect on recruitment of prawns, depending on the timing, location and severity of the cyclone (Penn & Caputi 1986).

2.1.3.5 Weight-Length Relationships

The relationships between the wet weight (*W*, g) and carapace length (*CL*, mm) of female and male brown tiger prawns in WA are described as:

Females: $W = 0.003739 \times CL^{2.5739}$

Males: $W = 0.002078 \times CL^{2.7645}$ (Penn & Hall 1974).

2.1.3.6 Age and Growth

Prawns have to moult (i.e. shed their external shell) in order to grow. Crustacean growth is a stepwise process and moult frequency depends on the sex and size of the individual, as well as the environmental factors such as food quality and quantity, population density, light, temperature and salinity (Dall et al. 1990). The size attained by crustaceans at any age is determined by the number of moults and the increase in size at each moult (Dall et al. 1990).

Small prawns moult frequently (daily to weekly), while adults moult around every month to two months (Kangas 1999). This often coincides with the lunar cycle, with a higher proportion of recently moulted prawns generally found during the full moon period. As newly moulted individuals are much more vulnerable to predation, they often remain buried in the sediment for a few days until the exoskeleton hardens and they re-emerge at night to feed.

Due to the lack of hard parts, ageing of crustaceans cannot be undertaken by traditional age determination methods (Garcia & Le Reste 1981) and is instead typically done using modal analysis of size frequencies or tagging studies. The growth of female and male brown tiger prawns in Exmouth Gulf has been described by fitting a von Bertalanffy growth curve to a large sample of monthly length-frequency data for each sex collected from fishery-independent surveys between 1992 and 1996 (Harris 2000). A birth date of 15 September was assumed, based on this being the middle of the spawning period for this species (August to October). The resulting estimates of the von Bertalanffy growth parameters are: L_∞ = 32.7 mm CL for males and 40.4 mm CL for females, k = 2.9 year^{-1} for males and 2.5 year^{-1} for females, and t_0 = -0.03 years for males and 0.06 years for females (Harris 2000).

The longevity of brown tiger prawns is generally 2 – 3 years (Penn 1988). As indicated by the very high value of *k*, individuals of this species grow very rapidly early in life, which means that they attain an economically valuable size at about eight months of age. Fishing thus concentrates on the 0+ and, to a less extent, 1+ (residual) individuals.

2.1.3.7 Diet

Prawns feed primarily at night and their diet includes small molluscs, crustaceans and polychaete worms (Dall et al. 1990). The diet of juveniles includes copepods, decapods, ostracods, gastropods, diatoms, filamentous algae and small protozoa diatoms, algae, and seagrass (O'Brien 1994).

2.1.3.8 Natural Mortality

Several values for natural mortality (*M*) of brown tiger prawns have been described in the published literature. In tiger prawn models for Australia's Northern Prawn Fishery, Wang and Die (1996) estimated *M* as 0.045 week^{-1}, while Somers and Wang (1997) assumed *M* to be 0.18 month^{-1} and considered values ranging from 0.12 to 0.26 month^{-1} when assessing the sensitivity of their model.

After reviewing estimates reported in the literature, Garcia (1985) recorded that the reported level of *M* for adults of *Penaeus* species was around 0.2 month^{-1}. This latter value was applied by Hall and Watson (1999) for brown tiger prawns in Shark Bay.

2.1.3.9 Parasites and Diseases

Bopyrid isopods and one species of copepod are the only crustaceans known to parasitise penaeids, including brown tiger prawns and western king prawns (Owens & Glazebrook 1985; Dall et al. 1990; Roberts et al. 2010). The parasites occupy the gill chamber of prawns and cause a conspicuous bulge of the branchiostegite (Dall et al. 1990). Female bopyrids have piercing mandibles which allow them to ingest the fluids of the host (Dall et al. 1990). Infection may cause the host to become sterile and take on the secondary characteristics of the opposite sex (Dall et al. 1990). It also affects the growth of infected prawns (Dall et al. 1990). Several types of virus have been reported to infect penaeid prawns in aquaculture farms (e.g. DoF 2009; Department of Agriculture 2013); however, testing of wild prawns in WA has consistently provided negative results (Jones 2003; Jones & Crockford 2009).

2.2 Western King Prawn

Figure 2.4. The western king prawn. Illustration © R. Swainston (www.anima.net.au).

2.2.1 Taxonomy and Distribution

The western king prawn (*Penaeus latisulcatus*) is a decapod crustacean of the family Penaeidae. Following the elevation of the subgenera of *Penaeus* to genera by Pérez Farfante and Kensley (1997), many adopted the name *Melicertus latisulcatus* for this species. There is some controversy over the revised nomenclature, and thus the older names are used for the Australian species following Baldwin et al. (1998), Lavery et al. (2004) and Flegel (2007). The species is easily distinguished by its distinctive bright blue legs and tail (Figure 2.4).

The western king prawn is widely distributed throughout the Indo-West Pacific region (Grey et al. 1983). Within Australian waters, this species occurs from South Australia, WA, Northern Territory, Queensland and down the east coast to northern New South Wales (Grey et al. 1983; Figure 2.5). 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.

Figure 2.5. Distribution of western king prawns in Australia.

2.2.2 Stock Structure

Electrophoretic studies on western king prawns have demonstrated genetic differences among populations sampled in WA, the Gulf of Carpentaria and South Australia (Richardson 1982). This species generally only forms large stocks in areas associated with the hypersaline waters of marine embayments (Kailola et al. 1993), which are likely to be largely independent of each other in terms of dynamics. The populations of western king prawns in Shark Bay and Exmouth Gulf thus function as independent, self-sustaining stocks, with distinct adult and juvenile habitats and independent variations in recruitment and abundance.

As with brown tiger prawns, the independent management and monitoring of western king prawns within each fishery is a conservative management approach that ensures that there is no serial depletion of prawns in different fishing areas. If there is any sustainability issue for this species in any area, management actions will be taken to maintain spawning stocks in each area.

2.2.3 Life History

The life cycle characteristics of western king prawns closely resemble those described above for brown tiger prawns (Penn & Stalker 1979; see Section 2.1.3). The larval development of this species has been described by Shokita (1984) and Dixon et al. (2010).

2.2.3.1 Movements and Important Habitats

As in other penaeid prawns, western king prawns undertake a migration from nursery areas to deeper, more offshore waters to spawn. This migration is clearly demonstrated by changes in the abundance and size composition of this species throughout the fishing season in Shark Bay.

Post-larval and juvenile western king prawns can be found inshore on shallow tidal flats with sand or mud sediments, which are often backed by mangroves (Penn & Stalker 1979; Kangas & Jackson 1998). Because there is very little freshwater input, such inshore areas can have salinities higher than seawater (i.e. hypersaline waters). The juveniles of western king prawns prefer this habitat, unlike most other species of prawns, which prefer estuarine conditions where seawater is diluted by freshwater.

Juvenile western king prawns spend about three to six months in the nursery grounds before they reach maturity and migrate offshore, entering the trawl fishing grounds (Penn & Stalker 1979). This migration takes place in April / May of each year (Penn 1980) in response to either biological cues, such as size, and/or some change in their environment (such as rainfall, salinity, currents or temperature) (Dall et al. 1990).

After moving out of the nursery areas, adult western king prawns inhabit coastal marine waters less than 80 m in depth, with bare sand substrate or with silt and shell grit, sponges and bryozoans (King 1977; Penn 1980). Western king prawns are nocturnal and highly sensitive to light, with their activity influenced by lunar cycles as well as temperature (Penn 1980). This species uses the sand as a defensive mechanism by burying itself to avoid predators (Tanner & Deakin 2001).

2.2.3.2 Reproduction

Western king prawns first mature at six to seven months of age, at a size of around 25 mm CL. As insemination rate is indicative of fertilisation success, Courtney and Dredge (1988) showed that ~ 50 % of females in Queensland populations of this species were inseminated at 34 mm CL, while ~ 95 % were inseminated at 42 mm CL. Females typically spawn their fertilised eggs in the water within a period of about one month of mating (Penn & Stalker 1979).

Spawning in western king prawns appears to be closely related to temperature, with increased spawning periods observed with decreasing latitude along the WA coast (Penn 1980). Although spawning of this species occurs throughout the year in tropical areas, the peak spawning period in both Shark Bay extends from May to October (Penn 1980).

2.2.3.3 Size-Fecundity Relationships

Fecundity of western king prawns in WA is positively related to the size of the prawn (Penn 1980). The relationship between the ripe ovary weight (z, grams) and carapace length (CL, mm) of western king prawns can be described as:

$z = 6.95 \times 10^{-5}\ CL^{2.916}$ ($n = 38$) (Penn 1980).

To relate the ovary weight data to fecundity, the relationship between size of the individual and number of ripe ova per gram of ovary was also investigated. As no significant difference in the number of ripe ova could be detected between prawns of different size, an overall mean value of 88 949 ova per gram was used. According to this estimate, female western king prawns can produce approximately 100 000 to 700 000 eggs per spawning (Penn 1980).

Females of this species are capable of spawning multiple times within a season (Penn 1980; Courtney & Dredge 1988).

2.2.3.4 Factors Affecting Recruitment of Juveniles

Key factors that affect larval development and survival of penaeid prawns are generally considered to be temperature and salinity (e.g. Jackson & Burford 2003). Faster development and higher survival rates of western king prawns have been observed with increasing water temperatures (Rodgers et al. 2013). Under constant laboratory conditions, the total larval period of this species varies from 12.7 days (at 24.4 ° C) to 31.3 days (at 17.1 ° C), while larval survival is greatest at 25 ° C (74 %) and lowest at 17 °C (36 %), demonstrating its strong tropical affinity (Rodgers et al. 2013).

Despite juvenile penaeids being very good osmoregulators (Dall 1981), prawn catch rates can be negatively correlated with salinity (Courtney et al. 1995). The optimum salinity range for rearing western king prawns is from 22 to 34 ‰, with the mean final weight, total length and specific growth being the highest at 34 ‰ (Sang & Fotedar 2004).

2.2.3.5 Weight-Length Relationships

The relationships between the wet weight (*W*, g) and carapace length (*CL*, mm) of female and male western king prawns in WA are described as:

Females: $W = 0.001557 \times CL^{2.7010}$

Males: $W = 0.0008474 \times CL^{2.8899}$ (Penn & Hall 1974).

2.2.3.6 Age and Growth

The growth of western king prawns has been described by fitting a von Bertalanffy growth curve to monthly length-frequency data collected in Shark Bay. The values of the estimated parameters are: L_∞ = 45.0 mm CL for males and 60.0 mm CL for females, k = 2.04 year^{-1} for males and 3.24 year^{-1} for females, and t_0 = -0.03 years. The mean asymptotic length (L_∞) for western king prawns is substantially greater than brown tiger prawns but the former species is more slender and longer and thus lighter for a given carapace length.

The life cycle of western king prawns is generally 2 – 3 years (Penn 1980). As with brown tiger prawns, individuals of this species grow very rapidly early in life, which means that they attain an economically valuable size at about 8 months of age. Fishing thus concentrates on the 0+ and, to a lesser extent, 1+ (residual) individuals.

2.2.3.7 Diet

Western king prawns are mainly detritus feeders, consuming benthic fauna and organic debris. They are nocturnal, burying themselves during the day and emerging at night to feed. Juvenile penaeid prawns feed on copepods, decapods, ostracods, gastropods, diatoms, filamentous algae and small protozoa diatoms, algae and seagrass (O'Brien 1994).

2.2.3.8 Natural Mortality

The daily instantaneous rate of *M* for western king prawns in Shark Bay has been calculated as 0.002 – 0.005 day^{-1} (Penn 1976). Similar values of *M* for this species for have also been determined in Spencer Gulf (0.003-0.005 day^{-1}; King 1977), Gulf St Vincent (0.003 day^{-1}; Kangas & Jackson 1997; Xiao & McShane 2000) and on the western coast of South Australia (0.001 – 0.014 day^{-1}; Wallner 1985).

2.2.3.9 Parasites and Diseases

For information about common parasites and diseases that affect penaeid prawns, see Section 2.1.3.9.

3. Fishery Information

3.1 Development of Fishery

Industrial fishing for penaeid prawns along the WA coastline started in the early 1960s, with two major fisheries developing at Shark Bay (26º S) and Exmouth Gulf (22º S; Penn et al. 1997). The Shark Bay fishery began in 1962, initially with four boats targeting western king and brown tiger prawns in the waters of Shark Bay. Prawn boats used in the fishery varied considerably in size and construction, from steel boats 15 m in length to several wooden trawlers from Queensland. A limited entry management system was introduced in 1963, along with a permanent trawling closure of the southern part of the embayment to protect small prawns (Slack-Smith 1969).

The fishery developed incrementally to a maximum of 35 vessels in the mid-1970s, with the majority of the fleet at this time consisting of twin-rigged trawlers larger than 21 m in length. As the understanding of spatial and temporal variation in prawn abundance increased, temporal closures of parts of the fishing grounds were introduced to permit prawns to grow to an acceptable market size before being harvested.

The prawn fishery in Shark Bay came under formally legislated management in 1993, when the *Shark Bay Prawn Limited Entry Fishery Notice 1993* was introduced. This plan included the formal legislation of a number of management measures, including seasonal opening and closing dates, gear standardisation and spatial closures (see more information in Section 4 below). The management areas of the SBPMF are outlined in Figure 3.1 and overall fishery boundaries are shown in Figure 4.1.

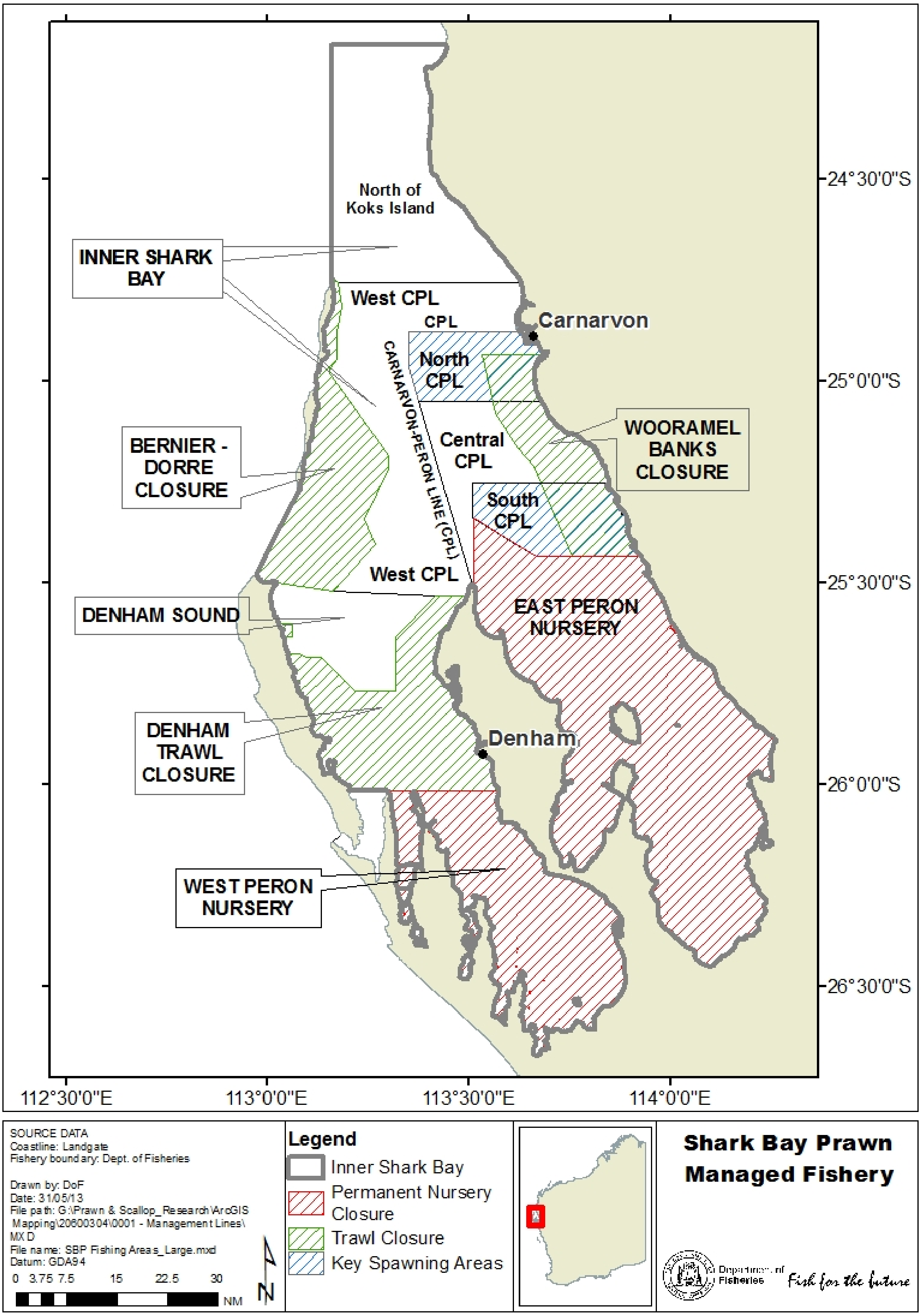

Figure 3.1. Management zones of the SBPMF within the Inner Shark Bay area

By 1996, all prawn boats in Shark Bay were towing twin-rigged 14.63 m (8 fathom [ftm]) nets, with a total fleet headrope length of 790 m (432 ftm). The fleet began trialling more efficient, quad-rigged trawl gear in 2005, with restructures and gear amalgamation resulting in the number of vessels in the fishery being gradually reduced to 18. Since 2007, all licenced vessels in the SBPMF have been towing quad-rigged trawl net.

The SBPMF is currently the highest producing prawn fishery in WA, with a total estimated value (including byproduct) of AUD 23.3 million in 2013 (Sporer et al. 2014). Fishers mainly target western king prawns and brown tiger prawns, although they also retain a number of small prawn species such as endeavour prawns (*Metapenaeus* spp.) and coral prawns (various spp.). The fishing industry is a major contributor to regional employment in the area, with approximately 100 skippers and other crew employed by the fishery in 2013. There are also approximately 55 processing and support staff directly employed in Carnarvon (Sporer et al. 2014).

3.1.1 Name Changes to Management Zones

Name changes to several of key management zones shown in Figure 3.1 have been made in recent years to reflect changing purposes and priorities in the SBPMF. Notably, the North CPL zone, also referred to as the 'key northern spawning area', was formerly known as the Tiger Prawn Spawning Area (TPSA). The South CPL, also referred to as the 'key southern spawning area', was formerly known as the Extended Nursery Area (ENA). An area of the Denham Trawl Closure that may open to fishing late in the season and that was formerly known as the area below the Snapper Trawl Line (STL) is now referred to as a partial opening of the Denham Trawl Closure or the Denham Extension.

3.2 Fishing Gear and Methods

Vessels in the SBPMF use low-opening demersal otter trawl nets in quad-rigged formation (Figure 3.2), with a current maximum headrope allocation of 724 m (396 ftm). Eighteen boats operated in the fishery in 2013, each towing four 10.1 m (5.5 ftm) nets.

Otter boards are attached to the extremities of each net, with the height of the fishing gear set by the height at the point where they are connected to the otter boards. Forces produced by water flowing over the otter boards open the trawl nets laterally. This lateral spread controls the catching efficiency of trawl gear and determines the area swept. Generally, the headrope and footrope are spread between 60 % and 85 % of their length.

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.

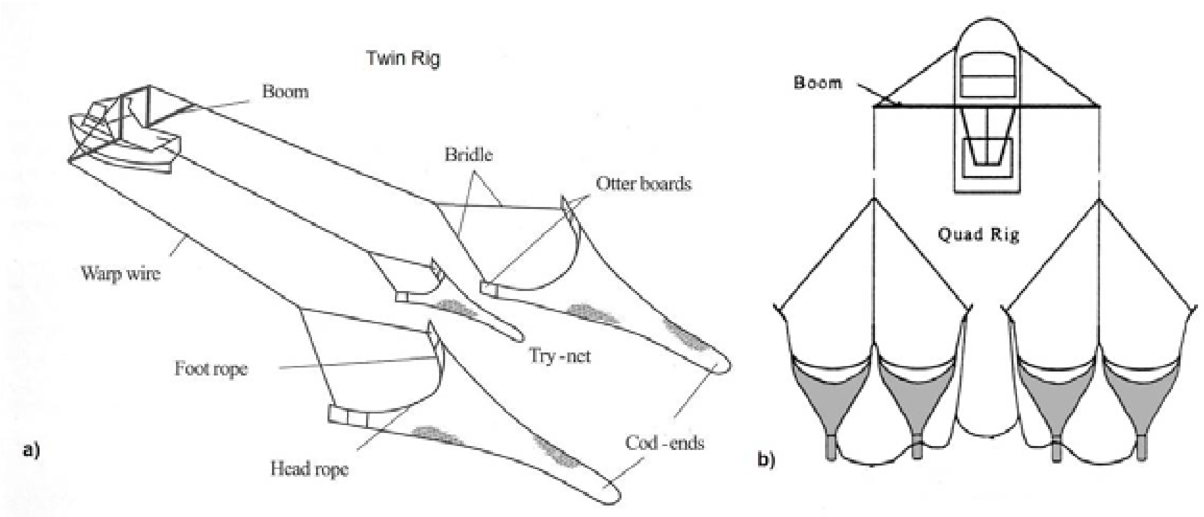

Figure 3.2. Standard twin-rig otter trawl (a) and quad-rig otter trawl (b) (Adapted from Stirling 1998). The quad-rig configuration is currently used by all vessels in the SBPMF.

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.

However, 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.

The permitted trawl area within the inner Shark Bay area is 6 063 km^2 (i.e. excluding the closed areas), however, fishing generally only occurs in 40 – 50 % of this permitted trawl area each season, which represents 14 – 18 % of inner Shark Bay. Trawling occurs over mud or sandy mud substrates, with fishing activities focused in the deeper areas of the central bay, north and northeast of Cape Peron and in the northern region of Denham Sound (see Figure 3.1). In 2013, ~ 17 % of inner Shark Bay was trawled by the SBPMF; Sporer et al. 2014).

The annual cycle of operation in the SBPMF is dynamic and depends on the strength and timing of prawn recruitment. After spending approx. six months in the inshore nursery areas of the southern Shark Bay, brown tiger prawns and western king prawns migrate into the deeper central parts of the embayment and enter the trawl grounds. The harvest strategy adopted for the SBPMF (DoF 2014a) 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.

3.3 Overview of Catch and Effort

As the prawn fishery in Shark Bay developed, fishing effort and catches of prawns steadily increased to a peak level in the early 1980s (Figure 3.3). Brown tiger prawns were initially fished heavily without any protection to the spawning stock, which resulted in a decline in annual catch of this species to an average of 303 t between 1980 and 1989 compared with an average of 649 t during the 1970s. Annual catches of western king prawns remained relatively stable at around 1400 t during this time (Figure 3.3). Following the implementation of spatial closures and time restrictions for fishing, and a reduction in the fleet associated with the introduction of a licence buy-back scheme in 1990, tiger prawn catches subsequently returned to levels over 500 t (Figure 3.3).

Low western king prawn catch years in the early 1990s (Figure 3.3) were partly attributed to very high scallop abundance (and landings) in Shark Bay, which reduced the amount of fishing effort directed on prawns. Further licence buy-backs and additional management measures to protect brown tiger prawns have also contributed to years of lower overall prawn landings since 1990. The decline in catches observed in 2007 (Figure 3.3) is likely due in part to the conversion of the fleet to using quad-rigged trawl gear for targeting prawns and skippers becoming familiar with the new gear configuration.

Fishing effort in the SBPMF in 2012 was the lowest seen in the fishery since 1967 (Figure 3.3), with 33 198 hours of effort (adjusted for comparison with twin gear). There was an 8 % increase in effort in 2013 compared to the previous year, with the 18 boats fishing a collective 35 897 hours. The increased cost of fishing, mainly due to high fuel prices and high value of the Australian dollar, is the main cause of decreased effort in the fishery (Sporer et al. 2013). Despite the low current effort level, however, catches in 2013 of brown tiger prawns (661 t) and western king prawns (1139 t) were as high as landings achieved in the 1970s and mid-1990s (Figure 3.3).

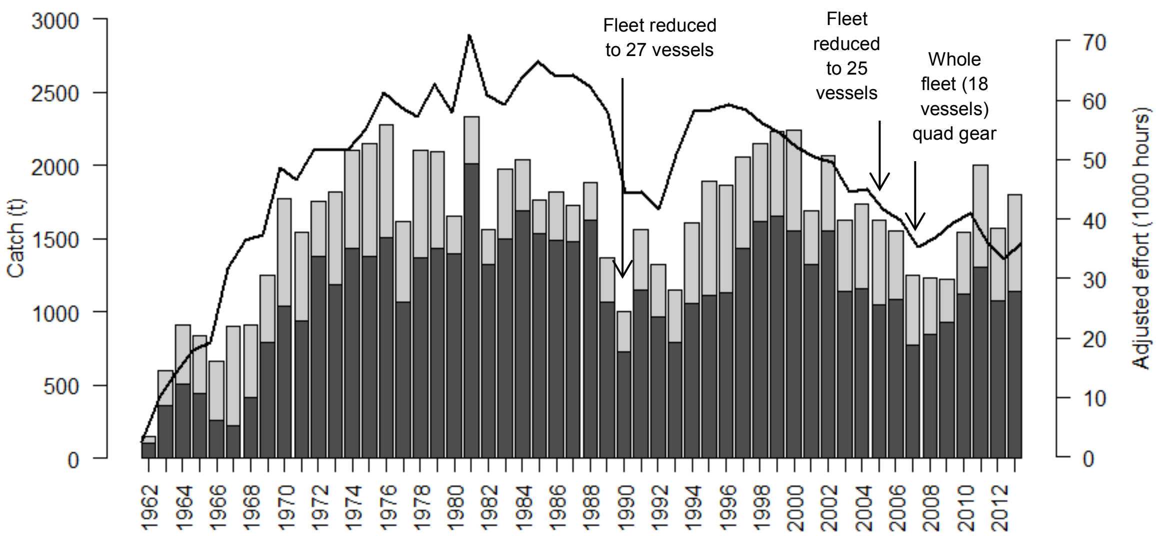

Figure 3.3. Annual adjusted (to twin gear) fishing effort (black line) and catches of brown tiger prawns (grey bars) and western king prawns (black bars) in the SBPMF between 1962 and 2013.

The stocks of brown tiger and western king prawns in Shark Bay are not commercially retained by any fishery other than the SBPMF. Recreational (and customary) catches of prawns in Shark Bay are considered negligible (see Section 5.3.5).

4. Fishery Management

4.1 Management System

An overview of the fishery-specific governance and management relating to the SBPMF is presented below. More detailed information, including a description of the long- and short-term management objectives for these fisheries, is provided in the MSC Principle 3 Sections 15 and 16.

The SBPMF is managed by the Department under the following legislation, which can be accessed via the Department's website[1]:

- *Fish Resources Management Act 1994* (FRMA)[2];
- *Fish Resources Management Regulations 1995* (FRMR);
- FRMA Part 6 – *Shark Bay Prawn Managed Fishery Management Plan 1993*;
- FRMA Section 43 Order – *Prohibition on Commercial Fishing (Shark Bay Marine Park) Order 2004*
- FRMA Section 7(2) Instruments of Exemption; and
- Managed Fishery Licence (MFL) Conditions;

Fishers must also comply with the requirements of the:

[1] http://www.fish.wa.gov.au/About-Us/Legislation/Western_Australian_Fisheries_Legislation/Pages/default.aspx
[2] Note the FRMA will be replaced by *Aquatic Resources Management Act* once enacted.

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *Western Australian Marine Act 1982*; and
- Western Australian *Wildlife Conservation Act 1950*.

4.1.1 FRMA

The FRMA provides the overarching legislative framework to implement the statutory management arrangements for SBPMF and contains the head powers to determine a management plan (section 54). WA management plans (see below) set out the operational rules that control managed commercial fishing activities. The management plan is subsidiary legislation that provides the power (pursuant to section 58) to issue and restrict the number authorisations and regulate other conditions and grounds relating to fishing. There is also power to set the capacity of the fishery under a management plan (section 59). The FRMA also sets out the procedure for determining and amending a management plan (sections 64 and 65). Under section 43 the Minister may prohibit fishing by order published in the Government Gazette.

4.1.2 FRMR

The FRMR contain a number of requirements pertaining to all commercial fisheries in WA. For example, regulation 64 requires commercial fishers to submit mandatory catch returns in the form approved for that fishery. Licensees in the SBPMF are required to report retained species catches, effort, any ETP species interactions and fishing location in daily logbooks.

4.1.3 Management Plan

The *Shark Bay Prawn Limited Entry Fishery Notice 1993*, which is now referred to as the *Shark Bay Prawn Managed Fishery Management Plan 1993* (or the Management Plan), is the primary statutory management instrument for the SBPMF. The Management Plan was established under the previous State *Fisheries Act 1905;* however all existing management plans established under section 32 of the *Fisheries Act 1905* were transitioned under section 266 of the FRMA when it was established in 1994. The Management Plan implements the following set of measures to meet the fishery-specific management objectives for the SBPMF:

- **Limited entry:**

  The number of managed fishery licences (MFLs) in the SBPMF is limited to 18. Each licenced fishing boat operating in the SBPMF must be endorsed on a MFL, and all persons commercially fishing in the SBPMF must hold a commercial fishing licence.

- **Areas of the fishery:**

  The Management Plan prescribes the following boundary and areas of the SBPMF-

  - The overall waters of the fishery (Figure 3.1);

- The boundaries of permanently closed prawn nursery areas in the southern and eastern parts of Shark Bay, and the Bernier-Dorre trawl closure north-east of Dirk Hartog Island (Figure 3.1);
- An area in which gear may be trialled no more than 14 days before the opening of the fishery with cod ends open and during daylight hours;
- A 24 hour trawling area; and
- Port area closures around Carnarvon and Denham.

- **Annual closed season:**

  The SBPMF is closed to fishing each year between November and March/April pursuant to clause 10 of the Management Plan (see Section 4.1.4 below). Season closure and opening dates are based on prawn biology and historical fishery information but vary each year, depending on lunar phase (i.e. after the full moon). For the 2013 season, official opening and closing dates were set at 11 March and 15 October.

- **Permanent temporal closure:**

  Fishing is only allowed at night when the fishery is open (daytime closures apply from 0800 hrs to 1700 hrs). This measure greatly reduces trawler visibility and conflict with other marine users.

- **Fishing (gear) capacity:**

  The SBPMF currently operates under a maximum net headrope capacity of 724 m (396 ftm).

- **Gear specifications:**

  All nets used in the fishery must be either a six fathom trawl net (i.e. being a net with a prescribed headrope length of between five metres and 10.97 m), an eight fathom trawl net (i.e. being a net with a prescribed headrope length of between five metres and 14.83 m), or a try net (i.e. being a net with a prescribed head rope length of no more than five metres). No more than four six (or eight) fathom trawl nets and one try net may be used at any one time.

  Each six and eight fathom trawl net can only have attached a single otter board on each side, which is restricted in size. Nets must also only have one ground chain, which is made of links < 10 mm in diameter, and meshes may be no greater than 60 mm.

- **Vessel Monitoring System:**

  Fishing activities (location and intensity) are monitored by the Department via a Vessel Monitoring System (VMS), with all licenced fishing boats operating in the SBPMF required to install an operational Automatic Location Communicator.

4.1.4 Determinations by the Director General (Chief Executive Officer)

The annual closed season in the SBPMF is implemented by virtue of an annual statutory determination made by the Director General (as the Chief Executive Officer, the designated authority, also referred to as the "Executive Officer" in the management plan) pursuant to clause 10 of the Management Plan. This framework provides the power for the Director General to statutorily open and close the SBPMF annually without the need for an amendment to the Management Plan. The annual determination is the statutory instrument that caps the maximum number of days that fishing is permitted each season, and also prescribes spatial management areas within the fishery that are used to manage the distribution of fishing effort during the season (see Section 4.2 below). These include spatial and temporal closures specifically to protect prawn spawning stock.

4.1.5 Exemptions

The FRMA provides the head power (see Section 15) to implement statutory management measures alternative to existing arrangements. Exemptions are often used when measures are being trialed, prior to them being implemented permanently (e.g. in the Management Plan). There are three current Exemptions relevant to the SBPMF which relate to gear, the number of boat units and the retention of scalefish.

4.1.6 Managed Fishery Licence Conditions

The SBPMF fleet is required to have BRDs in the forms of grids and fish exclusion devices (FEDs), such as square mesh panels, in each net. This requirement is currently implemented via a MFL condition.

4.1.7 Section 43 Orders

Following the establishment of the Shark Bay Marine Park, trawling closures were implemented pursuant to section 43 of the FRMA (see Section 4.5.1 below). The *Prohibition on Commercial Fishing (Shark Bay Marine Park) Order 2004* prohibits commercial fishing in any of the waters of the Shark Bay Marine Park with trawling in accordance with the *Shark Bay Prawn Management Plan 1993* in general use zones listed as an exception.

4.2 Harvest Strategy

The *SBPMF Harvest Strategy 2014 - 2019* (DoF 2014a) outlines the long- and short-term fishery-specific management objectives; a description of the performance indicators used to measure performance against these objectives; reference levels for each performance indicator; and associated harvest control rules, which articulate pre-defined, specific management actions designed to maintain each resource at target levels and achieve the management objectives for the fishery (see also Section 8 for more information).

4.3 Bycatch Action Plan

A program of bycatch reduction and assessment of biodiversity impacts have been in place for the SBPMF for more than a decade. The *SBPMF Bycatch Action Plan 2014 – 2019* (DoF 2014b) sets out the current and proposed activities aimed at achieving long- and short-term fishery-specific management objectives relating to bycatch, ETP species and ecosystem processes (see Section 16.4.1 for more detail).

4.4 Cooperative Management Framework

While the statutory annual determination opens the entire area of the SBPMF to trawling, the management areas defined in the determination are opened (fully or partly) and closed (fully or partly) a number of times throughout the fishing season under a co-operative framework between the Department and the licensees. This framework also outlines the moon closures (5 – 7 days), which occur around each full moon.

The in-season rolling openings / closings implemented under this co-operative framework are informed in real time by monitoring of survey and commercial catch rates, which allows for responsive and finer scale spatial management of fishing effort. While the rolling openings/closings are typically non-statutory (with the exception of the spawning area closure, see above), they are agreed to by the licensees and monitored by VMS. Please refer to Section 16.2 for further detail of the co-operative management decision making process.

4.5 Marine Protected Areas

4.5.1 State Marine Protected Areas

Several types of marine protected areas occur within the boundaries of the SBPMF to help in protecting marine biodiversity. Protected areas in the region include (Figure 4.1):

- Marine nature reserve: the Hamelin Pool Marine Nature Reserve;
- Marine parks: Shark Bay Marine Park and Ningaloo Marine Park; and
- Fish habitat protection areas (FHPAs): Point Quobba FHPA and Miaboolya FHPA.

Hamelin Pool Marine Nature Reserve[3]

Hamelin Pool is located at the base of the eastern gulf of Shark Bay and covers 1270 square kilometres. It is one of only a few places in the world where living marine stromatolites can be found. This reserve is protected from all activities.

Shark Bay Marine Park[3]

The Shark Bay Marine Park was gazetted in 1990, and in 1991, the Shark Bay World Heritage Area was inscribed on the World Heritage List. Commercial trawl fishing is permitted within the general use zones and Wooramel Special Purpose Trawling Area of the Marine Park, although these are not commonly trawled.

[3] http://parks.dpaw.wa.gov.au/sites/default/files/downloads/parks/shark_bay_marine_park_and_hamelin_pool_marine_nature_reserve.pdf

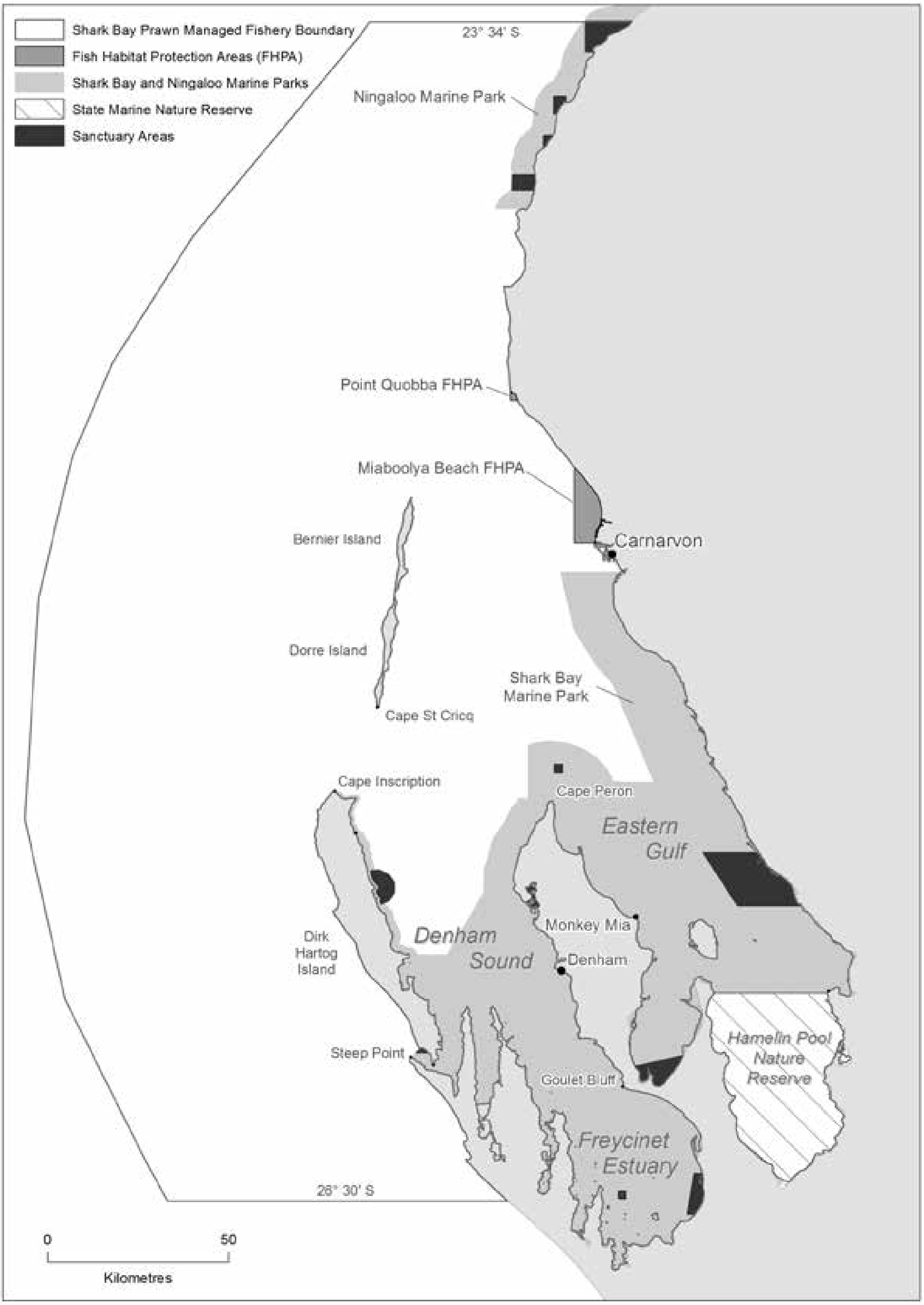

Figure 4.1. State-managed marine protected areas within the SBPMF boundaries

Ningaloo Marine Park[4]

Ningaloo Marine Park was gazetted in 1987 and is located in the northern part of the SBPMF boundary. Commercial trawl fishing in this part of the Marine Park is prohibited (Figure 4.1).

Point Quobba FHPA[5]

The Point Quobba coral reef and lagoon were originally protected by a fishing closure made in 1987 and was then declared a FHPA in 2004. In 2009, legislation gave protection to the entire coral reef and lagoon area, which is a restricted area and completely protected.

Miaboolya FHPA[6]

Following research findings that this area is an important fish nursery, the Miaboolya FHPA was declared in April 2003.

4.6 ESD Reporting and Risk Assessment

Ecologically Sustainable Development (ESD) is the concept that seeks to integrate short and long-term economic, social and environmental effects in all decision-making. The WA Government is committed to the concepts of ESD, and these principles are implicitly contained in the objectives of the FRMA. Under the WA *Policy for the Implementation of Ecologically Sustainable Development for Fisheries and Aquaculture within Western Australia* (Fletcher 2002), the Department is required to report on the progress of each commercial fishery against the major ESD objectives using the National ESD Framework for Fisheries (see Fletcher et al. 2002). This framework operates by identifying the relevant issues for a fishery, completing a risk assessment on each of the identified issues and providing suitably detailed reports on their status (Kangas et al. 2006).

The ESD report for the SBPMF (i.e. Kangas et al. 2006) provides a comprehensive overview of fishery information, a major component of which is the explicit determination of the operational objectives, performance measures and indicators used to assess the performance of the fishery. The annual *Status Reports of the Fisheries and Aquatic Resources of Western Australia: state of the fisheries* (e.g. Fletcher & Santoro 2013) reports on the evaluation of performance of the fishery against the sets of 'agreed' objectives and performance measures identified during these risk assessments.

SBPMF-specific component trees were developed during an open consultative process involving all stakeholder groups in June 2001 (Kangas et al. 2006). After the components / issues were identified, a process to prioritise each of these needs was completed using a formal risk assessment process. The risk assessment framework that was applied during the workshop was consistent with the Australian Standard AS/NZS 4360:1999, using a combination of the level of consequence and the likelihood of occurrence of that event to

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[4] http://parks.dpaw.wa.gov.au/sites/default/files/downloads/parks/Ningaloo%20Marine%20Park%20Zones%20January%202014.pdf
[5] http://www.fish.wa.gov.au/Documents/recreational_fishing/fhpa/fpha_point_quobba.pdf
[6] http://www.fish.wa.gov.au/Documents/recreational_fishing/fhpa/fhpa_miaboolya.pdf

produce an estimated level of risk associated with the issue(s) in question. Issues of sufficient risk (i.e. Moderate, High or Extreme) require specific management actions, with a full performance report completed for each issue at these levels (Kangas et al. 2006).

As an update on this initial risk assessment for the fishery, two internal workshop reviews of the 2001 Ecological Risk Assessment were undertaken in 2008 and 2010. As a number of key changes had taken place in the fishery since 2001, the aims of the internal risk assessment workshop were to revisit the risk ratings identified in 2001 and determine whether they were still relevant or whether they required amendment. In addition, any possible new risks were identified[7].

Additionally, in 2014, an internal risk assessment was conducted on target, byproduct, bycatch and ETP species for the SBPMF using Productivity Susceptibility Analysis (PSA) methodology. Thirty-one species were assessed, with one byproduct and six ETP species / groups assessed to be at medium risk; no species were assessed to be at high risk. The ETP species assessed to be at medium risk have mostly been assessed at this level due to low productivity attributes, with the majority of species recognised as an ecological issue for this fishery for many years. PSA tables generated as part of this risk assessment process are provided in Appendix A. The identified issues and their associated risk ratings are provided throughout the remainder of this document where relevant.

4.7 Assessments and Certifications

The SBPMF has been assessed under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act; Part 13A) and has been found to meet the Australian Government *Guidelines for the Ecologically Sustainable Management of Fisheries* (Commonwealth of Australia [CoA] 2007). Initial assessment of the fishery took place in 2003, with the most recent reassessment completed in February 2013[8]. The management regime of the SBPMF has subsequently been accredited under Part 13 of the EPBC Act accompanied by an amendment to the List of Exempt Native Species (LENS) to allow for export of product from the SBPMF until February 2018. Six recommendations were provided as part of the most recent accreditation, focusing on ensuring the continuation of good management practices in the fishery.

5. External Influences

External influences include other activities and factors that occur within the Shark Bay region that may or may not impact on the productivity and sustainability of fisheries resources and their ecosystems. The main external influences included here are (1) market influence, (2) environmental factors, such as the strength of the Leeuwin Current, (3) other fisheries, (4) other activities such as salt mining and shipping, and (5) introduced marine species.

[7] A copy of the final document is available at: http://www.environment.gov.au/system/files/pages/954b05b1-2c41-45ae-8810-7deddd9a784d/files/appendix-6-application-nov12.pdf

[8] Full details of the current and previous assessments are available at: http://www.environment.gov.au/topics/marine/fisheries/wa-sbprawn.

5.1 Market Influences

Increasing cost of fishing and lower returns due to the global economic climate, high value of the Australian dollar and competition from imported and Australian prawns has impacted harvesting activities in the SBPMF. Fishers have shifted to targeting larger prawns during efficient catch rate periods and focus on the domestic market rather than export markets. This has also lead the prawn industry to maximise the return from all species captured in the fishery where possible, particularly scallops (*Amusium balloti*) and blue swimmer crabs (*Portunus armatus*; Sporer et al. 2013).

5.2 Environmental Factors

There are a number of environmental factors influencing prawn fisheries in Australia, including temperature, rainfall and ocean currents. Extended periods of elevated temperatures in shallow nearshore waters may affect the distribution of prawn nursery habitats, such as seagrasses, as well as the growth and survival of various life stages of penaeid species (Hobday et al. 2008). Catches of prawns may also be impacted through changes in rainfall, which is predicted to slightly decrease in northern Australia (Hobday et al. 2008).

A key factor influencing prawn stocks in WA is the flow of the Leeuwin Current along the coastline. A relationship exists between strength of this current (measured by the sea level in Fremantle, WA) and the catches of western king prawns in Shark Bay (Lenanton et al. 1991; Caputi et al. 1996; Lenanton et al. 2009). It is suggested that higher catches are related to stronger flows during the March to June period, which has a positive effect on the catchability, growth and survival of prawns (Caputi et al. 1996).

The climate of the Gascoyne is primarily driven by El Niño/La Niña Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) patterns. Mesoscale inter-annual and seasonal variation in the strength of the Leeuwin Current has been shown to be related to the ENSO cycle, with a weaker current during ENSO events and a stronger current during La Niña (Pearce & Philips 1988; Caputi et al. 1996; Feng et al. 2003).

There has been a change in the frequency of ENSO events in recent decades that has influenced the trends in the Leeuwin Current strength. After experiencing a weakening trend from the 1960s to the early 1990s, the strength of the Leeuwin Current has rebounded in the past two decades (Feng et al. 2010, 2011). Feng et al. (2012) summarise the major trends in the Leeuwin Current over the past decades and projected changes in the 2012 Marine Report Card on the Leeuwin Current. They indicate that most climate models, as well as the climate downscaling models, suggest a weakened Leeuwin Current under the global warming forcing; however, decadal climate variability may mask the long-term trend (Feng et al. 2012).

5.2.1 Extreme Climate Events

Shark Bay generally receives very little rainfall and infrequent cyclonic activity; however, it is affected at times by significant river outflows (flood events) from inland cyclone-based summer rainfall (Fletcher and Santoro 2013).

There have been two significant flooding events in Shark Bay recently, in December 2010 and February 2011, which were most likely associated with a strong La Niña event in late-2010 and early-2011. Although the impact, if any, of these flooding events on demersal fish stocks has yet to be determined, they are thought to have contributed to declines in abundance of blue swimmer crabs and scallops in 2011/12.

A significant warming event also occurred off the coast of WA during the summer of 2010/11, with widespread reports of fish kills and movement of tropical species south of their normal range. Large-scale satellite-derived sea-surface temperatures and local temperature logger measurements showed temperatures were > 3 ° C above the normal summer averages in some regions. This "marine heat-wave" was associated with extremely strong La Niña conditions that lead to a record strength Leeuwin Current for that time of year, which resulted in record high summer sea levels along the mid-west and Gascoyne coast (Pearce et al. 2011).

The heat wave resulted in what is considered to be the first WA regional-scale coral bleaching event, affecting corals south to Rottnest Island and north to the Montebello and Barrow Islands. The onset of the bleaching was observed at Ningaloo Reef and the Montebello and Barrow Islands in mid-January 2011 and extended southwards to Rottnest Island during March 2011 (Pearce et al. 2011). It is almost certain that future warming events will occur, but their frequency and magnitude cannot be forecast at this time. This warming event may also have contributed to a significant decline in blue swimmer crab (Harris et al. 2012) and scallop stocks (Sporer et al. 2013) in Shark Bay and a subsequent recruitment failure for both of these species in 2011.

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

The paucity of spatially and temporally relevant pre- and post-impact data for indicator habitats and environmental drivers has limited the Department's ability to accurately quantify the impact of environmental changes in this fishery. In light of this, a project to develop methodologies to monitor and understand the associations between critical fish habitats, environmental drivers, ecosystem productivity and fishery recruitment in Shark Bay (and Exmouth Gulf) is currently being developed by the Department in conjunction with the University of Western Australia. The objectives of the project are to:

- Collate and review historical, satellite, habitat and 'environmental productivity' data for Shark Bay and Exmouth Gulf ecosystems to identify factors that may influence recruitment;

- Assess the ability of different techniques at various spatial scales to identify and assess critical fish habitat in a range of environmental conditions, comparing Shark Bay and Exmouth Gulf habitat and recruitment patterns in relation to environmental factors;

- Collect in-situ environmental and productivity data to assess the feasibility of collecting broad-scale data remotely;

- Develop a cost effective monitoring program for critical fish habitat and environmental drivers, which allows the development of mitigation measures to assist in alleviating poor recruitment events.

This project is considered to be high-priority for the Department, with funding recently secured.

5.3 Other Fisheries

The SBPMF operates in the same area as four other major fisheries: the Shark Bay Scallop Managed Fishery (SBSMF), the Shark Bay Crab (Interim) Managed Fishery (SBCIMF), the Gascoyne Demersal Scalefish Managed Fishery (GDSF) and the Inner Shark Bay Scalefish Fishery, which includes the activities of the Shark Bay Beach Seine and Mesh Net Managed Fishery (SBBSMNMF) and the inner Shark Bay recreational fishery.

5.3.1 Shark Bay Scallop Managed Fishery

The scallop resource in Shark Bay is fished by both the SBPMF and the SBSMF, with large areas of spatial overlap. The inter-relationship between trawling activities for the prawns and scallops has raised both management challenges and industry conflicts over time, and has also been the focus of an FRDC funded research project (Kangas et al. 2012). A comprehensive review of the fisheries was undertaken (Department of Fisheries [DoF] 2010) to address issues such as resource sharing and gear interaction issues between the scallop and prawn fleets and continued variations in scallop stock levels in Shark Bay.

As scallops have historically been an important component of the viability of the prawn fleet, the Minister for Fisheries adopted a formal catch share management objective for the annual scallop catch between A Class (scallop only) and B Class (prawn and scallop) boats of 70 % and 30 %, respectively (Sporer et al. 2013).

Due to the low catch predictions for scallops based on annual recruitment surveys, the SBSMF was closed in 2012 and 2013. A small area where some recruit scallops were identified in Denham Sound was closed to prawn trawling in 2013 as an additional protective measure for the scallop spawning stock (Sporer et al. 2013). Subsequent surveys have indicated that some recovery of the scallop stock is evident (DoF unpublished data).

5.3.2 Shark Bay Crab (Interim) Managed Fishery

The blue swimmer crab resource in Shark Bay is harvested commercially by the SBCIMF and the SBPMF, with small amounts also retained by the SBSMF. There are currently five 300-trap licences and 28 trawl licences (18 prawn and 10 scallop) authorised to take blue swimmer crabs in Shark Bay.

While blue swimmer crabs have been retained by the SBPMF since its inception, the prawn trawl licensees have steadily increased their capacity to process and retain crabs since 2000. Consequently, the trawl crab catch rose steadily from 43 t in 2000 (15 % of the total blue swimmer crab catch in Shark Bay) to 338 t in 2010 (41 % of the total blue swimmer crab catch in Shark Bay), with crabs now forming an important economic component of the trawl catch (Harris et al. 2012).

Since 2011, catches of blue swimmer crabs in Shark Bay have declined sharply for both the trap and trawl sectors, suggesting a significant depletion of large (≥ 135 mm carapace width [CW]) crabs. The mean monthly trap catch rate fell from 2.2 kg / traplift in June 2011, to 1.7 kg / traplift in August 2011, to less than 1 kg / traplift by October 2011. Similarly, the total monthly retained trawl catch declined from over 90 t in April 2011, to around 30 t by July 2011, with just two tonnes taken in September 2011. A significant reduction was also recorded in the abundance of recruits (< 85 mm CW) in the fishery. The reasons for this unexpected and substantial decline are yet to be clearly understood, but it is possibly linked to several adverse extreme environmental events that occurred during the summer of 2010/11 associated with a very strong La Niña event (Harris et al. 2012).

Due to this decline, commercial fishing for blue swimmer crabs in Shark Bay was voluntarily halted by industry in April 2012, continuing until October 2013 (Chandrapavan et al. 2013). During this time, there was no retention of blue swimmer crabs in Shark Bay.

Since the voluntary closure of the Shark Bay crab fishery in 2012, intensive monitoring of the resource and its recovery has been undertaken using a combination of trawl (FRDC project) and trap-based (funded by the Department) surveys (Chandrapavan et al. 2014). These surveys were designed to target key deep-water trawl grounds and inshore trapping grounds that have historically been used to target crabs. New survey sites have also been added to explore non-traditional crab regions to further understand stock distribution and movement at the lower abundances that currently exist.

In June 2013, an exemption was granted for a commercial crab fishing trial as a result of some improvement in the crab biomass indices from both of these surveys (Chandrapavan et al. 2014). A nominal 'quota' of 18 t was set for a single trap fisher for this fishing period (max. 400 traps) and was monitored on a daily basis. The trawl sector was also set a collective quota of 18 t, allowing for 1 t per fishing boat. The total trap catch was 20 t (slightly above the 18 t limit due to the addition of fishing days for inclusion of a commercial monitoring survey over 1 – 5 July). The total trawl crab catch was 16 t (Chandrapavan et al. 2014).

Based on the results of the commercial fishing trial and improving crab stock status as indicated by fishery-independent surveys, the resumption of limited commercial crab fishing was approved by the Department in 2013. A precautionary total allowable commercial catch (TACC) of 400 t was set for the 2013/14 season (Chandrapavan et al. in press). The 400 t approval provides for the harvest of up to 264 t of crabs by the trap sector and the harvest of up to 135.2 t by the prawn trawl sector. The Shark Bay blue swimmer crab stock continues to recover from environmental impacts on recruitment as indicated by the significantly high biomass levels in 2014 (DoF unpublished data; see also Section 10.1.1.3).

In order to facilitate stock rebuilding, the Department has been working on the development of an effective harvest strategy for the blue swimmer crab stock in Shark Bay, along with management arrangements to provide for the sharing of the fishery between trap and trawl sectors. In June 2013, the then Minister for Fisheries approved the development of a Shark Bay Crab Managed Fishery Management Plan, which will incorporate the prawn trawl, scallop trawl and trap sectors and be based on an Individual Transferable Quota (ITQ) system of entitlement. It was determined that the commercial blue swimmer crab resource in Shark Bay would be allocated across the prawn trawl, scallop trawl and trap sectors based upon the proportional catch history of each sector between 2007 and 2011, resulting in the following allocations:

- Trap sector: 66.0 %;
- Prawn trawl sector: 33.8 %; and
- Scallop trawl sector: 0.02 %.

The new management plan is expected to be completed in mid-2015.

5.3.3 Gascoyne Demersal Scalefish Managed Fishery

The GDSF encompasses commercial and recreational fishing for demersal scalefish in continental shelf waters of the Gascoyne Coast Bioregion. At Shark Bay, fishers primarily target the oceanic stock of pink snapper (*Pagrus auratus*) although several other demersal species are also retained. A limited number of licenced charter vessels and a large number of recreational vessels fish out of Denham, Carnarvon and around the Ningaloo area (i.e. Coral Bay, Tantabiddi and Exmouth) and catch a similar range of demersal species (Jackson et al. 2013a).

In 2013, the commercial GDSF retained 389 t of demersal scalefish, including 235 t of pink snapper (Jackson et al. 2013a).

5.3.4 Inner Shark Bay Scalefish Fishery

The Inner Shark Bay Scalefish Fishery encompasses the SBBSMNMF and the inner Shark Bay recreational fishery for scalefish species within the waters of the Eastern Gulf, Denham Sound and Freycinet Estuary in Inner Shark Bay. The SBBSMNMF operate from Denham and uses a combination of beach seine and mesh nets to target four main species / groups:

whiting (*Sillago* spp.), sea mullet (*Mugil cephalus*), tailor (*Pomatomus saltatrix*) and western yellowfin bream (*Acanthopagrus morrisoni*; Jackson et al. 2013b).

5.3.5 Recreational Fishing

Recreational fishing effort (for all species) in the Gascoyne Coast Bioregion during 2011/12 was estimated as 13 % of the entire State recreational fishing effort. Most recreational fishing in Shark Bay is boat-based, with fishers using rod and line or handlines to target demersal finfish species such as pink snapper (*P. auratus*) (Jackson et al. 2013b). Some netting for bait and sea mullet also occurs in the area.

Recreational fishing activity for prawns in Shark Bay is considered negligible. There is a state-wide recreational daily bag limit of nine litres of prawns. Prawns can be legally caught using a single hand-dip net, hand scoop net, hand throw net or prawn hand trawl (drag) net that is not more than four metres across with a mesh of not less than 16 mm, and must not be attached to a boat or set. A net fishing licence is required if using set, haul or throw nets. A recreational boat fishing licence is required if catching prawns from a powered boat.

5.4 Other Activities

Other activities within the Shark Bay region of Gascoyne Coast include mining, tourism and shipping and maritime activities.

5.4.1 Salt Mining

Salt constitutes the main mining activity in the Gascoyne. The region has significant salt mining operations at two locations, one at Lake MacLeod, north of Carnarvon, and one at Useless Loop in Shark Bay. The salt field in Shark Bay spans 7000 hectares and is surrounded by World Heritage listed property, although it is specifically excised from it. The site produces around 1.3 million tonnes of salt each year, which is predominantly sold to Asian food markets. The harvesting process is considered to be environmentally friendly, using only wind and the heat of the sun (Gascoyne Development Commission [GDC] 2010a). Discharge of waste products, such as bitterns, however, can have serious impacts on the surrounding habitat and associated faunal assemblages (Oceanica 2011).

Bitterns are a hypersaline (> 300 ‰) solution with a significantly different chemistry than ambient seawater. The oceanic discharge of bitterns in the past has resulted in a loss of the seagrass habitat adjacent to the discharge area (Oceanica 2011). Seagrass loss commenced with the discharge of bitterns in the late-1960s and continued progressively until 1989 when the discharge was discontinued (Sinclair Knight Merz [SKM] 2001). Bitterns are currently discharged into crystalliser ponds, where they filter down through the storage pond floor (SKM 2001); however, Shark Bay Resources Pty Ltd, a subsidiary of Mitsui & Co. that owns and operates the salt fields, has recently proposed to directly discharge pre-diluted bitterns into deep water via a subsea diffuser. With proper dilution and discharge over bare sand habitats well away from seagrasses, the proposed discharge is considered to be environmentally benign and easily monitored and managed (Oceanica 2011).

5.4.2 Tourism

The Gascoyne Coast is a focal point for winter recreation by the WA community. Apart from the scenic beauty, the main attraction of the coastline is the high quality of marine life (Shaw 2000). The region supports extensive scuba diving and snorkelling activities, particularly around Ningaloo Reef. Specialised eco-tourism activities include whale shark and manta ray observation at Ningaloo and dolphin and dugong interactions in Shark Bay (Fletcher & Santoro 2013).

Fishing is also a key component of many tourist visits, with a range of angling activities available.

5.4.3 Shipping and Maritime Facilities

The majority of shipping activities in the Gascoyne Coast Bioregion involve coastal cargo vessels, shipping activities associated with the two salt fields and fishing vessels operating out of the numerous small ports along the coast.

There are three deepwater port facilities currently operating in the Gascoyne: Useless Loop and Cape Cuvier (both private facilities servicing salt fields) and Point Murat, a naval port facility at Exmouth. Other harbours and maritime facilities can be found at Denham, Carnarvon, Coral Bay and Exmouth Gulf, all of which largely service local fishing and charter vessels. The expansion of oil and gas, along with increased recreational, charter and eco-tourism activities in the area has led to the expansion of many of these facilities.

Along with the privately managed Useless Loop salt facility port, there is a jetty and combined boat ramp and slipway on the foreshore of Denham. This facility caters to the commercial fishing fleet, as well as tourist and recreational boats in the World Heritage area of Shark Bay. This facility requires upgrading to meet with current demands, and community consultation is currently underway (GDC 2010b; Department of Transport WA 2012). There is also an extensive fishing boat harbour in Carnarvon, which is mainly used by scallop, prawn and other fishing boats, along with a new recreational boat ramp next to the pens of the Carnarvon Yacht Club (GDC 2010b).

5.5 Introduced Marine Species

In 2008, the Ports of Cape Cuvier, Useless Loop and Exmouth were assigned as low risk of introduced marine species (IMS) entering through ballast water and biofouling; however, the developments occurring within and immediately adjacent to this bioregion increase the likelihood of an invasive marine species introduction.

Oil and gas related developments within, and adjacent to, this region have their own ministerial guidelines to ensure marine and coastal resources are protected. These developments will be undertaking ‘proof of freedom’ pest monitoring to ascertain they have no pests present. As Exmouth is projected to be a transport hub for vessels moving to and from these developments, the onus will likely be placed on Exmouth Port to show pest free status.

Currently, there are no independent (non-private industry) marine pests monitoring programs (to the Australian National Standard) being conducted in the Gascoyne Coast Bioregion. To ensure the preservation of the areas unique coastal and marine attributes, it is recommended that a robust IMS monitoring program using the Australian "National System" be implemented in this region.

MSC Principle 1

MSC Principle 1 (P1) focuses on maintaining, indefinitely, fishing activity at a level that is sustainable for the targeted populations (MSC 2013).

6. Stock Status

The status of the stocks of brown tiger prawns and western king prawns in Shark Bay is assessed annually using a weight-of-evidence approach that considers all available information about the stocks (see Wise et al. 2007 for explanation of weight-of-evidence approach). The assessment approach, which is described in more detail in Section 7, is primarily based on monitoring of fishery-independent indices of recruitment and spawning stock levels relative to specified reference points. Although these abundance indices represent key indicators for the stocks, other information collected throughout the season (e.g. commercial catches, effort and environmental data, see Monitoring Section 8.4) is also evaluated to provide insight on, for example, any environmental factors affecting prawn recruitment.

6.1 Current Stock Status

At the time of writing this report, full assessments of the stocks of brown tiger prawns and western king prawns in Shark Bay were available for 2013, with some 2014 data also available for the two species. Both species are considered to have adequate spawning stock levels such that the only factor affecting recruitment is the environment.

6.1.1 Brown Tiger Prawns

Of the two target species in the SBPMF, brown tiger prawns are typically considered more vulnerable to overfishing than western king prawns because of their shorter breeding period and higher catchability (Penn & Caputi 1986). Therefore, monitoring and assessment has been largely focused on this species.

With the exception of 2012, the brown tiger prawn spawning stock index has fluctuated around the target level since 2002 (Figure 6.1). The spawning stock index in 2013 increased to be well above the limit reference point (10 kg / hr) and in 2014 the index increased to be above the target level (25 kg / hr; Figure 6.1). The reasons for the low brown tiger prawn spawning stock index (abundance) for the key northern spawning area (North CPL, formerly known as the TPSA) in 2012 is being examined (see below).

No declining trend in the fishery-independent recruitment index for brown tiger prawns is evident since 2000 (Figure 6.2), suggesting that recruitment variability in recent years has been driven largely by environmental factors given that the spawning stock is adequate. The recruitment index for this species in 2014 was within the historical levels and well above the target level of 25 kg / hr (Figure 6.2).

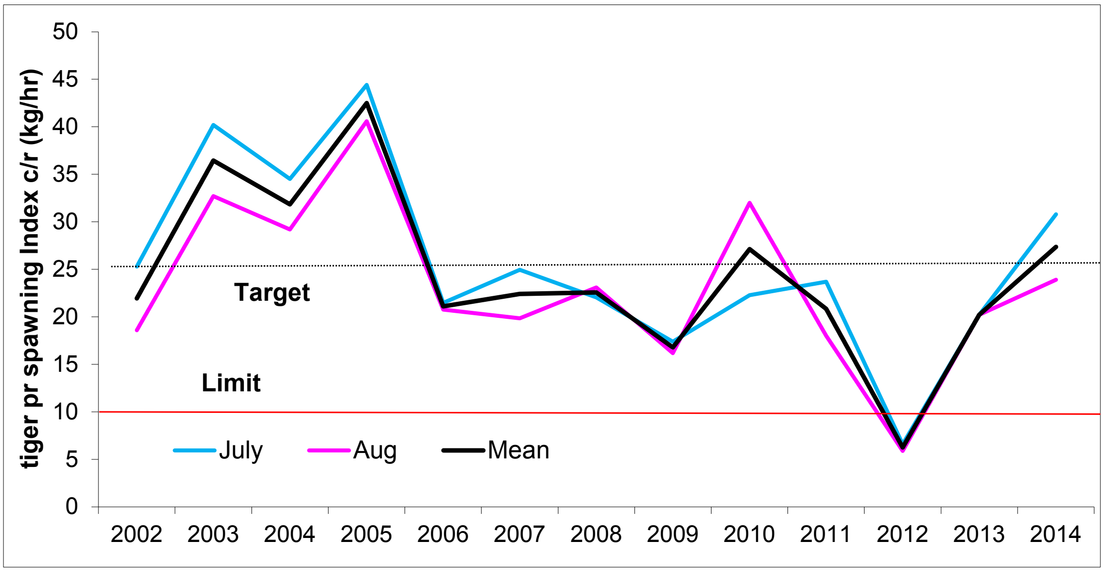

Figure 6.1 Mean catch rates of brown tiger prawn (quad gear equivalents) in the key northern spawning area, North CPL during July and August between 2002 and 2014 and target and limit reference points.

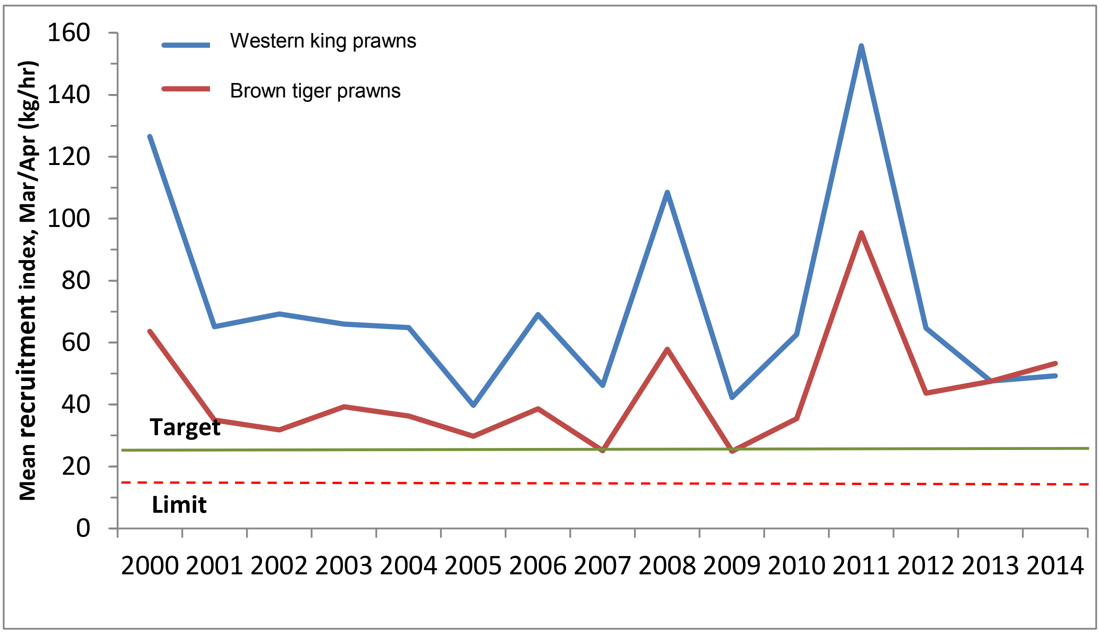

Figure 6.2. Mean recruitment indices for March and April surveys for brown tiger and western king prawns in Shark Bay from 2000 to 2014. The target and limit reference points are indicated.

There appears to be a poor correlation between spawning stock and recruitment levels of brown tiger prawns in Shark Bay between 2002 and 2014 (cf. Figure 6.1 and Figure 6.2; see also Figure 8.2 in Section 8.2.4), indicating that the spawning stock is being maintained well above the level that resulted in recruitment overfishing and subsequent low catches in the 1980s (Penn et al. 1995; see also Section 3.3). Very high recruitment occurred in 2011, probably due to favourable environmental conditions associated with the marine heatwave of late 2010 and early 2011 (Pearce et al. 2011).

Although the level of recruitment (and catch) of brown tiger prawns in Shark Bay in 2012 was well above the target reference level, the main abundance of this species in that year (as shown by commercial catch rates) occurred south of the northern spawning area. As of 2013, additional survey sites have been incorporated into spawning stock survey regime to provide a fishery-independent measure of spawning stock in the key southern spawning area (South CPL, formerly known as the ENA, and which has always closed from August onwards). This will be used in combination with the northern spawning area index in the future to provide a more robust overall spawning stock index than the northern spawning area alone. At this stage, the combined spawning stock index for 2013 and 2014 indicates that the abundance of brown tiger prawns in the southern spawning area in August / September is generally higher than in the key northern spawning area.

6.1.2 Western King Prawns

As western king prawns have a longer breeding period than brown tiger prawns and lower catchability (Penn & Caputi 1986), they have long been considered to be less vulnerable to overfishing. Although western king prawns are more widely distributed than brown tiger prawns in Shark Bay, the fishery-independent spawning stock survey undertaken for brown tiger prawns in the key northern spawning area also contains a significant proportion of western king prawns during the spawning period. It is thus considered appropriate that the catch rates of western king prawns from these surveys can be used as a fishery-independent measure of spawning stock abundance for this species (see Section 7.1.2 for more information).

Between 2002 and 2012 the western king prawn spawning stock has fluctuated around the target level of 25 kg / hr but has increased to well above this level in 2013 and 2014 (Figure 6.3). As with brown tiger prawns, there is no declining trend in recruitment evident in fishery-independent survey index for western king prawns since 2000 (see Figure 6.2 above). The annual western king prawn recruitment index is fluctuating at a level well above the target reference level each year, indicating most of recruitment variability is driven by environmental factors. The recent high abundance of western king prawns in Shark Bay is also evident in the large catches relative to fishing effort in the fishery over the past few years (see Section 3.3).

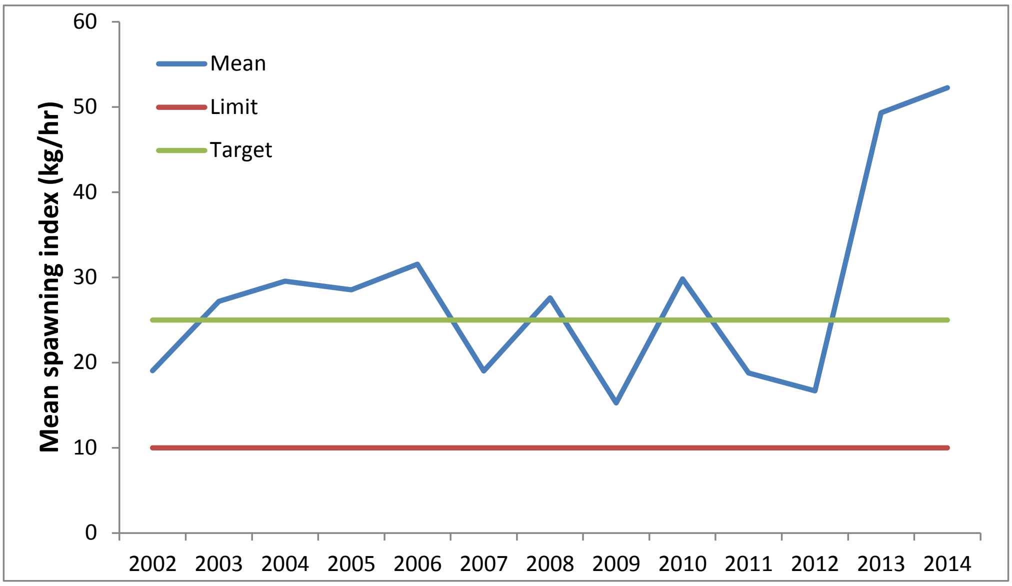

Figure 6.3. Mean catch rates of western king prawn (quad gear equivalents) in the North CPL during June to August between 2002 and 2014 and target and limit reference points.

There is no significant correlation between spawning stock and recruitment indices for western king prawns for the range of spawning stock levels observed in Shark Bay since 2001 (see Figure 8.3 in Section 8.2.4). This is believed to reflect the maintenance of the spawning stock above the levels that would result in recruitment overfishing (noting that there has never been a collapse of the western king prawn stock in Shark Bay). As with brown tiger prawns, high recruitment of western king prawns occurred in 2011, likely due to favourable environmental conditions associated with a combination of the marine heatwave and flood events of early 2010/11 (Pearce et al. 2011). A second peak in recruitment of this species observed in 2008 was also associated with above-average water temperatures due to a strong Leeuwin Current in that year.

7. Stock Assessment

7.1 Assessment Description

The stocks of brown tiger prawns and western king prawns in Shark Bay are assessed throughout each fishing season and at the end of each fishing season, based primarily on inter- and intra-annual trends in recruitment and spawning stock abundance relative to specified reference points (Section 8.2). Note, however, that the annual weight-of-evidence assessment of each species is based on all of the stock status information (i.e. catch, catch rates and size composition data) collected throughout the year (see Monitoring Section 8.4 for more detail).

7.1.1 Recruitment Indices

Before fishing commences in the eastern fishing grounds (east of the CPL) in Shark Bay, fishery-independent recruitment surveys are undertaken in March and April each year to provide abundance (and size / grade) information from the key recruitment areas for both species within these areas (see also Section 8.4.2.2.1 for more information about the recruitment surveys). The mean catch rate (kg / hr) for standardised sites for each of the two target species are used as indices of recruitment strength (derived from the previous year's spawning), which are compared to specified reference points (Section 8.2). The standardised sites take into account the migration patterns of each species from nursery areas so that the derived catch rates are a robust indicator of abundance of each species.

For each species, the relationship between the recruitment index and annual landings (between April and November) is also used to provide a catch prediction for the upcoming season.

7.1.2 Spawning Stock Indices

A spawning stock abundance index for brown tiger prawns in Shark Bay was historically determined from standardised commercial catch rates in the key brown tiger prawn fishing grounds during July and August (Penn et al. 1995). The boundaries of the key brown tiger prawn spawning area, the North CPL, were initially determined from a dedicated trawl survey in 1995, however, have since been re-defined over time in response to an increased understanding of where brown tiger prawns are spawning. Recent data has further demonstrated that these areas also represent an important spawning area for western king prawns in Shark Bay (DoF unpublished data).

Dedicated, fishery-independent surveys are now undertaken to measure the spawning stock abundance of brown tiger prawns (and western king prawns) in Shark Bay during the key spawning period (June to September), when the spawning areas are closed to fishing (see Section 8.4.2.2.2 for more information about these surveys). The fishery-independent spawning stock survey for brown tiger prawns in the key northern spawning area also contains a significant proportion of western king prawns during the spawning period and can thus be used as a fishery-independent measure for the western king prawn spawning stock abundance. Although western king prawns are more widely distributed than brown tiger prawns (also occur west of the CPL) and thus this measure does not represent the full distribution of the western king prawn spawning stock, the closure of this area provides protection of this component of the spawning stock during the spawning period.

In response to a review of the spawning stock survey methodology in 2013, spawning stock surveys for brown tiger prawns and western king prawns are now conducted in both the North CPL and South CPL (see Section 8.4.2.2.2; Figure 8.18). For each species, the annual mean catch rate from standardised sites, calculated based on all spawning stock surveys undertaken, provides an index of spawning stock abundance and is compared annually against reference points (see Section 8.2).

Note that another survey is undertaken in Denham Sound in July / August to provide further data for assessing the status of western king prawns (and to a lesser extent brown tiger prawns) prior to this area being opened to fishing (see Section 8.4.2.2.2.1).

7.2 Appropriateness of Assessment

The empirically-based stock assessment methodology that has been adopted for brown tiger and western king prawns in Shark Bay is reflective of their biology, life history, habitat preferences and inherent population variability. Short lifespans, inter-annual and intra-annual recruitment variability and spatial variations in size / maturity distributions are key factors in their biology that are explicitly accounted for within assessments to support the constant escapement-based harvest strategy (as described in Section 8).

The assessments of brown tiger and western king prawns are designed to not only maintain the sustainability of these stocks but also that of other retained species, provide the opportunity for industry to optimise the economic return to the fleet, and ensure cost effective management for the Department and therefore the benefits to the community. The assessments work together within a constant escapement harvest strategy to ensure that, irrespective of the level of recruitment, the appropriate amount of catch, and also size composition, is taken using the minimum amount of fishing effort annually.

7.3 Assessment Approach

As described in the above section, the approach used to assess brown tiger and western king prawns in Shark Bay provides adequate information for evaluating the status of these stocks in relation to specified, precautionary reference points (see Section 8.2).

7.4 Uncertainty in the Assessment

The stock assessments for brown tiger and western king prawns in Shark Bay are based on comprehensive and robust indices of abundance for the two species. Uncertainty in these performance measures is reduced by using data from fishery-independent recruitment and spawning stock surveys that have been collected using standardised sampling methods. The approaches employed to address the uncertainty in the measures that form the basis of the assessment include:

- Fishery-independent spawning stock surveys are designed to ensure that the same sites are sampled on the same moon phase each survey period for consistency. Due to the apparent low level of brown tiger prawn spawning stock in 2012, supplementary surveys were developed in the southern key spawning area which in combination of the northern key spawning area will provide a more robust index of spawning stock in the future.

- Uncertainty in the overall landings are accounted for by validating commercial catch data against processor unloads; however, each carton is weighed accurately onboard the boat. When unloaded each carton is counted by grade by the trucking company, and the total weight by grade are provided to the Department. Therefore, daily estimates of catch have a high degree of accuracy. There are multiple checks of the landed catch, i.e. trucking company and fishing company prior to data being received by the Department.

- Fleet behaviour, reduction of numbers of boats (over time) and major changes to fishing gear is dealt with through maintaining regular communication (including annual gear surveys) with fishers about their operations.

7.5 Evaluation of Assessment

Although the current assessment approach has been in practice since 2001 in Shark Bay, this same approach has been used for several decades for the same species in the Exmouth Gulf Prawn Managed Fishery. In Exmouth Gulf, this approach has been shown to maintain stocks at appropriate levels. On the two occasions when the brown tiger prawn stock collapsed from external causes, the stock recovered within the expected 3-4 years. This demonstrates that the constant escapement harvest strategy implemented for this fishery, and the associated stock assessments based on direct measurement of relative spawning stock levels that are used to inform management decisions, are robust.

The basis for the current assessment of brown tiger prawns is the stock-recruitment relationship (SRR) for this species in Shark Bay (Penn et al. 1995; Caputi et al. 1997; see Section 8.2.1). An alternative hypothesis that recruitment for these species was only environmentally driven was effectively tested in Shark Bay by not intervening or providing additional protection of the breeding stock when it had declined to low levels in the early 1980s. This strategy was shown to be incorrect because the recovery of brown tiger prawn stocks in Shark Bay took much longer than in Exmouth Gulf where management actions were implemented immediately. The recovery in Shark Bay only occurred when the spawning stock was eventually protected.

7.6 Peer Review of Assessment

The SRR that has underpinned the assessment of brown tiger prawns in Shark Bay has been published in the scientific literature (Penn et al. 1995). Significant independent peer review of all aspects of the fishery, including the stock assessment components have been conducted through the ESD assessments of the fishery to meet the Commonwealth's requirements for export accreditation under the EPBC Act (see Section 4.7).

Up until the third party certification initiative began in WA, whereby all the state's fisheries would undergo a pre-assessment review against the MSC standard for sustainability, the Department adopted a schedule for the periodic peer-review of assessments for all fisheries in WA. This "rolling" schedule aimed to generate major reviews of five to eight fisheries per year, employing a mix of internal and external fisheries experts (e.g. from universities, CSIRO and inter-state fisheries departments). The prawn fisheries in Exmouth Gulf and Shark Bay were both reviewed by Dr Malcolm Haddon (Marine Research Laboratory Tasmanian Aquaculture and Fisheries Institute, University of Tasmania) during a two-day workshop undertaken in November 2012.

8. Harvest Strategy

A harvest strategy (decision rule framework) for the SBPMF (DoF 2014a) makes explicit the management objectives, performance indicators, reference levels and harvest control rules for the brown tiger prawn and western king prawn resources, which are taken into consideration by the Department when preparing advice for the Minister for Fisheries. The harvest strategies have been developed in line with the Department's over-arching *Harvest Strategy Policy for the Aquatic Resources of Western Australia* (DoF in press) and relevant national policies / strategies (ESD Steering Committee 1992) and guidelines (e.g. Sloan et al. 2014). In addition to target species (i.e. brown tiger prawns and western king prawns) they also incorporate retained non-target species, bycatch, ETPs, habitats and ecosystem components to ensure the risks to these elements are effectively managed.

8.1 Framework

A summary of the harvest strategy in place for managing the brown tiger prawn and western king prawn resources in Shark Bay is presented in Table 8.1 (see also DoF 2014a). Additional information about the reference points and associated harvest control rules specified for these species is provided in Section 8.2 and 8.3. Information and monitoring undertaken to inform the harvest strategy and the overall weight-of-evidence approach used for assessing the status of these resources are outlined in Section 8.4.

8.1.1 Design

The harvest strategy for brown tiger and western king prawns in the SBPMF is based on a constant escapement harvesting approach. The use of a this type of approach recognises that short-lived prawn species exhibit naturally variable annual recruitment and that, regardless of the level of recruitment in any year, it is necessary to ensure that sufficient spawning stock is maintained. A detailed biological understanding of the two target species in the fishery (Section 2) has underpinned the development and application of in-season temporal and spatial closures in the fishery that contribute to the constant escapement harvest strategy and also generate economic benefits for the fleet (i.e. by minimising harvest of small-sized prawns which are less valuable than larger prawns). This harvesting approach has contributed to a high level of cooperation from industry regarding adherence to regulations.

Table 8.1. Summary of the Shark Bay Prawn Managed Fishery harvest strategy brown tiger and western king prawn stocks in Shark Bay. Note the reference levels essentially prescribe the operational objective which is to maintain each resource above the threshold level. * indicates decisions made prior to season opening and provided to fishers as part of annual season arrangements. Note that the actual starting date can be either March or April. If the latter, then opening / closing in subsequent months may be rescheduled, subject to survey results and species biology.

Component	Management Objectives	Species	Performance Indicators		Reference Levels	Control Rules
In-season Operations						
Target Species	**Ecological:** To maintain spawning stock biomass of each target species at a level where the main factor affecting recruitment is the environment.	Brown tiger & western king prawns	**Season Opening***	Feb/March lunar phase	After late Feb or March full moon phase. Depending on interannual variability in moon phases, fishing may start in 1st week of March	Fishing season opens and fishing permitted in area outside CPL and north of Denham Sound.
			All areas east of the CPL	Catch rates of western king and brown tiger prawns from recruitment surveys in areas inside CPL.	**Target:** Mean catch rate of either species is ≥ 25 kg / hr.	If the target level is met, area opens to fishing.
					Threshold: Mean catch rate of <u>either</u> species is < 25 kg / hr and >15kg / hr	Review options for modifying the spatial or temporal extent of fishing operations within the area.
					Limit: Mean catch rate of either species is ≤ 15 kg / hr.	If the catch rate of either species is below the limit, the area remains closed to fishing and a review is triggered to investigate the reasons for the low catch rate.
			North CPL (formerly TPSA) Closure*	June lunar phase	Start of June moon closure	North CPL key spawning area (formerly TPSA) closed to fishing; may be re-opened following September spawning stock survey (see North CPL Re-opening rules below)

Component	Management Objectives	Species	Performance Indicators		Reference Levels	Control Rules
			South CPL (formerly ENA) Closure*	August lunar phase	Start of August moon closure	South CPL key spawning area (formerly ENA) closed to fishing.
			North CPL (TPSA) Re-opening	Final fishing period.		North CPL (TPSA) re-opens to fishing on the third quarter moon phase of the final fishing period each year.
			Denham Sound Opening*	August lunar phase	July /August	Denham Sound area (excluding Denham Trawl Closure) opens to fishing based on July/August survey results.
			Denham Trawl Closure (Partial) Opening	Catch rates of western king and brown tiger prawns and snapper (no. of snapper per trawl hour) in fishery-independent stock surveys	Combined catch rates of both prawn species is ≥ 50 kg / hr AND pink snapper numbers at acceptable levels (< 200 snapper per trawl hour).	Partial opening of the Denham Trawl Closure by Notice for a fishing period of 10 days.
			Season Closure*	Number of total available fishing nights since the season opening date	Season has been open for a maximum of 175 fishing nights depending on other performance indicators.	Fishing season closes.

Component	Management Objectives	Species	Performance Indicators	Reference Levels	Control Rules
Annual Operations					
Target Species	**Ecological:** To maintain spawning stock biomass of each target species at a level where the main factor affecting recruitment is the environment.	Brown tiger & western king prawns	Catch rate of brown tiger and western king prawns from spawning stock surveys.	**Target:** Mean catch rate of each species is ≥ 25 kg / hr.	If the target level is met, no change to season management arrangements required for the following season.
				Threshold: Mean catch rate of either species is ≤ 25 and > 10 kg / hr.	A review of season arrangements and monitoring system is triggered to investigate the reasons for the variation, which may trigger changes to the arrangements for the following season if sustainability is considered to be at risk.
				Limit: Mean catch rate of either each species is ≤ 10 kg / hr.	If the catch rate of either species is at or below the limit, a comprehensive review of the fleet's spatial fishing pattern and catch rates are undertaken to investigate the reasons for the low catch rate in the monitored spawning areas. This will either trigger management actions to limit fishing on that species for the following season if sustainability is considered to be at risk or a change to the monitoring system if it is considered to be inaccurate.

The SBPMF harvest strategy involves constant monitoring of stock status of brown tiger and western king prawns from just prior to the commencement of fishing in each year to the end of each fishing season, based on a combination of fishery-dependent and fishery-independent data. In-season monitoring of catch rates and size-based performance measures for the two target species is used to determine (based on defined control rules) when to open and close certain areas of the fishery, to provide protection to spawning stocks, prevent growth overfishing and help facilitate optimal economic harvesting of the stock by industry. At the end of the season, the stocks of brown tiger and western king prawns in Shark Bay are assessed based on inter-annual trends in recruitment and spawning stock indices (against specified reference points), together with additional data on annual landings, fine-scale spatial data on patterns of fishing effort and catch, and size composition data. The end-of-season assessments are linked to control rules which ensure that, if stocks are considered to be at risk of other factors adversely impacting recruitment (i.e. environment), measures are in place to provide protection for the stocks during the next fishing season.

The reference points developed for brown tiger and western king prawns are based on a detailed understanding of the biology of these species, including key aspects such as their longevity, growth, movements and reproductive biology, including SRRs relationships (Penn et al. 1995; Caputi et al. 1997). This, combined with the history of detailed monitoring of the key target species, i.e. since early 2000, has led to a sound understanding of the level of spawning stock abundance of each species required to ensure that fishing does not impact on recruitment success.

Throughout much of the history of the fishery, brown tiger prawns were the primary focus of management with respect to sustainability, as this species has been found to be the most vulnerable to overfishing (Penn & Caputi 1986). This reflects the different reproductive and behavioural characteristics of brown tiger prawns compared with western king prawns. For example, brown tiger prawns spawn over a more restricted period of the year in Shark Bay and have a greater catchability due to reduced tendency to burrow.

The suite of management measures implemented to maintain the brown tiger prawn stock in Shark Bay (e.g. the brown tiger prawn spawning closure [North CPL]), also provide a significant level of protection to western king prawn spawning stocks (as well as other retained non-target species, e.g. blue swimmer crabs). The added measure of ceasing fishing in the South CPL from August when smaller western king prawns begin to appear in the catches provides protection to these new recruits that will contribute to the spawning stock the following year as well as to the larger brown tiger prawns in this area which will contribute to the spawning stock of the same year.

8.1.2 Evaluation

The success of the harvest strategy for brown tiger and western king prawns in the SBPMF is evaluated every year based on the performance of the fishery and the outcomes of the annual assessment of the species. The current harvest strategy has been developed over the past 20 years allowing its performance to be comprehensively evaluated and refined over time.

During this time the harvest strategy has been demonstrated to be effective in ensuring that recruitment is not adversely impacted by fishing.

Relatively stable landings have been maintained in the SBPMF despite both species having highly variable, environment-driven recruitment. The brown tiger prawn spawning stock index has triggered the limit reference point only once (in 2012) since monitoring began in 2002 and is currently above target level. Catch rates of western king prawns from the spawning stock surveys have been above or fluctuating around the target level in all years. Indices of recruitment levels of both species have always been above the target reference level. Together these suggest that the harvest strategy has been successful in meeting the management objective of maintaining the stock at levels where the main factor affecting recruitment is the environment.

The harvest strategy has also been shown to be effective for rebuilding stocks of the target species. During the early 1980s tiger prawns stocks were depleted in both Shark Bay and Exmouth Gulf, prior to the introduction of the harvest strategy. In Exmouth Gulf, a similar harvest strategy was introduced and led to the stock being rebuilt within three to four years by the mid-1980s. In comparison, the management response in Shark Bay was delayed until the early 1990s, because the Departmental focus had been on Exmouth Gulf, during which time there was little evidence of stock recovery. Following the introduction of the present harvest strategy, recovery of the brown tiger prawn stock was rapid (Penn et al. 1997). The harvest strategy in place for both these fisheries now ensures a quick response to stock decline.

8.1.3 Monitoring

As outlined in Section 8.4, the SBPMF has a comprehensive monitoring program, including collection of both fishery-dependent and fishery-independent data for both brown tiger and western king prawns. The provision of data throughout the fishing season permits rapid detection of changes in catch rate and prawn size, which in combination with the highly responsive management system can quickly enact control rules (see Section 8.3) to ensure that the spawning stocks of the target species are sufficiently protected.

The performance of the harvest strategy in maintaining spawning stock abundance at appropriate levels for both species is monitored annually and reported within the annual *Status Reports of the Fisheries and Aquatic Resources of WA: the State of the Fisheries* (e.g. Fletcher & Santoro 2013), as well as in industry reports and at Annual Management Meetings.

8.1.4 Review

Elements of the harvest strategy have been reviewed a number of times over the past 20 years. These reviews have mostly been in response to changes in fleet dynamics (boat numbers, net configurations, headrope lengths and regular changes to gear to improve fishing efficiency). The spatial extent of the permanently closed nursery areas for protecting juvenile prawns have been increased three times (see Appendix B) and the location and extent of the brown tiger prawn spawning area has been adjusted twice; first in the 1980s to better reflect the main areas of abundance of this species and second in 2001 when the current North CPL area was formally defined. The implementation of the harvest strategy is continuously reviewed incorporating all the information available at the commencement of the season and marked changes to fishing operations (ie. fleet size, changes in gear and technology) and economics of fishing.

The SBPMF harvest strategy for brown tiger and western king prawns, including the performance measures and control rules, was externally reviewed in 2012 by Dr Malcolm Haddon (CSIRO). Review of the harvest strategy has also been undertaken through the process of the fishery being assessed multiple times against the Commonwealth's requirements for export accreditation under the EPBC Act (see Section 4.7).

8.2 Reference Points

A range of annual and in-season references points are used for the target species in the SBPMF (Table 8.1). The reference points are predominantly based on fishery-independent catch rates, which represent the primary performance measures for the fishery and are designed to preserve sufficient spawning stock whilst also providing industry the opportunity to optimise economic efficiencies. A number of additional reference points (e.g. relating to the size of prawns) also exist and trigger spatial and temporal closures in the fishery (Table 8.1).

For reference points associated with stock performance, three levels are in place; target, threshold and limit. Target levels correspond to stock levels at or above B_{MSY} and limit levels correspond to stock levels below which future recruitment levels will be directly affected. Consistent with the Harvest Strategy Policy (DoF in press), threshold levels are intermediate levels between the target and the limit and designed to ensure that management actions are taken before a stock triggers the limit level.

8.2.1 Appropriateness of Reference Points

For brown tiger prawns, catch and effort data from the 1970s and 1980s, when recruitment of this species was found to have been affected by low spawning stock, were used to develop a robust SRR for this species in Shark Bay (Penn et al. 1995; Caputi et al. 1997; see Figure 8.1). From these data, catch rate-based reference points have been developed into a set of robust performance measures for this species. These reference points have continued to be refined over time and adjusted to reflect changes in fleet efficiency, gear types, and the economic objectives of Industry. Although developed for brown tiger prawns, they have also been demonstrated to be equally suitable for western king prawns, a species that is inherently less vulnerable to the fishery due to its behaviour and life history characteristics.

The use of empirically-based reference points for brown tiger and western king prawns in the SBPMF is appropriate given the biology of the target species. Brown tiger and western king prawns have high instantaneous rates of natural mortality and only a relatively small proportion of individuals survive each year. There is no long-term accumulation of spawning stock biomass and an ongoing need to adjust fishing to account for intra- and inter-year variability in the timing and strength of recruitment.

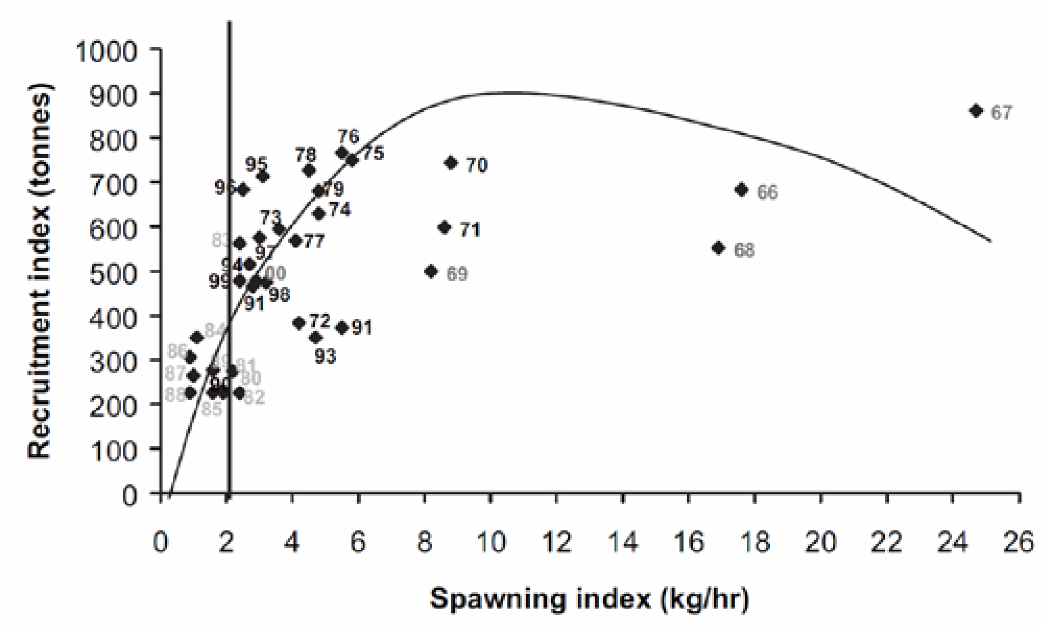

Figure 8.1. The SRR for the Shark Bay brown tiger prawn with the years of spawning and recruitment the following year indicated. The original reference point of 2 kg / hr is indicated with a vertical line.

8.2.2 Level of Target Reference Points

The target reference point is particularly important for the SBPMF; in addition to maintaining the stock at a precautionary level, it also takes into account economic objectives recognised by Industry. During in-season operations fishing typically ceases as the target level is approached in order to optimise economic returns. Consequently, threshold and limits, while in place, are unlikely to be triggered under normal environmental condition.

A target level of ≥ 25 kg / hr is used for both brown tiger and western king prawns and applies to both the recruitment and spawning stock indices (Table 8.1). The target level is based on a brown tiger prawn SRR developed in the 1980s using commercial logbook information (Figure 8.1). This target was originally set at a lower level but has been modified through time, based on the robust fishing gear comparisons, to account for fishing gear and efficiency changes (Table 8.2).

Based on the original SRR, the target level was considered as 3-4 kg / hr, and the threshold / limit was considered as 2 kg / hr. In 2001 the target level was subsequently increased to 10 kg / hr. This was done to account for gear and efficiency changes as well as limitations in the early spatial resolution of logbook data that meant areas were included in the analysis that were not reflective of brown tiger prawn spawning stock abundance. In 2005, discussions with industry led to a more conservative target level of 20 kg / hr as it was agreed that 10 kg / hr may not have accounted sufficiently for all the efficiency changes over time. The current target of 25 kg / hr was set in 2007 and was based on further adjustment to account for the use of quad trawl gear (see Appendix C). The target level of 25 kg / hr has proven successful in maintaining consistent catches of brown tiger and western king prawns, providing strong evidence that it is at a level that corresponds with, or is above, B_{MSY} for both species.

Table 8.2. Explanation of catch rate target level adjustments through time. (Note that original term was threshold but is referred to as target in this document).

Year	Level	Target % increase	Explanation
1970s	3 – 4 kg / hr	N/A	Fishery-dependent data on catch rates.
2001	10 kg / hr (twin gear)	250 %	Based on fishery-dependent data on catch rates in the 1970s to represent 2 – 4 kg / hr
2005	20 kg / hr (twin gear)	100 %	Increased in consultation with industry to be more conservative.
2007	25 kg / hr (quad gear)	37.5 %	Increased due to larger nets.

8.2.3 Level of Threshold Reference Points

Consistent with the Harvest Strategy Policy (DoF in press), threshold reference levels have been adopted for brown tiger and western king prawns in the SBPMF, which are designed for management actions (and review) to be instigated well before the limit reference point is breached.

A threshold catch rate of between 15 kg / hr and 25 kg / hr is used for the recruitment indices of both brown tiger and western king prawns (Table 8.1). For the spawning stock indices of each species, the threshold catch rate is between 10 kg / hr and 25 kg / hr. This threshold level is considered to be well above the level where recruitment is impaired.

8.2.4 Level of Limit Reference Points

A limit of ≤ 15 kg / hr applies to the recruitment indices for both brown tiger and western king prawns. A limit of ≤ 10 kg / hr is used for the spawning stock indices of both species (Table 8.1). This current spawning stock limit reference point is based on knowledge of SRR for brown tiger prawns (Figure 8.1) and is considered to be sufficiently conservative because, for each species, values of the spawning stock index between the target (25 kg / hr) and the limit (10 kg / hr) have still generated acceptable recruitment levels the following year (Figure 8.2 and Figure 8.3).

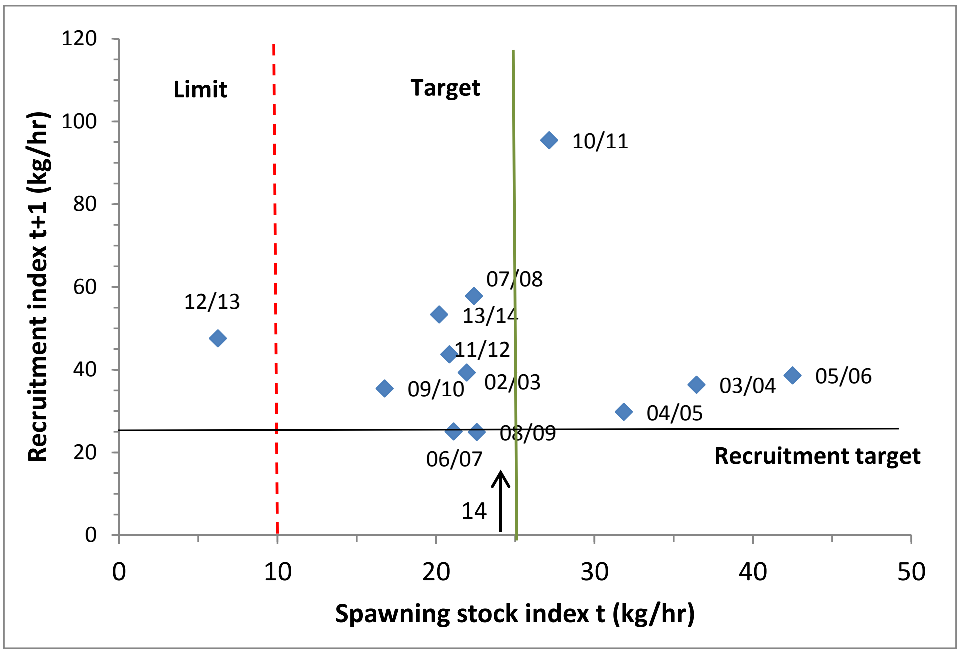

Figure 8.2. Relationship between the brown tiger prawn spawning stock survey index (kg / hr) during July and August in the North CPL in year t and the mean recruitment index (kg / hr) during March and April in year t+1 in Shark Bay between 2002 and 2013. Note the spawning stock index for 2014 is indicated.

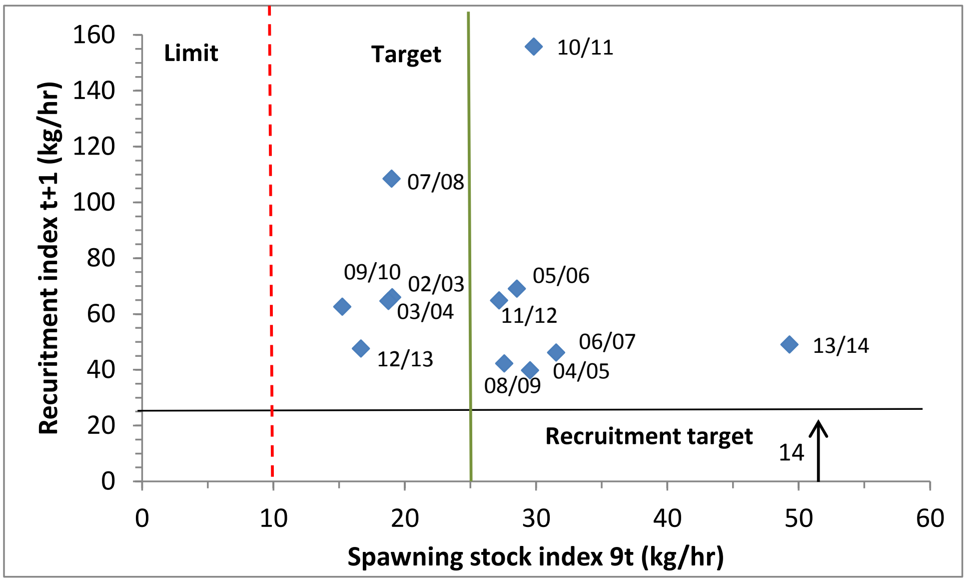

Figure 8.3. Relationship between the western king prawn spawning stock survey index (kg / hr) during July and August in the North CPL in year t and the mean recruitment index (kg / hr) during March and April in year t+1 in Shark Bay between 2002 and 2013. Note the spawning stock index for 2014 is indicated.

8.2.5 Additional Reference Points

Note that some additional reference points are used during in-season operations in the SBPMF but are not explicitly associated with a target, threshold or limit stock levels (Table 8.1). The timing of lunar phases between March and August (variable from year to year) are used as triggers for several of the rolling spatial openings and closures in the fishery. For example, following the March full moon phase fishing is permitted in the area outside the CPL and north of the Denham Sound line. A combined catch rate of both species ≥ 50 kg / hr in the Denham Sound spawning stock survey along with low-levels of snapper bycatch (< 200 snapper / trawl hour) also triggers a partial opening of the Denham Trawl Closure for a period of 10 days.

8.3 Control Rules and Tools

8.3.1 Design and Application

Harvest control rules are in place for the SBPMF that are consistent with the constant escapement harvest strategy for the fishery (DoF 2014a). The control rules are directly responsive to changes in the catch rate and size-based performance measures for brown tiger prawns and western king prawns, which are critical for ensuring the sustainability of the stocks of these species.

The harvest control rules for the SBPMF are designed to meet the ecological objectives of the fishery by minimising fishing of vulnerable life stages (e.g. pre-spawning and small prawns), whilst also optimising economic efficiencies. In-season control rules govern the timing and duration of fishing in particular areas of the fishery throughout the season, with annual control rules in place to ensure that the season arrangements are effective in maintaining sufficient spawning stock so that recruitment is not impaired. Table 8.1 outlines the control rules in place for the SBPMF and Figure 8.4 illustrates how they guide the annual operations of the fishery.

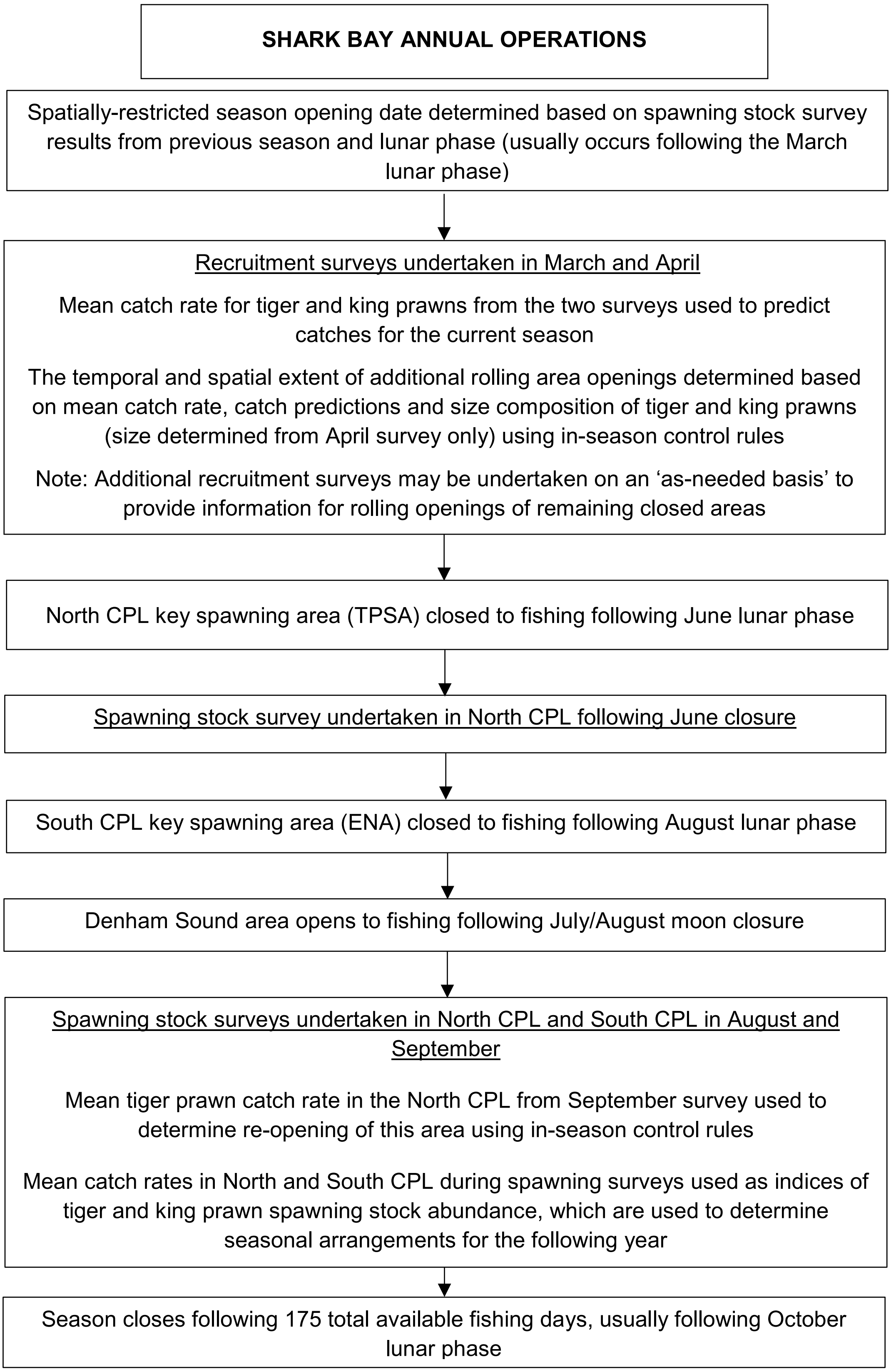

Figure 8.4. Flowchart of the general annual harvest strategy operations in the SBPMF

Additionally, Figure 8.5 to Figure 8.13 (see below) provides a visual representation of the effect of control rules on harvest within in a season.

8.3.1.1 In-season control rules

- **Season opening**: The timing of the March lunar phase dictates when the fishery can open. Under the control rule fishing is permitted in the area outside the CPL and north of the Denham Sound line. These decisions are based on the historical understanding of prawn biology and when migration onto the trawl grounds occurs. Fishing activities early in the season are predominantly focused on the capture of larger residual western king prawns (and in some years brown tiger prawns) and avoiding small prawns moving through areas of the fishery.
- **Opening areas east of the CPL**: Catch rates of western king and brown tiger prawns from both recruitment surveys determine when and what areas open to fishing during the main part of the season. Catch rates above target levels permit an area to open to fishing. Catch-rates below the threshold trigger a review of the spatial and temporal extent of areas opened. Catch rates below the limit result in an area remaining closed to fishing. The purpose of these control rules is to limit total effort through spatial and temporal closures in order to reduce exploitation of the spawning stock biomass.
- **North CPL and South CPL closures**: The June lunar phase triggers the closure of the North CPL. Its purpose is to protect spawning brown tiger prawns as well as western king prawns. The lunar phase around the beginning of August triggers the closure of the South CPL to fishing. Its purpose is to protect spawning brown tiger prawns and small western king prawns that move onto the fishing grounds after over-wintering in the nursery grounds.
- **North CPL re-opening**: This area re-opens to fishing from the third quarter moon phase of the last fishing period for the season because the prawns in this area are likely to have spawned more than once and majority of prawns (both species) have migrated out of the area.
- **Denham Sound and Trawl Closure opening**: The August lunar phase may trigger the opening of Denham Sound (excluding the Denham Trawl Closure) to fishing. This area opens late in the season to restrict effort and protect small sized western king prawns. High ($\geq$ 50 kg / hr) catch rates of prawns and a low by-catch of snapper (< 200 snapper / trawl hour) may also trigger a partial opening of the Denham Trawl Closure for a period of 10 days. This control rule is similarly designed to restrict effort, and also ensures low-incidental capture of snapper, a species important to recreational anglers in Shark Bay.
- **Season closure**: This control rule is designed to control effort levels and protect small prawns that start to occur on fishing grounds towards the end of the season, ensuring a flow through of prawns to the next season. The season closure date is set such that fishing cannot exceed a maximum of 175 fishing nights.

8.3.1.2 Annual Control Rules

Control rules associated with spawning stock indices for brown tiger and western king prawns are in place to ensure the effectiveness of the annual operations of the fishery in maintaining sufficient spawning stock. Catch rates above target levels result in no changes to season management arrangements for the following year. Catch rates below the target level (in the threshold range) trigger a review of management arrangements for the next season, which may subsequently result in management action if sustainability is considered to be at risk. Catch rates below the limit will trigger a review of the fleet's spatial fishing patterns and catch rates to investigate why stock abundance is low. This will either result in more severe management action to protect the stock, or a change in monitoring if it is considered to be inaccurate.

8.3.2 Accounting for Uncertainty

Harvest control rules in place for the SBPMF are highly precautionary and as such are designed to account for a wide range of uncertainties. In addition to control rules that operate on an annual basis, there are many well-defined in-season control rules. These ensure a rapid response to evidence of stock depletion and are appropriate given the biological characteristics of the target species. Also important are the existence of control rules associated with both the opening and closing of the main fishing grounds. For example, catch rates from the recruitment surveys must demonstrate that the stock is above target levels before fishing can commence within the areas east of the CPL in a given season. Control rules also govern the total number of fishing nights within the season, restricting the total level of exploitation that can occur given the fishery is a limited entry fishery and effort is partly constrained by a maximum fleet headrope allocation (as a standardised fleet).

8.3.3 Evaluation

Evidence indicates that the current harvest control rules are appropriate and effective in achieving target exploitation levels. With the exception of 2012, catch rates of brown tiger prawns from the spawning stock surveys, a key annual performance indicator, have fluctuated around the target level and above the limit level since 2002 (see Section 6.1.1 for a review of the cause of the low brown tiger prawn spawning stock index for 2012 and what the outcomes were). Catch rates of western king prawns from the spawning stock surveys have fluctuated around the target level in all years since 2002. In summary, there is strong evidence that the harvest control rules for both species are working effectively for achieving acceptable exploitation levels.

8.4 Information and Monitoring

8.4.1 Range of Information

Research and monitoring of the prawn fishery in Shark Bay has been conducted since the commencement of the fishery in the 1960s and there is a comprehensive range of information available to support the harvest strategy for brown tiger and western king prawns (Table 8.3).

Commercial catch and effort statistics (for both target and byproduct species) have been collected from the Shark Bay trawl fleet since 1962 through daily logbooks (Section 8.4.2.1). These data, which are validated by processor unloads and VMS, provide a valuable long-term data set spanning varying effort levels and environmental conditions. As the biology and movement patterns of brown tiger and western king prawns in Shark Bay became better understood and spatial and temporal fishery closures were implemented to protect spawning prawns, these fishery-dependent data alone were no longer considered adequate as the single source of information for monitoring these stocks.

Fishery-independent recruitment and spawning stock surveys have been undertaken annually since 2000 to determine the brown tiger and western king prawn recruitment and spawning stock levels. These measures of prawn abundance are used to assess the performance of the fishery each year and ensure that there is a sufficient level of escapement of prawns to sustain a sufficient level of breeding stock.

In addition to an abundance of biological information available from studies of the brown tiger and western king prawn stocks in Shark Bay (see Section 2), several FRDC-funded projects have examined various aspects of this fishery over the past decade. These have included:

- A study of the effectiveness of bycatch reduction devices in trawl nets was completed in 2002 (Kangas & Thomson 2004; Broadhurst et al. 2007).
- A biodiversity project comparing faunal assemblages in trawled and untrawled areas within Shark Bay was completed in 2007 (Kangas et al. 2007; Kangas & Morrison 2013).
- A collaborative study with researchers at Edith Cowan University analysed prawn logbook data using geostatistics to provide a better understanding of stock and fleet dynamics and to assess the appropriateness of the North CPL was completed in 2008 (Mueller et al. 2008, 2012).
- A project undertaken in collaboration with researchers at the University of Western Australia focused on minimising gear conflict and resource sharing issues in Shark Bay, and which included oceanographic modelling of prawn and scallop larval movement within the embayment (Kangas et al. 2012).

Data on environmental variables (e.g. Leeuwin Current strength, rainfall and temperature) that have shown to be important drivers of recruitment of prawns are also collected in Shark Bay annually.

Table 8.3. Summary of monitoring of brown tiger and western king prawns in the SBPMF

Data type	Fishery-dependent or independent	Analyses and purpose	Areas of data collection	Frequency of collection	History of collection
Daily logbooks	Dependent	Catch and effort trends, calculation of commercial catch rates and area trawled	Detailed, by shot latitude and longitude	Daily (shot-by-shot since 1998)	Since 1962 Compulsory since 2008
Processor unloads	Dependent	Validation of logbook catches	Shark Bay	Monthly	Since 1960s
VMS	Dependent	Verification of boat locations for logbook analysis	Shark Bay	Every fishing season	Since 2000
Recruitment surveys	Independent	Catch rates provide indices of recruitment strength for tiger and king prawns and is used to predict catches for season Size composition data are used to inform the rolling opening/closures of different fishery areas during season	Eastern Shark Bay	March and April	Since 2000
Spawning stock surveys	Independent	Catch rates provide indices of spawning stock abundance, which is used to determine the SRR for both species Provides information on sex ratios and the reproductive stage of female prawns	North CPL, South CPL and Denham Sound	June, August and September	Since 2002
Biological information	Dependent and independent	Patterns of growth and reproduction, stock structure	Shark Bay	Occasional	Since 1970s

8.4.2 Monitoring

8.4.2.1 Fishery-Dependent Monitoring

Licensees involved in fishing operations and / or the master of every licensed fishing boat are required by law to submit accurate and complete catch and effort returns on forms approved by the Department. Daily logbooks (see example provided in Appendix D) have been completed by all skippers in the Shark Bay prawn fishery since 1962, and have been a compulsory requirement since 2008. Prior to 1998, daily catches and nominal effort were reported by 10 × 10 nm blocks or fishing grounds but are now recorded by the latitude / longitude of the start location for each trawl shot. Fishers record the start position, start time, duration and mean depth of each trawl, as well as the catches of each retained species in each trawl, interactions with ETP species and environmental data (water temperature and moon phase). Log sheets are completed daily and returned to the Department after each fishing period (approximately monthly).

The daily logbook data are entered into a database, with various computer-automated checks applied to ensure the data are entered accurately (e.g. to detect if required fields are missing). The data are also examined visually by experienced research staff to detect any unusual entries that may not have been picked up by computer validation procedures. Any anomalies that cannot be easily dealt with would be followed up directly with the relevant vessel skipper.

Unload information and prices have been provided by processors since the early 1960s and are used to validate the logbook data. Daily logbook estimates of catches are adjusted (scaled up or down) to actual landings as recorded from processor returns, which provide the most accurate measure of the total retained catch in the fishery.

8.4.2.1.1 Commercial Catch

Analysis of commercial catch data for the SBPMF shows that the dominant species in the overall annual catch is western king prawns (see Section 3.3 for a catch summary). Brown tiger prawns, due to the shorter recruitment period, tend to diminish in abundance by the fifth fishing period, after which the western king prawns dominate the catches and brown tiger prawns catches fall to low levels (see Section 8.4.2.1.3 below for more information on the temporal variation in catch rates of the two species in Shark Bay).

Exploration of the spatial distribution of catches of brown tiger and western king prawns shows that catches of the two species in Shark Bay generally overlap (Figure 8.5).

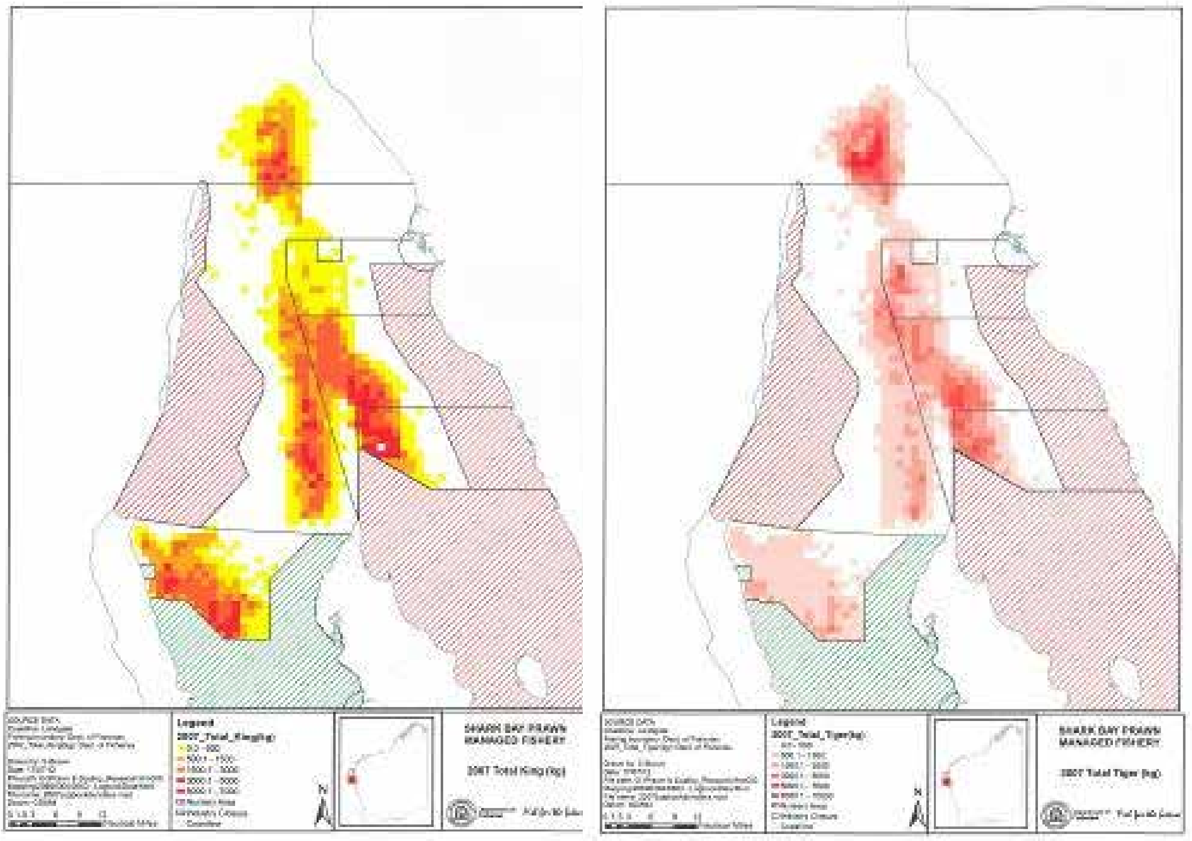

Figure 8.5. Spatial distribution of catches of western king prawns (left) and brown tiger prawns (right) in Shark Bay in 2007.

8.4.2.1.2 Commercial Effort

Nominal effort in the SBPMF is obtained from the daily logbook sheets completed by all skippers and is recorded as minutes trawled (and converted to hours). Between 1965 and 1991, nominal effort was adjusted using 'standard boats' (i.e. those boats that were considered to be consistent between years and had the same skipper) to determine relative fishing power. The effort was then allocated to each species by two methods; fishing ground and proportion of preferred habitat type given (Hall & Penn 1979). This was deemed to be 'effective effort'. The methodology was discontinued in 2005 due to changes in the skipper, boats and trawl gear configuration.

Since 2005, nominal effort has been adjusted to the size of nets used so that the whole time series is comparable and related to twin gear (2 × 7.5 ftm nets). The adjusted effort takes into account changes in the net size but does not consider other increases in catch efficiency (e.g. changes in gear design, net material and fishing technology, as well as skipper knowledge and experience). A system of fishery-independent surveys has been established to monitor the performance of the fishery to reduce the importance of these changes in efficiency over time.

8.4.2.1.3 Commercial Catch Rates

Commercial catch rates for brown tiger and western king prawns in the SBPMF are calculated based on the validated catch and effort data obtained in the daily logbooks. Since

1998, when this information has been reported on a shot-by-shot basis, the spatial resolution of the data is by 1 × 1 nm blocks, based on the start latitude and longitude for each trawl (typically ranging in distance from 1 to 3 nm).

Due to the overlap of the spatial distributions of the brown tiger and western king prawns in Shark Bay (see Figure 8.5 above), the effort is not apportioned by species when determining catch rates. Although past studies (Hall & Penn 1979) have shown that brown tiger prawns tend to prefer mud / sand sediments and western king prawns prefer slightly harder sandy sediments, the fine-scale spatial data from logbooks and fishery-independent surveys indicate that both species occur in most areas of the fishery but can differ in their abundance depending on annual recruitment strength and migration patterns (Figure 8.6). Apportioning effort to each species would be difficult for this fishery because of a range of factors that influence the catchability and, consequently, the targeting of each species by fishers (i.e. moon phase, sediment, temperature and area openings).

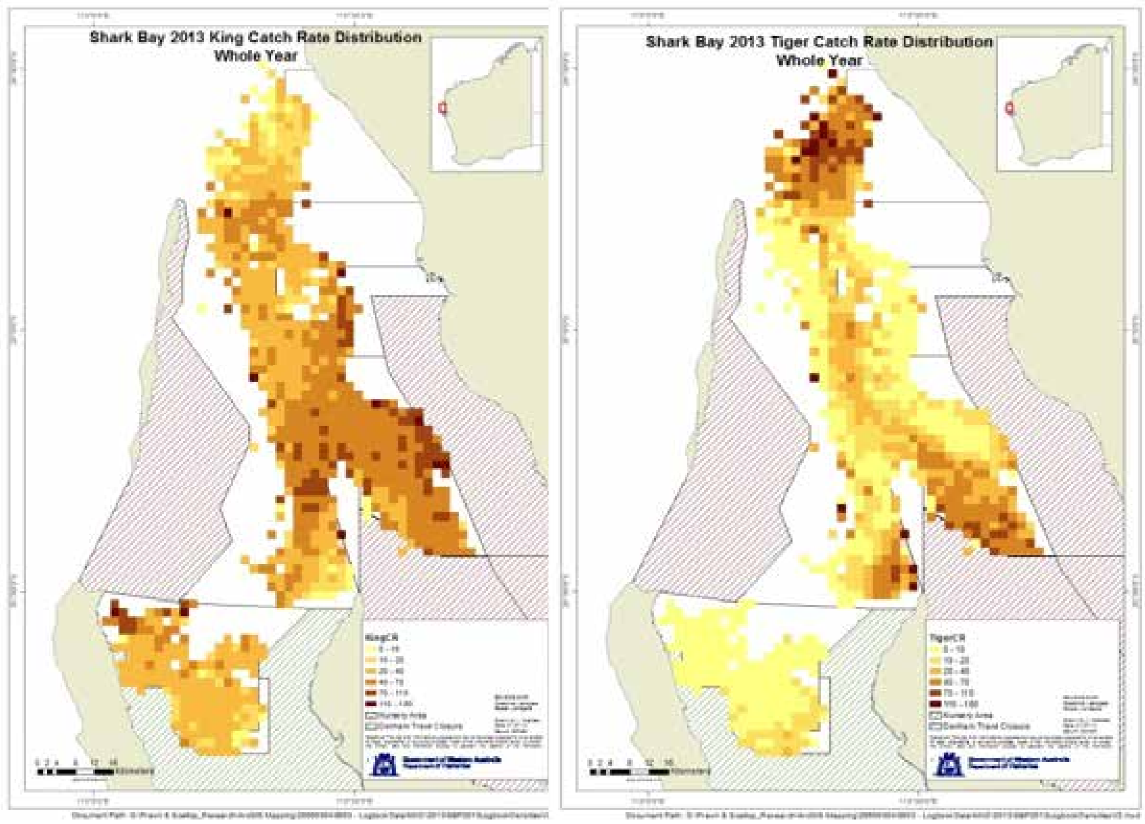

Figure 8.6. Spatial distribution of catch rates of western king prawns (left) and brown tiger prawns (right) in Shark Bay in 2013

Due to the general overlap in the spatial distribution of brown tiger and western king prawns in Shark Bay, the overall fishing area that is covered by the SBPMF remains similar between years. Nonetheless the abundance (catch rates) of the two species can vary between years and is also influenced by the seasonal area openings and closings.

Figure 8.7 to Figure 8.13 below illustrate the spatial and temporal changes in the catch rates of western king prawns and brown tiger prawns over the course of a typical fishing season.

2013 Catch Rate Monitoring

- During the first fishing period (2 – 24 April; see Figure 8.7), only areas west and north of the CPL are open because generally the prawns east of the CPL are small at this time of year. The highest catch rates of western king prawns were found directly adjacent to the CPL and in the northern area just north of the CPL. Brown tiger prawns had highest catch rates west of Cape Peron and north Koks Island.
- During the second fishing period (29 April – 23 May; Figure 8.8), the areas west of CPL were open and the area in North CPL opened on 17 May. The highest western king prawn catch rates still adjacent to the CPL and in eastern side of the North CPL. Brown tiger prawn catch rates were highest in the same areas as in Period 1 but the overall catch rates had declined.
- During the third fishing period (28 May – 21 June; Figure 8.9) the Central CPL opened on 1 June with high catch rates of both western king and brown tiger prawns. The western king prawns were more concentrated on the eastern parts whilst the brown tiger prawns were more concentrated in the Central CPL area. There is virtually no effort in the northern part of the fishery during this time due to the high catch rates in the newly opened area.
- During the fourth fishing period (26 June – 22 July; Figure 8.10) the South CPL area opened on 29 June with high catch rates of both species with the catch rates of western king prawns still remaining high in the Central CPL area. The North CPL was closed at this time.
- During the fifth fishing period (26 July to 18 August; Figure 8.11) western king prawn catch rates remain moderate while the brown tiger prawn catch rates have declined in the areas open to fishing because the North CPL and South CPL (closed 26 July) have been closed to protect the spawning stock. This is when western king prawns are migrating to the west and central parts of Shark Bay. In response, the extent of fishing has expanded to areas west and north of the North CPL.
- During the last two fishing periods (Figure 8.12 and Figure 8.13), Denham Sound opens to fishing, and most of the fishing occurs in Denham Sound and west Peron, with western king prawns dominating the catches (and catch rates). In recent years the Denham Sound area is only open to fishing from July/August onwards to avoid the capture of small prawns early in the season.

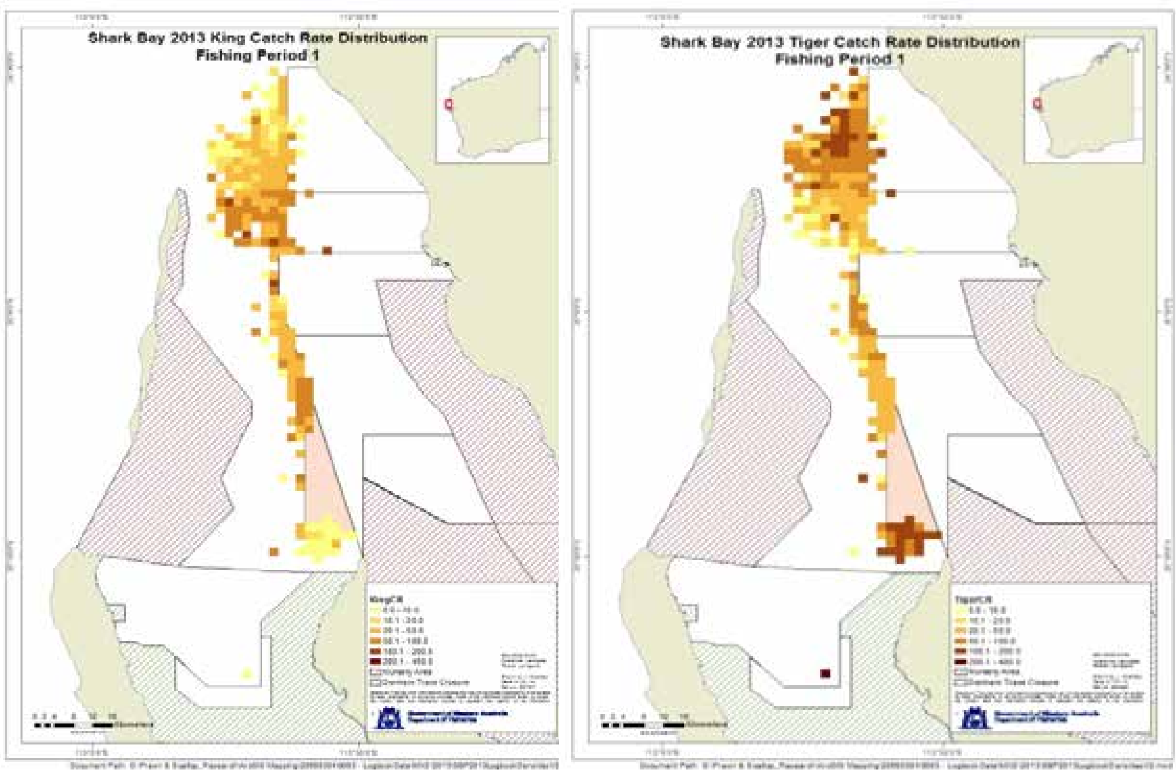

Figure 8.7. Spatial distribution of catch rates of western king prawns (left) and brown tiger prawns (right) in Shark Bay during the first fishing period in 2013

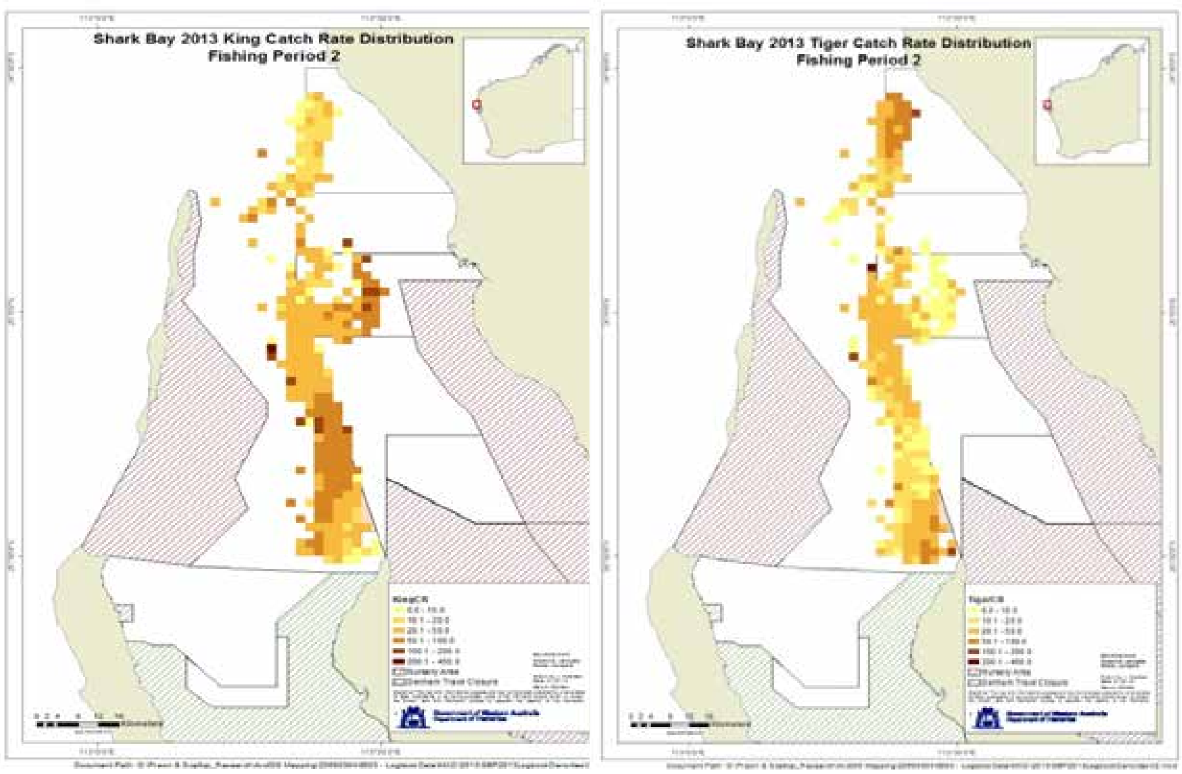

Figure 8.8. Spatial distribution of catch rates of western king prawns (left) and brown tiger prawns (right) in Shark Bay during the second fishing period in 2013

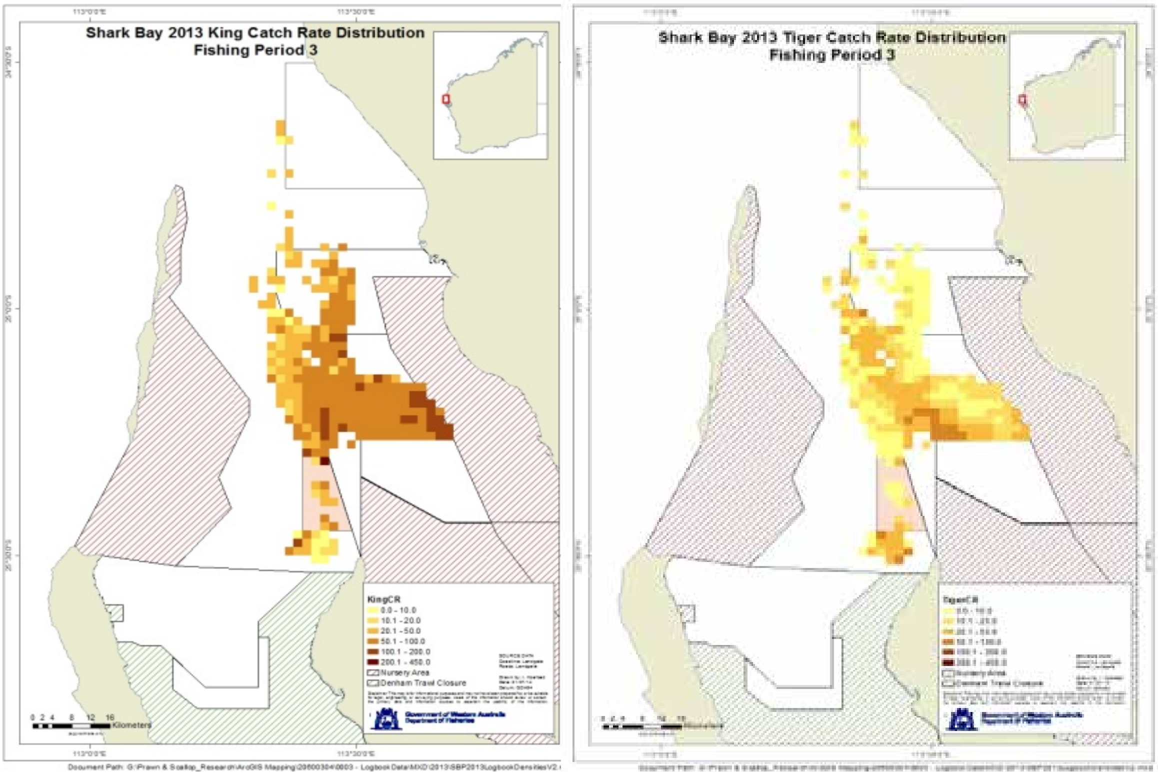

Figure 8.9. Spatial distribution of catch rates of western king prawns (left) and brown tiger prawns (right) in Shark Bay during the third fishing period in 2013

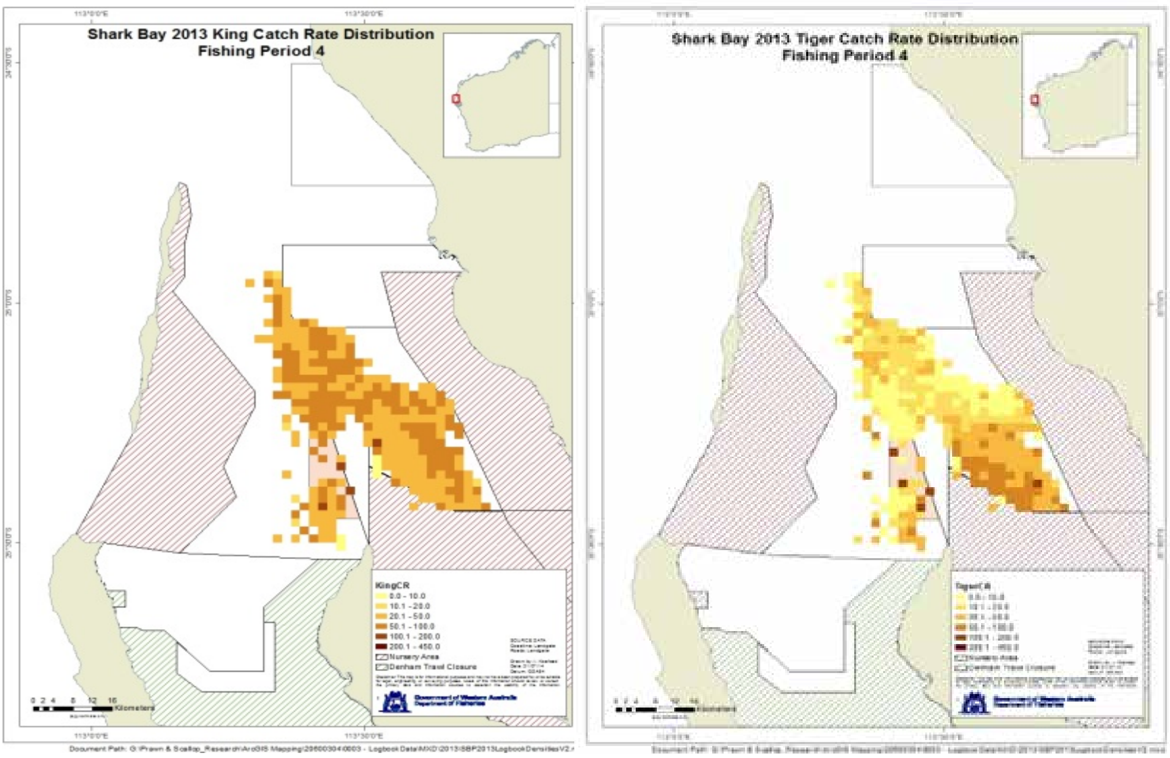

Figure 8.10. Spatial distribution of catch rates of western king prawns (left) and brown tiger prawns (right) in Shark Bay during the fourth fishing period in 2013

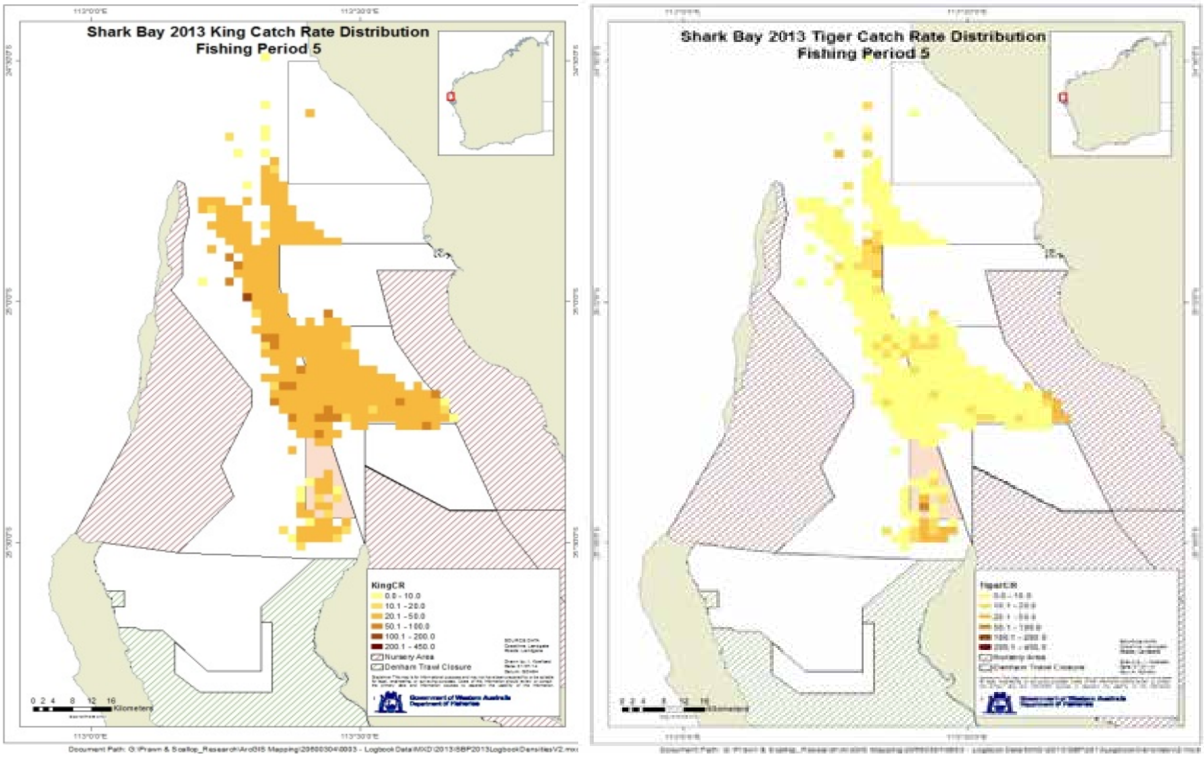

Figure 8.11. Spatial distribution of catch rates of western king prawns (left) and brown tiger prawns (right) in Shark Bay during the fifth fishing period in 2013

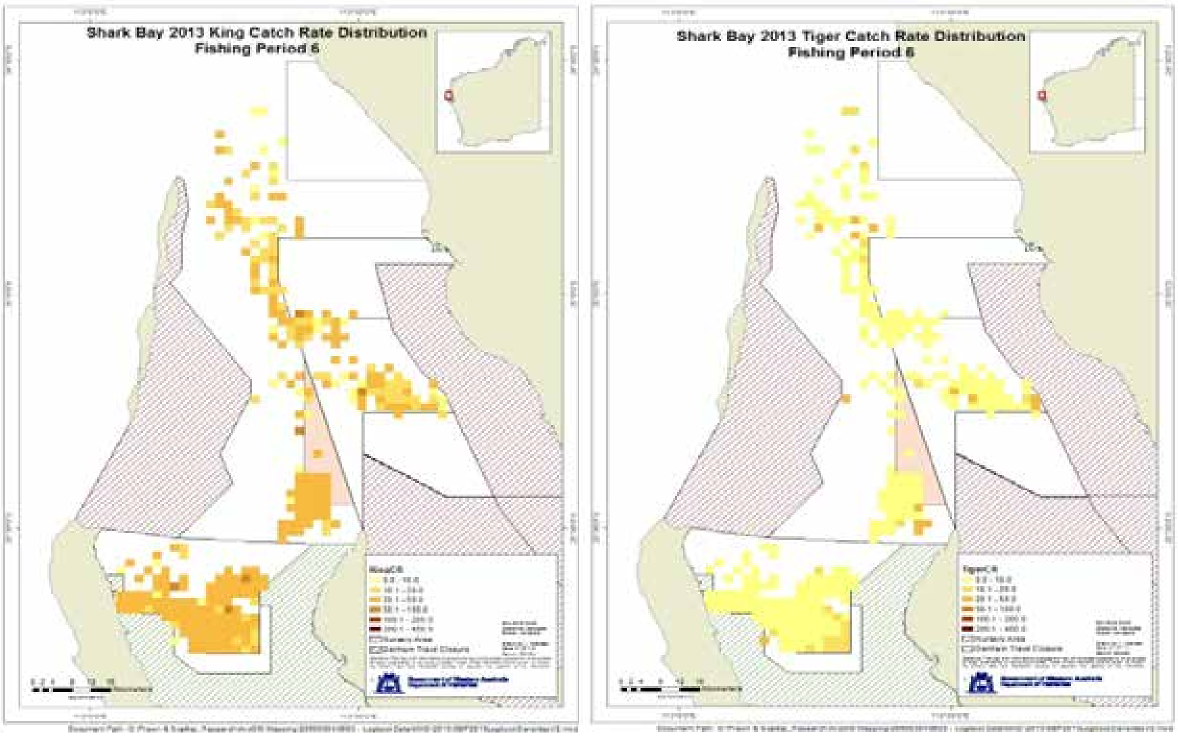

Figure 8.12. Spatial distribution of catch rates of western king prawns (left) and brown tiger prawns (right) in Shark Bay during the sixth fishing period in 2013

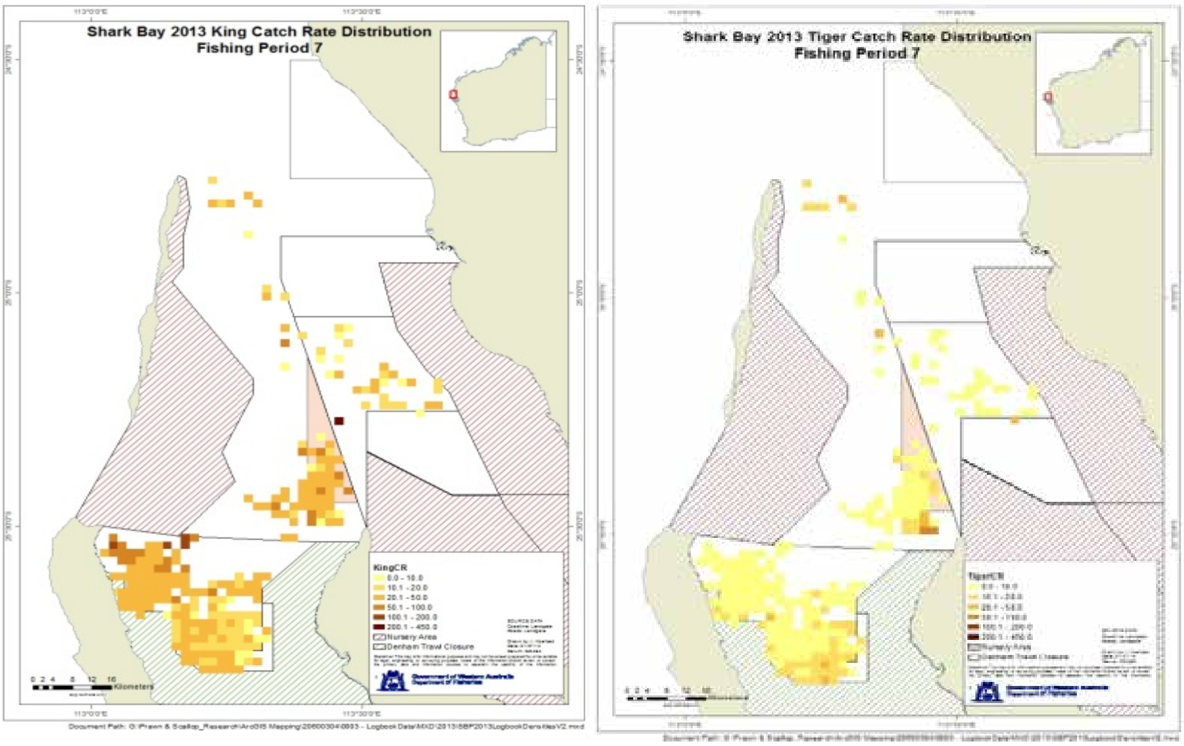

Figure 8.13. Spatial distribution of catch rates of western king prawns (left) and brown tiger prawns (right) in Shark Bay during the seventh fishing period in 2013

In the past, real-time monitoring of commercial catch rates of brown tiger prawns in Shark Bay was used for determining when to close the North CPL to ensure that adequate breeding stock remained in the fishery. That is, the area would close to fishing only after the daily brown tiger prawn catch rate fell below 25 kg / hr (based on daily communication with skippers on the fishing vessels); however, to provide added protection to the spawning stock at the commencement of the spawning period, the closure of the North CPL from 2014 onwards will always occur at a set date, at the start of the June moon closure. This is also the case for the South CPL, which has closed at the start of the August moon closure since 1983.

Monitoring of daily catch rates of both western king and brown tiger prawns throughout the season is valuable for evaluating the effectiveness of the seasonal arrangements for managing the fishery. This information has been used to improve strategies for increasing catch efficiency (i.e. remove low catch rate fishing days) and develop more refined moon closure periods and area openings. These data have also demonstrated to industry that delaying the opening of the South CPL has not resulted in reduced catch rates in these areas.

As examples (see Figure 8.14 and Figure 8.15), the daily catch rates in 2011 and 2013 provide detailed information on how the two species were targeted throughout these fishing seasons in Shark Bay. The breaks in catches indicate the moon closure periods and where the subsequent peaks reflect the increased prawn catch rates associated with the growth and movement of prawns onto the trawl grounds during the closed period. The larger peaks indicate openings of new areas within the fishery and clearly demonstrate the ability of the fleet to rapidly reduce stock levels in the areas open to fishing. It also highlights the seasonality of the fishery, with brown tiger prawns targeted during the first part of the season and western king prawn catch rates maintaining the fishery during the latter part of the season.

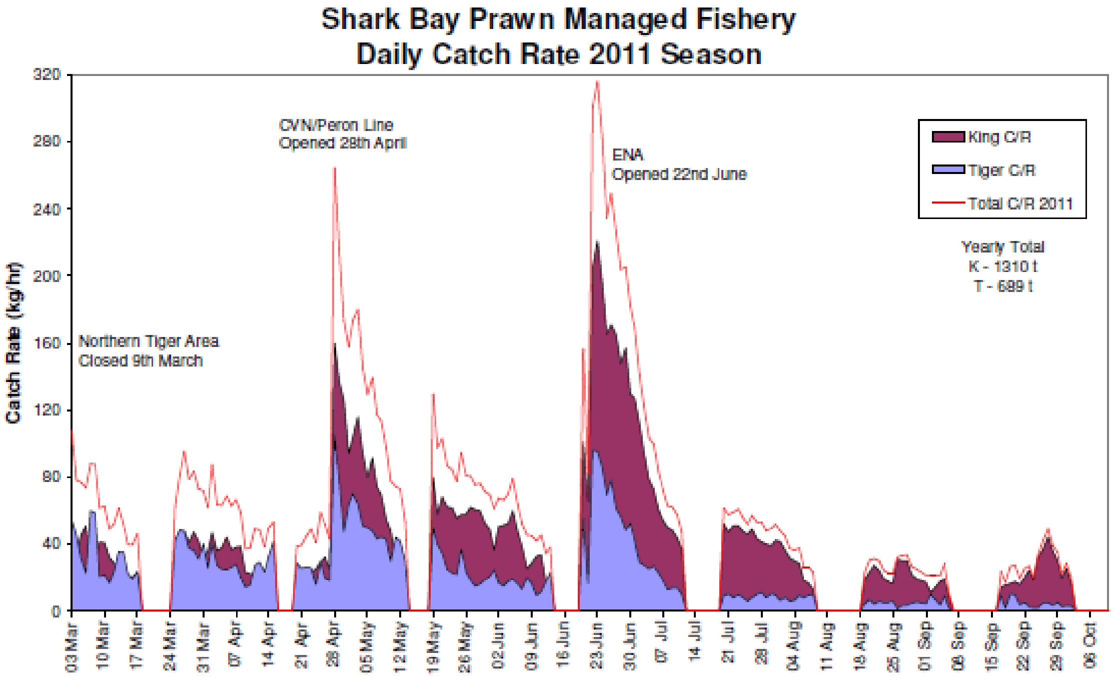

Figure 8.14. **Daily catch rates of western king prawns and brown tiger prawns in the SBPMF during the 2011 fishing season (a year of high overall western king and brown tiger prawn abundance).**

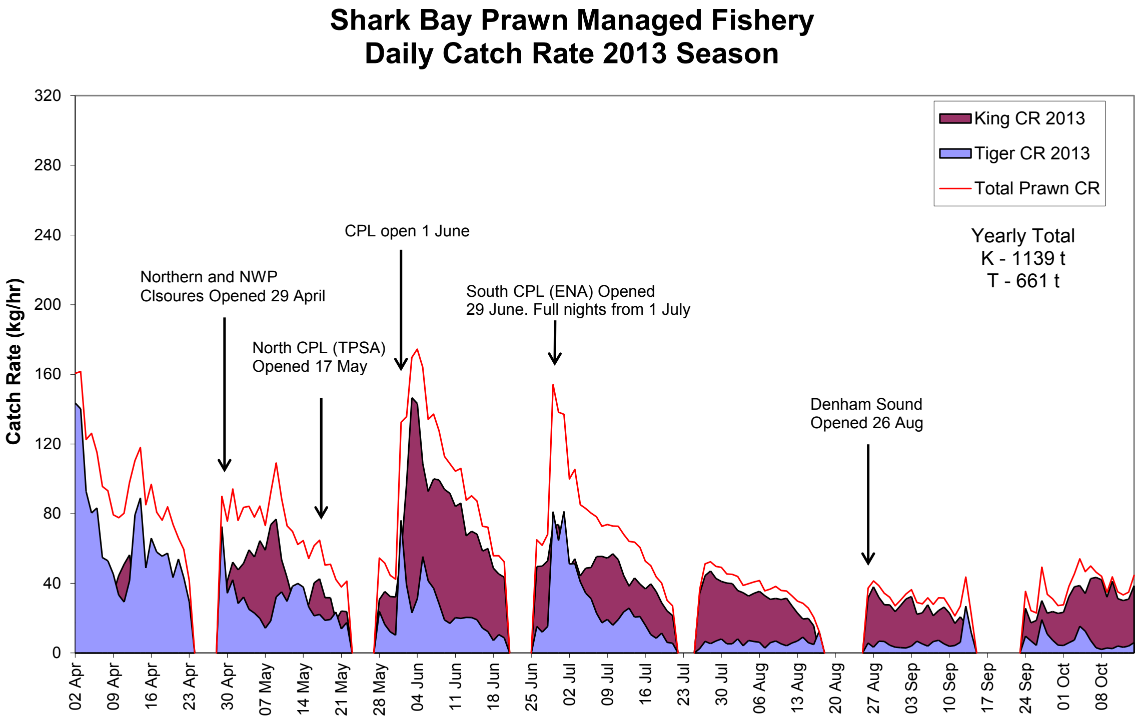

Figure 8.15. **Daily catch rates of western king prawns and brown tiger prawns in the SBPMF during the 2013 fishing season (a year of high overall western king and brown tiger prawn abundance).**

8.4.2.2 Fishery-Independent Monitoring

Fishery-independent trawl surveys are undertaken in Shark Bay each year to monitor the recruitment and spawning stock levels of brown tiger and western king prawns. Sampling is carried out using commercial fishing boats (and, to a lesser extent, the R.V. Naturaliste), with the intention to use the same boat(s) throughout the year for all surveys. As the net headrope length and gear configuration has changed over the years in the fishery, adjustments to survey catch rates have been made to take these changes into account (see Appendix C). Since 2003, all nets have been fitted with grids and secondary BRDs.

The timing of surveys and the sites sampled (see below) has been determined based on an extensive understanding of the biology and timing of recruitment and migration patterns of the target species in Shark Bay, historical fishing patterns, early research surveys and the natural topography of the embayment. Each site is a 2×1.5 nm^2 box in which one trawl is undertaken, generally in a north to south direction due to prevailing wind conditions. Although the location of the boxes are fixed from survey to survey and year to year, the locations of the trawl transects are likely to vary between surveys. The duration of survey trawls is 30 minutes, which corresponds to a distance of approximately 1.5 – 2.0 nm.

For each site surveyed, the start and end latitude and longitude of the trawl shot are noted so that trawl distance can be calculated. The estimated catch of each prawn species is recorded and a representative sample of ~ 200 brown tiger and/or western king prawns is collected from each trawl to provide information on size compositions and sex ratios. During spawning stock surveys (see below), data are also collected on the reproductive stage of female prawns in the survey catch. Weather/sea conditions and moon rise are recorded each night, as well as any protected species interactions. All data are entered into a database for validation, analysis and reporting.

8.4.2.2.1 Recruitment Surveys

Two fishery-independent recruitment surveys are undertaken in Shark Bay each year, generally in March and April around the third lunar phase. Each survey, 19 standard sites across the main fishing grounds in eastern Shark Bay (i.e. within the CPL) are sampled (Figure 8.16). The sites are located adjacent to the permanently closed nursery area and cover the trawl grounds into where the recruits migrate at around this time.

At each survey site, catch rates and size structure information (grades and length frequencies) are collected for both brown tiger and western king prawns. The mean catch rate (kg / hr) data for each of the two target species from the surveys are used as indices of recruitment strength (see Figure 6.2) and provide an indication of likely catch ranges for the season. Moderate correlations between the recruitment survey index and annual catch of brown tiger and western king prawns are evident between the years 2002 and 2013 (e.g. Figure 8.17). The mean predicted value ± 20 % from a linear regression of annual catch as a function of recruitment strength provides the range of values for the catch prediction.

Combined with information collected on the movement patterns and growth of prawns among the survey sites, the catch rate data are also used to inform the timing of the rolling openings of the defined areas within the CPL (e.g. the North CPL, Central CPL and South CPL) for the fishing season. The timing of each area opening is based on the in-season control rules and aims to provide industry with the opportunity to optimise the size (grade) and quality of prawns and, hence, the value of catches. Generally industry is seeking to market prawns at grade sizes from 16 – 20 count per pound (1 pound = 454 grams) and larger.

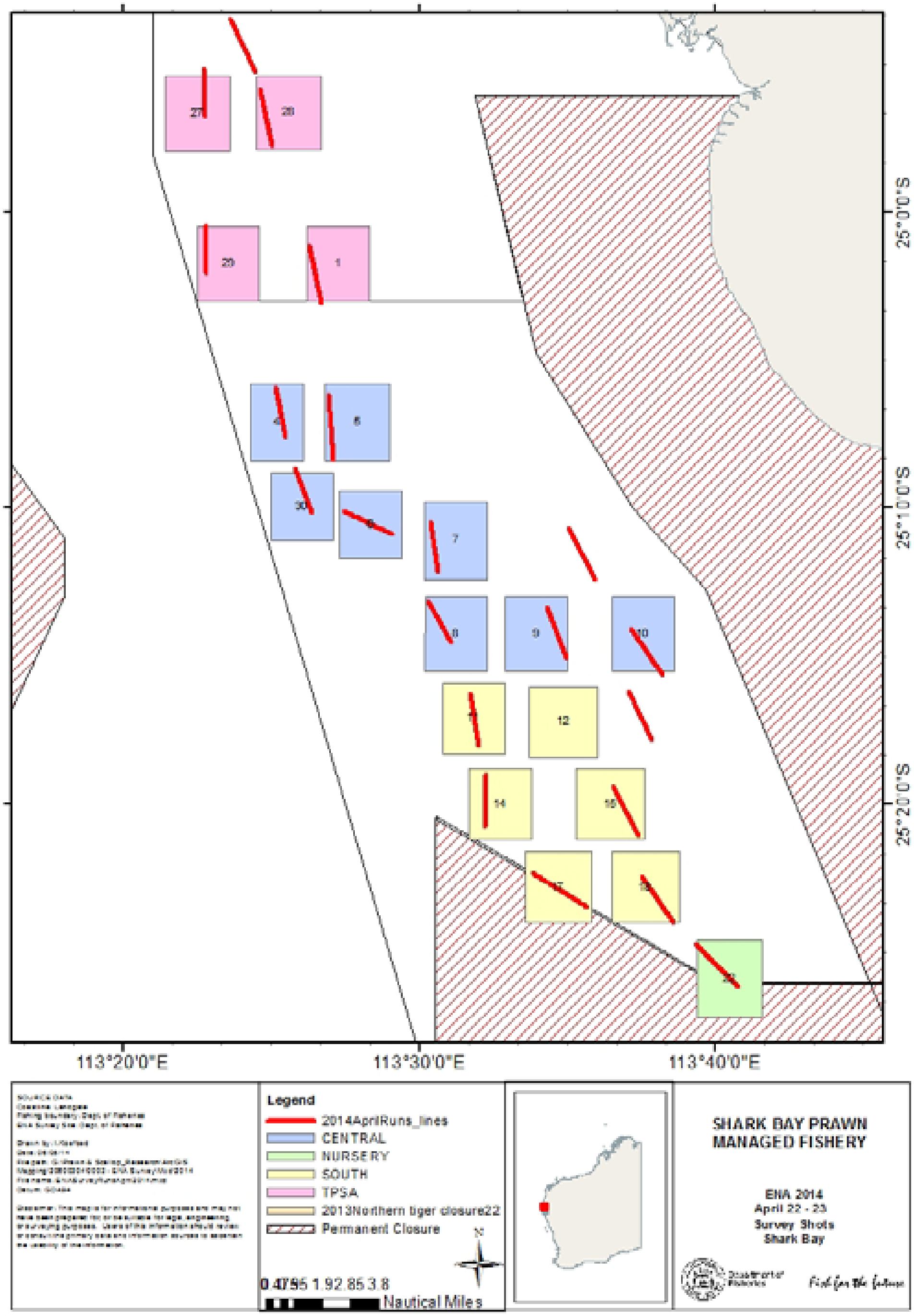

Figure 8.16. Recruitment survey sites in Shark Bay, North CPL (pink), Central CPL (blue), South CPL (yellow and green) indication location of actual trawls in April 2014.

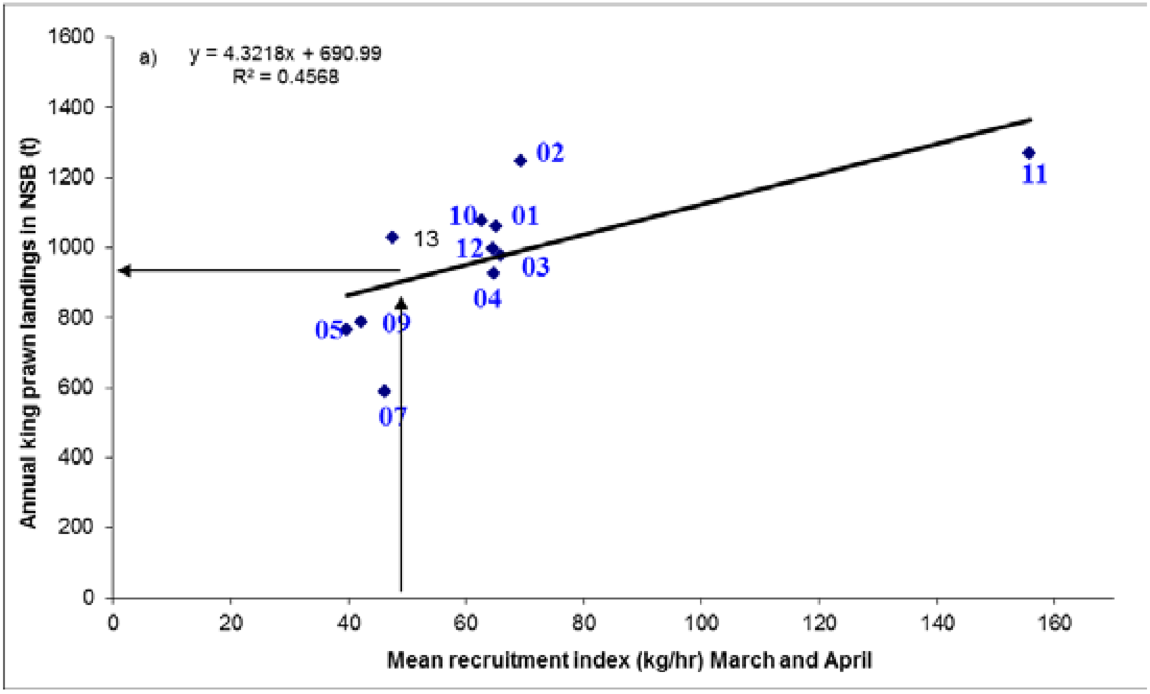

Figure 8.17. Annual king prawn landings as a function of recruitment strength. The mean predicted value of a linear regression of these variables ± 20 % is used to provide a catch prediction for the season.

8.4.2.2.2 Spawning Stock Surveys

A spawning stock abundance of brown tiger prawns in Shark Bay was historically estimated using standardised commercial catch rates in the key brown tiger prawn fishing grounds during July and August (Penn et al. 1995). Since 2001, when a closure of the North CPL was implemented to provide protection to brown tiger prawns before and during their key spawning period (June – September), fishery-independent surveys have been undertaken to provide more robust measures of spawning stock level of brown tiger and western king prawns in Shark Bay during these months as commercial catch rates are no longer available.

Spawning stock surveys have typically been carried out in the North CPL two times each year, a month apart, between June and August (depending on the lunar phase). Following a review of the survey methodology for assessing brown tiger prawn stocks in Shark Bay in 2013, as a response to a low brown tiger prawn spawning stock index and evidence of higher commercial catch rates (through logbook investigation) south of this area, the South CPL has been included in the survey regime. Also, the timing of the surveys has shifted so that each area is surveyed when they are closed to trawling, i.e. North CPL is surveyed in June, August and September whereas the South CPL is surveyed in August and September. Sampling is undertaken at eight sites in the North CPL and seven sites in the South CPL (Figure 8.18). A new combined area index is being developed over the next few years.

At each survey site, the representative sample of brown tiger and / or western king prawns are collected from the trawl and sexed (to provide sex ratio information), measured and occurrence of parasites noted. Generally, the species in higher abundance is measured, with grades of both western king and brown tiger prawns recorded for each survey site. The reproductive stage (White 1975) of females is also recorded.

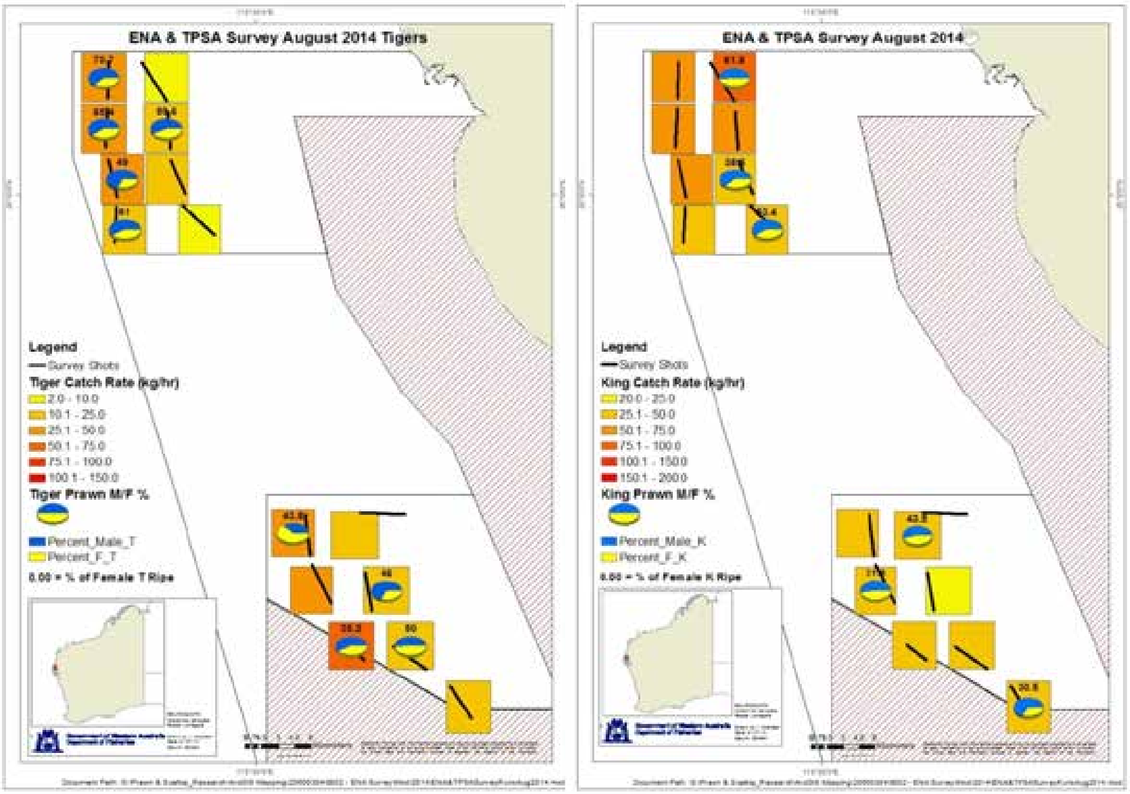

Figure 8.18. **Spawning stock survey sites in Shark Bay (a) brown tiger prawn abundance (kg / hr), sex ratio and % ripe females; (b) western king prawn abundance (kg / hr), sex ratio and % ripe females in August 2014. TPSA and ENA are now referred to as North CPL and South CPL, respectively.**

8.4.2.2.2.1 Denham Sound

Since 2004, surveys have also been undertaken in Denham Sound over two nights in June / July or July / August to collect data used to inform the opening of this area to trawling during the latter part of the season, when fishing primarily focuses on western king prawns. Twenty survey sites are sampled in Denham Sound (Figure 8.19), covering all of the fished areas and some sites inside the Denham Trawl Closure. As part of the Harvest Strategy each year, a part of the closed area in Denham Sound could be opened (Denham extension in Figure 8.19, formerly the Snapper Trawl Line) if the survey target levels are met (Table 8.1).

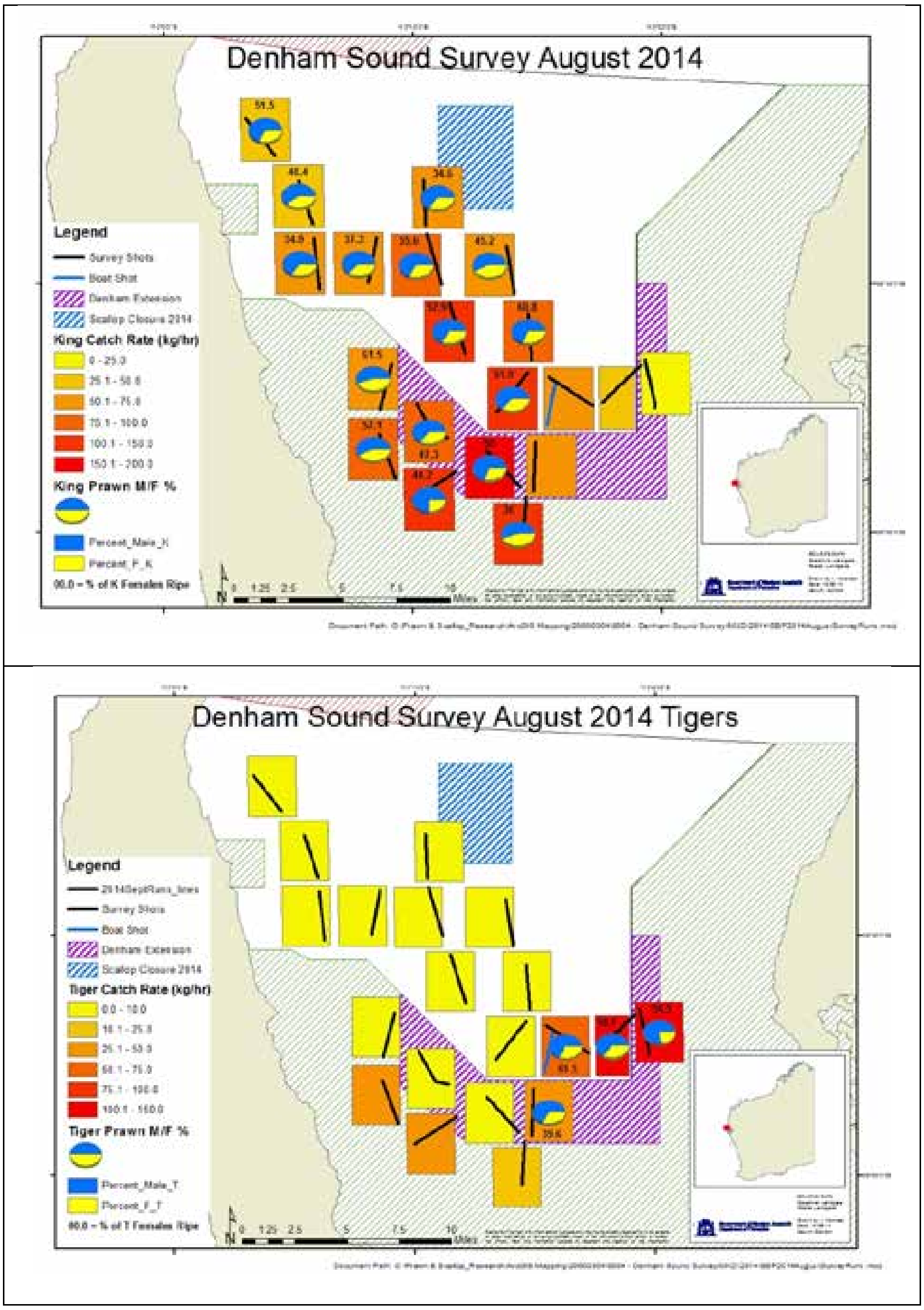

Figure 8.19. **Denham Sound survey sites in the western gulf of Shark Bay indicating western king and brown tiger prawn abundance (kg / hr) and sex ratio and percentage ripe females in August 2014.**

8.4.3 Comprehensiveness of Information

All information required for the harvest control rules is monitored frequently allowing a high degree of certainty that the decision rules in place for the fishery are being applied appropriately. The management approach for this fishery has been developed based on a strong biological understanding of the two target species in relation to recruitment dynamics, movement and growth patterns, and productivity. Brown tiger prawns and western king prawns are both considered as functionally independent stocks within Shark Bay. The

SBPMF is the only fishery in this embayment that catches prawns; therefore, there is detailed and reliable information available on all removals from the stocks of these two species.

Catch and effort levels in the SBPMF have been monitored since the commencement of the fishery in the early 1960s, with this information currently reported on a shot-by-shot basis. There is a good understanding of the uncertainties present in these data and they are considered to be robust. Fishery-independent research surveys are now undertaken throughout the year in Shark Bay and provide robust measures of the recruitment and spawning stock levels of brown tiger and western king prawns. These data are used to evaluate the performance of the fishery and ensure that the harvest strategy is effective in maintaining a sufficient breeding stock levels of both species during the spawning season so that recruitment is not impaired.

A preliminary biomass-dynamics model has been developed to be fitted to annual fishery-dependent catch and effort data, and an age-structured model is being developed to be fitted to a combination of commercial catch and effort data and catch rate data (kg / hr) from fishery-independent recruitment and spawning stock surveys. The age-structured model uses a short (weekly) time step and may be fitted to annual and / or monthly commercial data (depending on the type of data that are available for different time periods). The preliminary model estimates annual trends in spawning biomass, the levels of spawning biomass that correspond to currently-used empirical target and limit catch-rate based reference points, as well as maximum sustainable yield (under equilibrium conditions).

MSC Principle 2

MSC Principle 2 (P2) focuses on minimising environmental impact, such that fishing operations should be managed to maintain the structure, productivity, function and diversity of the ecosystem on which it depends (MSC 2013).

9. MSC Principle 2 Research

A substantial amount of research has been done on the environmental impact of trawl fisheries both globally and throughout Australia. Within Shark Bay, the Department and the fishing industry have conducted research on:

- The use of BRDs (i.e. grids and square mesh panels) to reduce trawl bycatch, ETP species interactions and improve the quality of retained species catch;
- Trawl bycatch species composition;
- The impact of prawn trawling on scallop populations; and
- The impact of trawling on faunal abundance and assemblages within the Bay.

9.1 BRD Trials and Bycatch Composition

Trawling is a relatively non-selective method of fishing, resulting in the discard of non-commercially important species that are captured as bycatch. In December 1998, the Australian Standing Committee on Fisheries & Agriculture finalised the National Policy on Fisheries Bycatch (SCFA 1998). The Policy was developed to provide a national framework for coordinating action to address bycatch issues and in June 1999 the WA government adopted this national policy as its own. As part of this policy, the Department commenced trialling and the implementation of bycatch reduction devices (BRDs) into all WA prawn and scallop trawl fisheries in 2001 (Bunting 2002).

BRDs fall into two categories: primary bycatch reduction devices (i.e. grids) are those that physically exclude large organisms allowing them to pass out of the net; and secondary bycatch reduction devices, such as square mesh panels (‘fish exclusion devices’ [FEDs]), are more passive devices that take into account the behavioural differences between target and bycatch species in order to allow bycatch species to escape (Broadhurst et al. 2002).

In 1998/99, experimental trials of grids were undertaken in WA using grid types used in other Australian trawl fisheries and in the United States (Watson & Taylor 1996; Robins & McGilvray 1999; Olsen 1999). A few fishers also trialled several grids independently, indicating a proactive approach by some operators to reduce bycatch before any government legislation was considered. However, subsequent adoption by industry of some of the grid types trialled during this experimental phase showed that these grids were not effective in eliminating large animals and / or bycatch without substantial loss of target species under some conditions.

Hence, an FRDC-funded project (i.e. Kangas & Thomson 2004) was initiated to tailor BRD usage to the specific requirements of a number of WA trawl fisheries, including the SBPMF, the SBSMF and the Exmouth Gulf Prawn Managed Fishery. As the SBPMF and SBSMF operate within the Shark Bay World Heritage Property, part of the project was to identify those species important to the overall values of the World Heritage Property and develop gear that was successful at reducing bycatch of those species in particular (Kangas & Thomson 2004).

Although there are some similarities in fish species between Shark Bay and Exmouth Gulf, there are differences in bottom type and bycatch species affecting the efficiencies of BRDs and their impact in the fishery. For example, due to the large seagrass beds in Shark Bay, the trawl fishery has problems with capturing large amounts of free-floating 'weeds'. Fishers in the SBPMF must also consider scallop bycatch during periods when the scallop season is closed. In order to tailor BRDs to the different fisheries, key fleet personnel travelled to Queensland and met with people experienced in the design, construction and use of BRDs and used the information from these fishers to decide which BRDs to trial in WA (Kangas & Thomson 2004).

Commercial catch and bycatch information is available from grid trials in Shark Bay in 2000 and 2001. Departmental observers were used to record commercial catch and bycatch for most trawl shots conducted, with a 'shot' defined as a trawl of two nets, for between 30 minutes and three hours. During the trials, each boat typically towed two types of nets, a control or standard net and one fitted with some type of BRD. Eight main types of grids were trialled in Shark Bay including various combinations of:

- circular or rectangular;
- straight vertical bars or a horizontal 'flounder' gap at the bottom;
- narrow or wide bar spacing; and
- If top section of grids had bars that are bent as an accelerator or not (Kangas & Thomson 2004).

The categories recorded for each side were: total bycatch weight or volume (including small or juvenile fish, crustaceans, echinoderms and molluscs); target species catch and component that is soft and broken (king, tiger, endeavour, coral prawns and scallops); and numbers of sharks, rays, sea snakes, sponges and turtles (i.e. ETP species). Pink snapper and tailor were also noted in Shark Bay due to their commercial and recreational importance (Kangas & Thomson 2004).

During the grid trials, 1180 trawl shots comprising 1237 hours of trawling were recorded by observers on board commercial vessels in Shark Bay. Grid type was found to be a significant factor in total prawn catches, but did not result in a significant increase in the proportion of soft and broken prawns (Kangas & Thomson 2004).

Differences among grid types were significant on the amount of bycatch retained in nets compared to control nets, with a general reduction in bycatch between 0 and 17 %. There were 87 % less sharks and 88 % less rays retained by nets with grids compared to the control nets, with the majority of sharks caught in the control nets less than one metre in length. Only a marginal difference was observed with catches of 'other large finfish' (excluding pink snapper and tailor) between nets with grids and control nets; however, only a small number of trawl (n = 19) recorded catch of 'other large finfish'. Overall, there was a 9 % reduction in scallop catch in nets with grids compared to the control nets, with no significant difference between grid-types (Kangas & Thomson 2004).

From a total of 914 trawl shots with a grid on one side and the control net on the other, 20 turtle captures were observed on the control side (no grid) and only one turtle capture was recorded with a BRD-net. This represents a 95 % reduction in the number of turtles caught. The captured turtle was returned to the sea alive. The number of sea snakes caught in nets with grids was also 42 % lower than in control nets, which may be related to the movement of weed and snakes out of the escape opening (Kangas & Thomson 2004).

Grid type was found to have a significant impact on sponge catches, with the reduction of sponges retained in nets varying between 79 and 100 %. Differences were also observed between the proportion of weed retained by different grid types compared to control nets, with between 79 and 96 % reduction in most commonly used grid types (Kangas & Thomson 2004).

Two experimental trials of grids and secondary BRDs were also completed on established prawn-trawl grounds in Shark Bay in August 2000 using two chartered commercial prawn trawlers. The experiments were done using a twin-rig system (each with a headline length of 14.6 m), with all trawls made from polyethylene twine with a stretched mesh size of 52 mm in the body and 47 mm in the cod end. All tows were done over a combination of sandy and light coral bottoms in depths ranging from 13.7 to 18.5 m and at speeds of between 3.5 and 4.6 knots (Broadhurst et al. 2002). The grid trialled was an industry-designed aluminium grid with the upper third offset at 45° and bar spacing of 100 mm (Figure 9.1a). The grid was located at a 45° angle in a 30-mesh extension piece, with the anterior end attached to the trawl body. The BRD had no funnel or guiding panel but included two flexible panels of 47 mm diamond-shaped mesh hung loosely above and below the escape exit (Figure 9.1b). Three cod ends were constructed and rigged with zippers so that they could be attached posterior to the extension containing the grid. The first cod end was a conventional 47 mm diamond-shaped mesh, while the two other cod ends were composite square mesh panels (aft [CSMPA] and forward [CSMPF]). These cod ends included secondary BRDs comprising composite panels made of 47 mm, 94 mm and 155 mm mesh cut on the bar and inserted into the top sections of the cod ends (see Kangas & Thomson (2004) for more detail).

Using zippers, the conventional (i.e. no BRD), CSMPA and CSMPF cod ends described above were alternatively attached posterior to the grid (Figure 9.2) and the entire assembly tested against the control cod end, on each side of the twin-rigged gear (i.e. three separate paired comparisons: grid only - i.e. no secondary BRD vs. control; grid and CSMPF cod end vs. control; and grid and CSMPA cod end vs. control). Two replicate 40-minute tows of each paired comparison were made on each night, providing a total of 10 replicate comparisons of each configuration over five nights (Kangas & Thomson 2004).

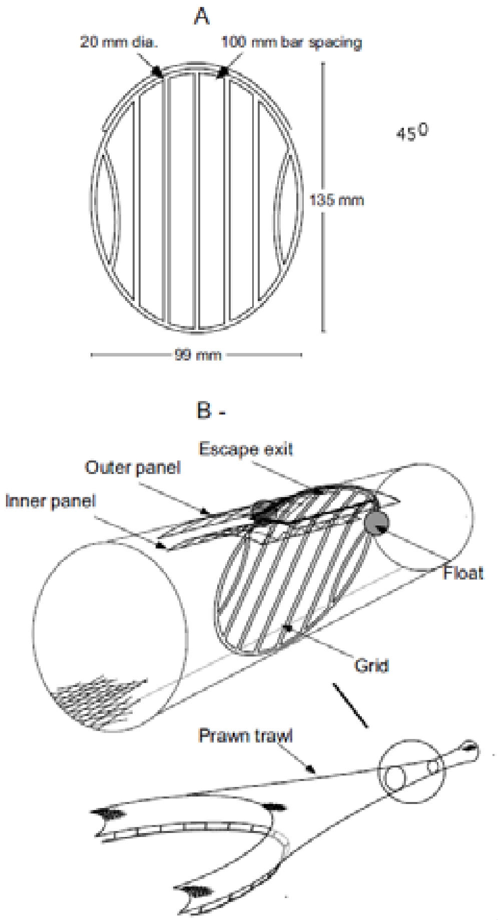

Figure 9.1. Diagrammatic representation of (a) the grid used in Shark Bay experiments and (b) its location in the prawn trawl (Source: Kangas & Thomson 2004)

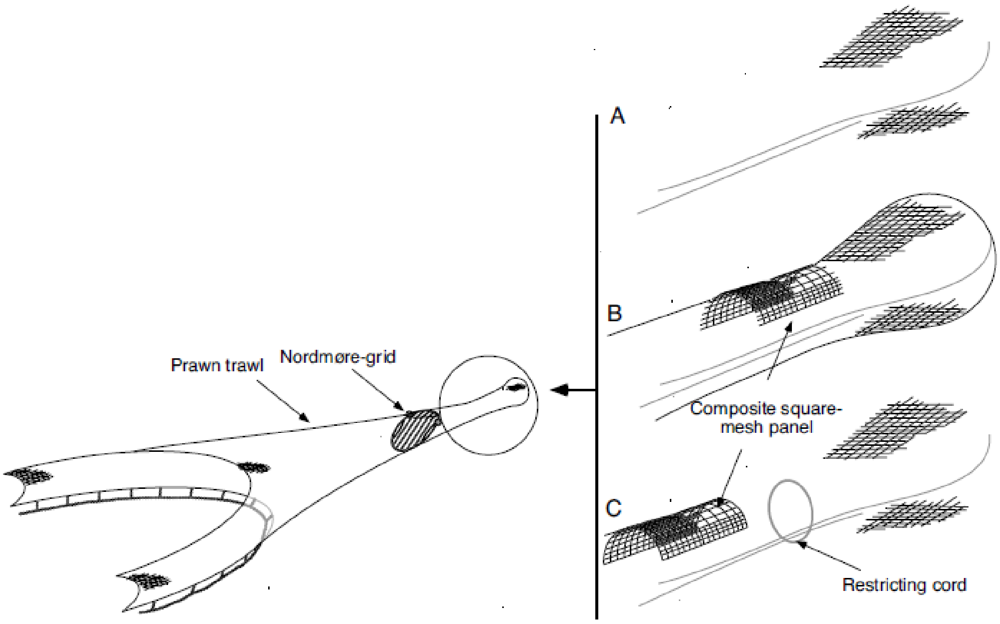

Figure 9.2. Diagrammatic representation of the prawn trawl with the Nordmøre-grid and location of the (a) conventional cod end, (b) composite square mesh panel aft (CSMPA) cod end and (c) composite square mesh panel forward (CSMPF) cod end (Source: Kangas & Thomson 2004)

Results from the experimental trials indicated differences in bycatch for the control nets, the grid only and the grid in combination with a secondary BRD. Compared to the control, the grid in combination with the CSMPA cod end significantly reduced the weight of bycatch (by 48.9 %) The grid only and the grid in combination with the CSMPF cod end showed some reduction in weight of bycatch, by 4.9 and 15.5 %, respectively (Figure 9.3). Trials on commercial boats indicate around 20 – 30 % reduction in overall bycatch, with up to 70 % reduction of some individual fish species (see Kangas & Thomson 2004 for species-specific reductions).

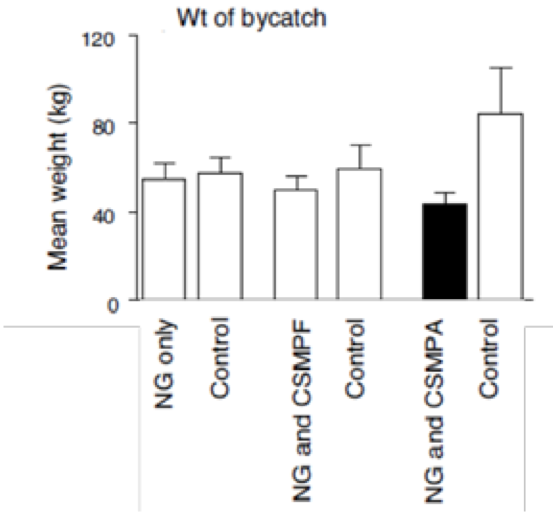

Figure 9.3. Differences in mean catch (± SE) of bycatch between the BRD and the control nets in Shark Bay. Black bars represent significant reductions. NG: Nordmøre grid;

CSMPF: composite square-mesh panel forward cod end; CSMPA: composite square-mesh panel aft cod end (Source: Kangas & Thomson 2004)

9.2 Risk Assessment of Bycatch and ETP Species at a Bioregional Level

The cumulative risk to bycatch from multiple fisheries in the Gascoyne Coast Bioregion was assessed as part of a Ranked Risk Assessment for Multiple Fisheries (RRAMF; Evans & Molony 2010). The RRAMF is designed to overcome the differences in fisheries data collection methods that include use of a variety of measures and variable observer coverage ranging from < 1 % to 20 % of the actual fishery catch in WA fisheries. To overcome these issues the RRAMF method compares the ranks of the relative amount of bycatch from each fishery and compares the ranks of the species catch within each fishery. This method provides a rapid and relatively inexpensive method to conduct a multi-fishery risk assessment. It also enables managers to prioritise which fisheries have the greatest impact and which species may require more biological and ecological study to understand the risks of multiple fisheries (Evans & Molony 2010).

Of the 11 fisheries (commercial and recreational) identified in the Gascoyne Coast Bioregion, data was available for only five, i.e. the SBPMF, the Exmouth Gulf Prawn Managed Fishery, the Shark Bay Snapper Fishery, the Gascoyne charter fishery and the Gascoyne recreational fishery; however, much of these data were from relatively old studies and many changes in gear and/or fishing effort have occurred in the fisheries since then (Evans & Molony 2010). For example, the SBPMF data was collected during the BRD trials in 2002 – 2003, using nets without grids. As BRDs are now mandatory in the fishery, the bycatch data used in the study does not reflect the commercial bycatch of the contemporary trawl fishery (which is lower than the amount that was used by Evans & Molony [2010]).

The study focused on teleosts and elasmobranchs, due to the limited data available on invertebrates. The RRAMF was conducted as a three-step process; firstly, four initial variables were used to reduce the number of species to a manageable list. For the Gascoyne Coast Bioregion, the list reduced from 412 to 122 in the Gascoyne Coast Bioregion (see Appendix 1 in Evans & Molony 2010 for a complete species list). The second stage involved assignment of the biological and fishery impact parameters to the sub-set of species and the weighting of these parameters based on comparative catch abundance in each fishery. The overall risk was calculated as the weighted average risk across all parameters (Evans & Molony 2010).

The third step was an arbitrary notation for each of the species based on the latest scientific and fisheries knowledge of that species. This list focussed on only the top twenty ranked species for each Bioregion, with the notation providing advice on the species' risk assessment relative to other species (Evans & Molony 2010).

No species from either Bioregion scored higher than ~ 45 % of the maximum risk assessment score (i.e. 23). Elasmobranchs featured highly in the risk assessment, and held nine of the 20 top places in the Gascoyne Coast Bioregion. Many elasmobranchs had higher scores than most teleosts due to their life history characteristics rather than the impact of fisheries. *Taeniura meyeni* (black-blotched sting-ray) and *Rhyncobatus* spp. (white spot shovelnose ray) had the highest average score (8.59), non-weighted score (8.5) and the highest overall score with the parameters 'size and management' (10.06) in the Gascoyne Coast Bioregion. The *Rhyncobatus* spp. result is the accumulation of a number of species and therefore is not the most vulnerable in this Bioregion. The scores for these species vary between low-moderate to moderate depending on which of the parameters were double weighted (see risk scores in Appendix E; Evans & Molony 2010).

It is important to note that the risk assessment scores for the teleosts and elasmobranchs are not directly comparable to the risk assessment scores for ETP species, as different parameters and data sets were used. The biological scores for all ETP species were relatively high; however, the fishery impact profile was very low. This was driven by the low reported catch rates, relatively low mortality rates and very wide distributions. Thus, the risk assessment maintained low to moderate risks categories for most species groups. Turtles in the Gascoyne Coast Bioregion had a moderate risk category, while all other species (i.e. sea snakes, cormorants and syngnathids) were low or low-moderates risks (Evans & Molony 2010).

9.3 Impact of Prawn Trawling on Shark Bay Scallops

The SBPMF boundaries and fishing areas overlap fishing areas of the Shark Bay Scallop Managed Fishery (SBSMF; Figure 9.4), and some prawn vessels catch scallops during the scallop season under licences as part of the SBSMF. The interaction of the different fishing gear configurations and fishing dynamics with the benthic habitat and biota means there is potential for the activities of one industry to influence the other in the areas of stock overlap (Kangas et al. 2012).

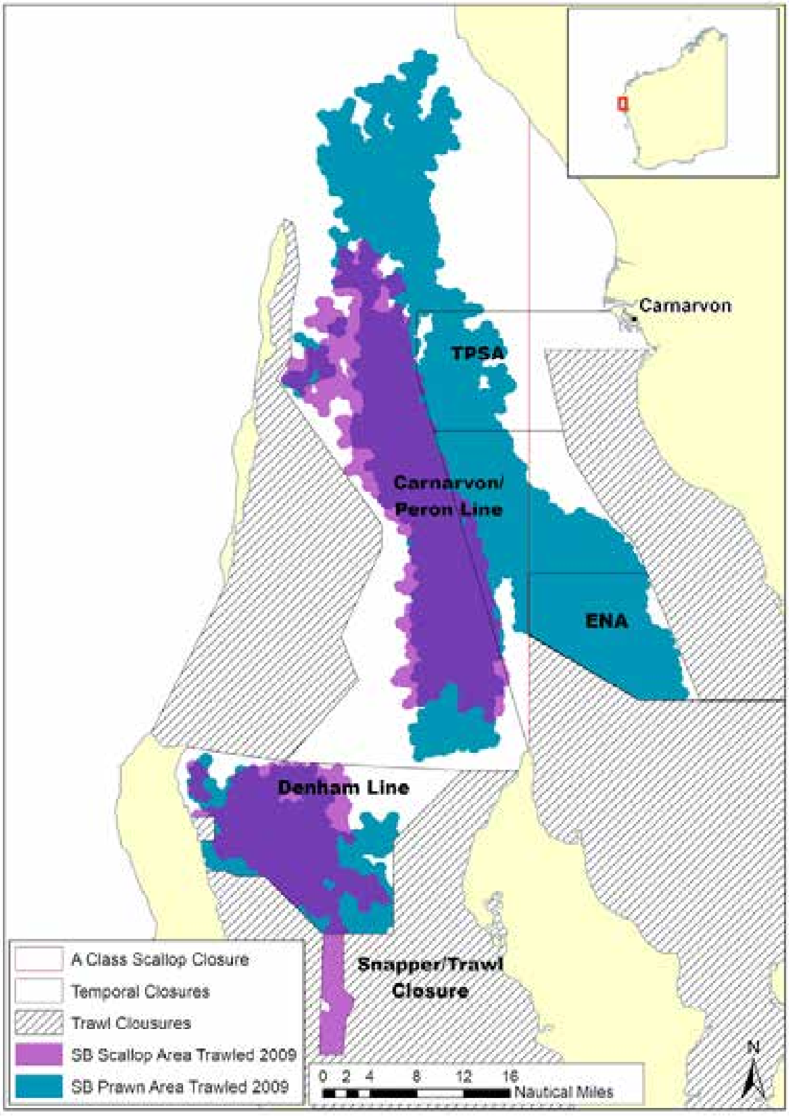

Figure 9.4. General map of Shark Bay with key management lines and spatial overlap (dark purple) in fishing grounds of the scallop (light purple) and prawn (blue) trawl fleets in 2009. TPSA: Tiger Prawn Spawning Area (now referred to as North CPL); ENA: Extended Nursery Area (now referred to as South CPL) (Source: Kangas et al. 2012)

Unlike prawns, juvenile scallops recruit directly onto the main fishing grounds where adults occur and become vulnerable to gear impacts from both the scallop and prawn fleets. Scallops can tolerate air exposure for longer periods than many bycatch species, thus discarded scallops are more likely to survive to be recaptured later; however, the overlapping fishing grounds where both fleets operate are of high trawl intensity, where the rate of repeated scallop discarding is likely to be high and their long-term survival is unknown (Kangas et al. 2012).

Historically, the prawn fleet commenced fishing before the scallop fleet on the main prawn fishing grounds, but they were not permitted to retain any scallops until the scallop season commenced (generally April / May). As such, there was a period of several weeks when scallops were being continuously captured and discarded, which resulted in some trawl-induced morality and unavoidable damage to prawn nets from the accumulation of large amounts of scallops within the nets (Kangas et al. 2012).

In 2004, this system was abolished, and both fleets began fishing on the same date (except in the Denham Sound fishing grounds, which has its own opening and closure dates based on meat size and quality). The change in regulation to simultaneous openings for both fleets has had positive outcomes for scallop harvesting, as most scallops that are caught in summer are retained. Scallops of non-market sizes (< 85 mm), however, still continue to be discarded by both fleets during this time. In order to reduce the amount of discarding over this period, industry has recently trialled square mesh cod ends instead of the traditional diamond mesh cod ends in order to improve gear selectively to reduce the capture of sub-legal scallops. Additionally, the forward shift in scallop season commencement in 2004 meant that the scallop fleet ceased fishing before the peak scallop spawning period began, which resulted in an overall reduction in fishing intensity during the key spawning months. The prawn fleet, however, continues fishing operations during this period (June – August) but are required to discard all scallops caught in their nets during this time to maintain scallop spawning abundance (Kangas et al. 2012).

The need to develop an understanding of the impact from gear interactions between the scallop and prawn fisheries led to an FRDC-funded project (no. 2007/051), which included research to:

1. Determine size-specific recapture mortality rates of scallops (*Amusium balloti*) as a result of repeated capture and release experiments and gear impacts on newly recruited juvenile scallops;
2. Investigate if small-scale spatial closures assist recruitment of *A. balloti* by reducing gear impacts and capture mortality but without affecting prawn catches; and
3. Examine whether existing hydrodynamic models can guide the selection of spatial closures and investigate the larval transport mechanisms of both prawns and scallop larvae in Shark Bay (Kangas et al. 2012).

The spatial and temporal differences in the survival of discarded scallops were investigated under different post-capture treatments from field experiment simulating commercial trawl activities using multiple mark-recapture trials. Tag-recapture experiments were conducted at sites of moderate scallop abundance (~ 3000 – 5000 scallops / trawl) based on annual scallop survey data collected in 2007 / 2008 (Figure 9.5). Scallop tagging and recapture experiments were conducted in winter (September 2008), when most scallops were in post-spawning phase, and in summer (February 2009), when scallops were in pre-spawning phase (Kangas et al. 2012).

Experimental sites were trawled to capture approximately 2000 scallops for marking on the tagging night, with scallops separated into an air exposure treatment (exposed for approx. 40 minutes), a hopper treatment or a control treatment. Experimental sites were trawled the following four nights (winter) and three nights (summer) after the tagging night to recapture tagged scallops (Kangas et al. 2012). Direct damage and injury to scallops were visually assessed from a sub-sample of 300 scallops (tagged and untagged) collected across all trawl sites during the summer experiments using a damage scale of 0 (i.e. no damage) to 5 (i.e. dead scallop; Kangas et al. 2012).

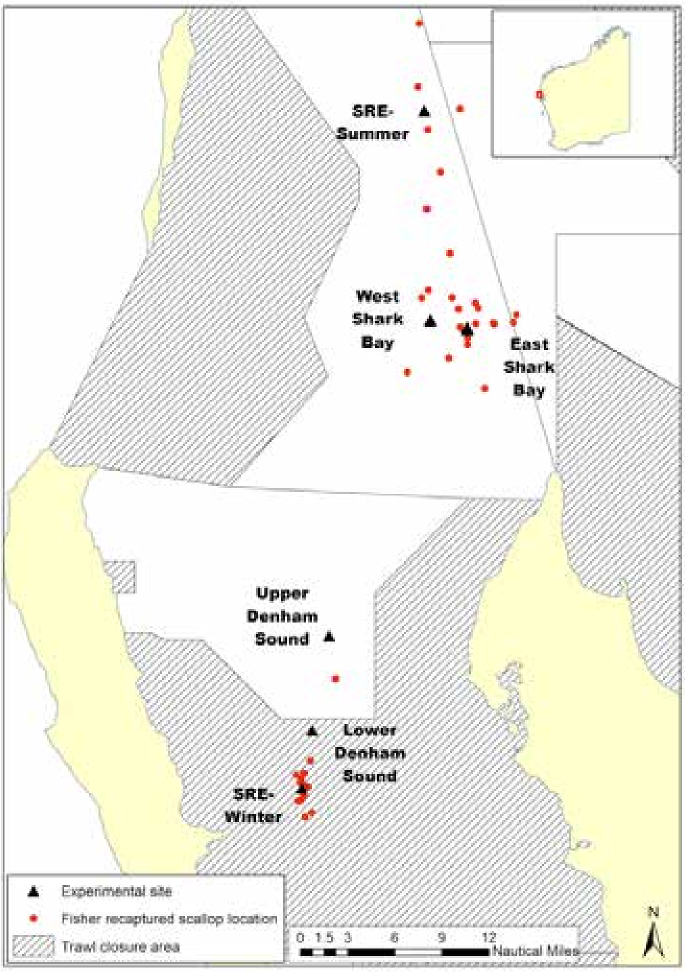

Figure 9.5. Experimental tagging sites in the central bay region of Shark Bay in summer (West Shark Bay, East Shark Bay and Short Recovery Experimental [SRE] site) and lower bay region (Upper Denham Sound, Lower Denham Sound, SRE site). Red dot indicates location of scallop recaptures by commercial fishers during the scallop fishing season in 2008 (prawn boats) and 2009 (prawn and scallop boats). (Source: Kangas et al. 2012)

Survival estimates of discarded scallops were found to be significantly higher in winter (post-spawning) than during summer (pre-spawning), but there were no large differences in survival between fishing grounds or between post-capture treatment groups (air exposed or hopper). This suggests that thermal stress from large differences in seasonal temperatures is more critical to scallop survival than differences in scallop reproductive condition. Cooler conditions during the spawning months would favour greater survival of the discarded spawning scallops, while reproductive energy diverted to spawning is likely to prolong their recovery period, thus decreasing their catchability by trawl nets (Kangas et al. 2012).

The majority of scallops sampled indicated a Level 1 injury (i.e. minor chipping to the edges of valves), and 94 % of scallops were below a Level 3 damage grading. Level 3 damage (i.e. extensive chipping of valves exposing soft tissue) was seen in 4 % of scallops; 1.1 % had Level 4 damage (i.e. proportions of valves missing, visible injury to soft tissue but scallop alive) and mortality was seen in 1.4 % of scallop assessed (Kangas et al. 2012). These results are similar to *A. balloti* harvested in the Queensland fishery, where estimates of dead scallops with crushed or cracked valves were very low (1 %), while the majority incurred chipping to the outer edges of the valves (Campbell et al. 2010).

The impact of trawl effort intensity and distribution on scallop recruitment in Shark Bay was also investigated as part of the FRDC project in order to explore potential benefits of spatial closures of areas within key scallop grounds in Shark Bay. This included evaluating the impacts of management actions (i.e. the introduction of the CPL in 1991) on historical spatial effort distribution of the prawn fleet; evaluating historical and current spatial effort distribution of the scallop fleet; and evaluating temporal effort distribution by both fleets on the central Shark Bay fishing grounds (Kangas et al. 2012).

In evaluating both the historical and recent catch and effort data of the prawn and scallop fisheries, it was apparent that changes in trawl effort distribution were not a major driver of the scallop recruitment in Shark Bay. Other factors, such as environmental factors, or a combination of effort and these external factors are more likely to drive recruitment success (Kangas et al. 2012).

Despite the potential impact of changing environmental conditions on the variability in annual scallop recruitment, there is a lack of understanding of the detailed hydrodynamic processes that are required to interpret the recruitment dynamics in the Shark Bay region. Using a combination of field measurements and numerical modelling Kangas et al. (2012) examined the dynamics of circulation throughout the scallop trawl grounds during the scallop spawning season with the aim of establishing source-sink relationships for larvae.

The hydrodynamic modelling indicated limited larval connectivity between Denham Sound and northern fishing grounds, and it appeared that the key grounds were largely self-seeding. Northern Red Cliff and Denham Sound had a higher likelihood of larval loss (flushing) out of Shark Bay under certain environmental conditions. The management implications from these results are that it is essential to retain spawning stock in each fishing ground in order to replenish stocks on each fishing ground. The current management strategy of fishing scallops to a catch rate threshold to ensure carryover of stock is therefore appropriate, however, the implementation of spatial closures may still be a reasonable strategy to protect spawning stock and newly settled scallops due to the lack of connectivity between fishing grounds (Kangas et al. 2012).

9.4 Ecosystem Impacts of Trawling

Like most trawl fisheries, bycatch in the SBPMF comprises of a large number of taxa in low abundance, with the majority of species being uncommon or having little biological information available (Kangas & Thomson 2004). Thus, it is not practical to monitor and evaluate the sustainability of each species using traditional methods. However, as bycatch cannot be eliminated entirely, it is important to determine and monitor which species can or cannot sustain the impact of fishing and which species may be suitable as indicator species to reflect trawl impacts on the total suite of bycatch species (Kangas et al. 2007; Kangas & Morrison 2013).

Baseline data of faunal abundance and composition in Shark Bay in areas that are both currently open to trawling and adjacent areas closed to trawling is available from an FRDC-funded study conducted in 2002 and 2003 (Kangas et al. 2007). Daily logbook information was used to map trawled and untrawled areas within Shark Bay in order to identify sample sites, i.e. sites representing varying levels of trawl effort from both prawn and scallop grounds that were spatially separate in parts of Shark Bay and overlapping in others, and adjacent areas that were closed or open but were untrawled (Figure 9.6). All of the 26 selected sites were fixed for the survey period (2002 and 2003) and were sampled during three different seasons, i.e. during the start (February / March [2003]), middle (June / July [2003]) and end (October / November [2002 and 2003]) of the trawl season. During each sample, trawls were undertaken using twin-rig demersal otter trawl nets, with a six fathom (10.97 m) headrope length. Net mesh size was 50 mm, with a 45 mm mesh cod end. No BRDs were included in trawl nets. For each trawl, all species of fish and invertebrates were identified, counted and abundance determined as number per nautical mile trawled (Kangas & Morrison 2013).

Non-metric multi-dimensional scaling (MDS) ordinations were undertaken to examine variation in the fish and invertebrate assemblages, with richness, evenness and diversity indices calculated for the sites within the assemblages identified. The DistLM routine (Primer 6) was also used to analyse faunal assemblages for each site incorporating environmental variables (i.e. salinity, water temperature and depth) and whether the site was trawled or untrawled for all 2003 sampling periods combined. BEST (Primer 6) was used to identify which environmental variable was most closely correlated with species distribution, diversity and abundance patterns (Kangas & Morrison 2013).

Similarity indices for each fish and invertebrate sample taken at trawled and untrawled sties were analysed using PERMANOVA (Primer 6). The spatial distribution and abundance of some of the more abundant fish and invertebrate bycatch species were looked at in detail and included species that were shown to have high, moderate and low catchability ('vulnerability'; Kangas & Morrison 2013).

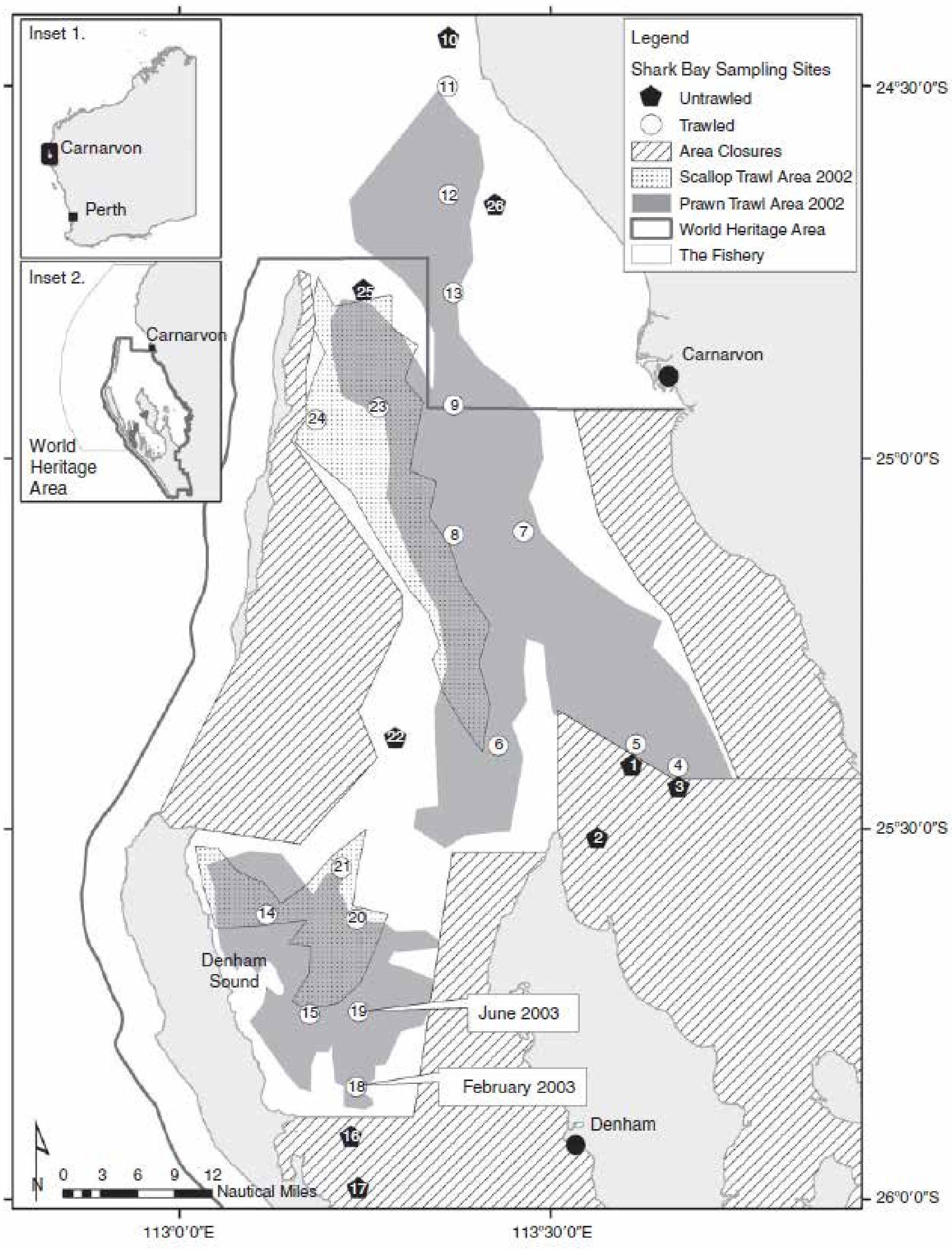

Figure 9.6. Location of sample sites in Shark Bay and two sites for depletion experiments conducted in Denham Sound. (Source: Kangas & Morrison 2013)

In total, 241 fish and 360 invertebrate species were recorded in Shark Bay during this study (see species list in Kangas et al. 2007). The 20 most abundant fish species contributed to 80 % of the total number of fish caught overall, with these species occurring at 73 – 100 % of the site sampled (Table 9.1). The 20 most abundant invertebrate species contributed up to 88 % of the total numbers of invertebrates caught and occurred at 62 – 100 % of sites sampled, except for the ascidian *Herdmania pallida*, which was only found at one site (Table 9.2). Seventy two species of fish (30 %) and 173 species (48 %) of invertebrates were uncommon and were only caught in one or two sites during the study (Kangas & Morrison 2013).

Table 9.1. Twenty most abundant (number per nm trawled) fish species in Shark Bay in 2002 and 2003 and proportion of sites in which they were caught (Source: Kangas & Morrison 2013)

Family	Species	Common name	Ave. no per nm	% sites
Monacanthidae	*Paramonacanthus choirocephalus*	Leatherjacket, hair-finned	447	100
Mullidae	*Upeneus asymmetricus*	Goatfish, asymmetrical	438	100
Terapontidae	*Pelates quadrilineatus*	Trumpeter	392	100
Lethrinidae	*Lethrinus genivittatus*	Emperor, threadfin	303	81
Tetraodontidae	*Torquigener pallimaculatus*	Toadfish, orange-spotted	152	100
Scorpaenidae	*Paracentropogon vespa*	Scorpionfish, bullrout	146	81
Callionymidae	*Callionymus goodladi*	Stinkfish, goodlad's	136	96
Monacanthidae	*Colurodontis paxmani*	Leatherjacket, Paxman's	106	77
Nemipteridae	*Pentapodus vitta*	Monocle bream, western Butterfish	105	77
Sillaginidae	*Sillago robusta*	Whiting, robust	101	92
Leiognathidae	*Leiognathus leuciscus*	Ponyfish, whipfin	93	85
Harpodontidae	*Saurida undosquamis*	Lizardfish, large-scaled grinner	83	100
Bothidae	*Engyprosopon grandisquama*	Flounder, spiny-headed	78	100
Scorpaenidae	*Apistus carinatus*	Scorpionfish, long-finned waspfish	51	88
Gerreidae	*Gerres subfasciatus*	Roach/banded silver biddy	50	81
Lethrinidae	*Lethrinus punctulatus*	Emperor, blue-spotted	48	77
Monacanthidae	*Monacanthus chinensis*	Leatherjacket, fan-bellied	47	81
Mullidae	*Upeneus tragula*	Goatfish, bar-tailed	45	77
Sillaginidae	*Sillago burrus*	Trumpeter whiting	42	73
Pinguipedidae	*Parapercis nebulosa*	Grubfish, red-barred	31	85

Table 9.2. Twenty most abundant (number per nm trawled) invertebrate species in Shark Bay in 2002 and 2003 and proportion of sites in which they were caught (Source: Kangas & Morrison 2013)

Family	Species	Common name	Ave. no per nm	% sites
Penaeidae	*Metapenaeopsis sp.*	Coral prawn	441	100
Pectinidae	*Amusium balloti*	Saucer scallop	403	73
Penaeidae	*Penaeus latisulcatus*	King prawn	231	100
Pectinidae	*Annachlamys flabellata*	Fan scallop	159	85
Portunidae	*Portunus armatus*	Crab, blue swimmer	139	100
Penaeidae	*Penaeus esculentus*	Brown tiger prawn	90	88
Portunidae	*Portunus rubromarginatus*	Swimmer crab	87	100
Portunidae	*Portunus tenuipes*	Swimmer crab	61	85
Penaeidae	*Metapenaeopsis crassissima*	Coral prawn	53	77
Ascidiacea	*Ascidiacea*	Ascidian	49	85
Ascidiacea	*Herdmania pallida*	Ascidian	42	4
Philinidae	*Philine* sp.	Sea slug	40	81
Penaeidae	*Metapenaeus dalli*	Western school prawn	38	46
Penaeidae	*Metapenaeus endeavouri*	Endeavour prawn	36	62
Cucumariidae	*Colochirus quadrangularis*	Holothurian	34	69
Scyllaridae	*Eduarctus martensii*	Slipper lobster	33	81
Portunidae	*Thalamita sima*	Swimming crab	19	92
Cucumariidae	*Colochirus crassus*	Holothurian	19	96
Portunidae	*Portunus hastatoides*	Swimmer crab	18	62
Portunidae	*Charybdis feriata*	Coral crab	12	88

When individual sites were examined for environmental variables, salinity attributed to the highest variation observed for fish species, with no significant contribution of whether the site was trawled or untrawled for any of the diversity indices examined. For invertebrate species, depth was the variable providing the highest per cent variation for any of the indices, but there was some evidence that the Margalef's richness index had a significant variation associated with whether the site was trawled or untrawled (Kangas & Morrison 2013).

Many of the individual species examined were absent or had very low abundance in the northernmost sites of Shark Bay, which had typically oceanic conditions and greater depths than the rest of the bay. These were shown to have a much higher abundance in the southern parts of Shark Bay, however, their distributions were often similar in both trawled and untrawled sites in these regions (Kangas & Morrison 2013).

Pooled data for 2002 and 2003 indicated three main groups of sites for fish and invertebrate assemblages (Figure 9.7), with each grouping containing both trawled and untrawled sites. Site 22, however, had completely different assemblages, with several fish and invertebrate species much more abundant compared with other sites. This was the also only site to have extensive dense meadows of wireweed *Amphibolis antarctica* (Kangas & Morrison 2013).

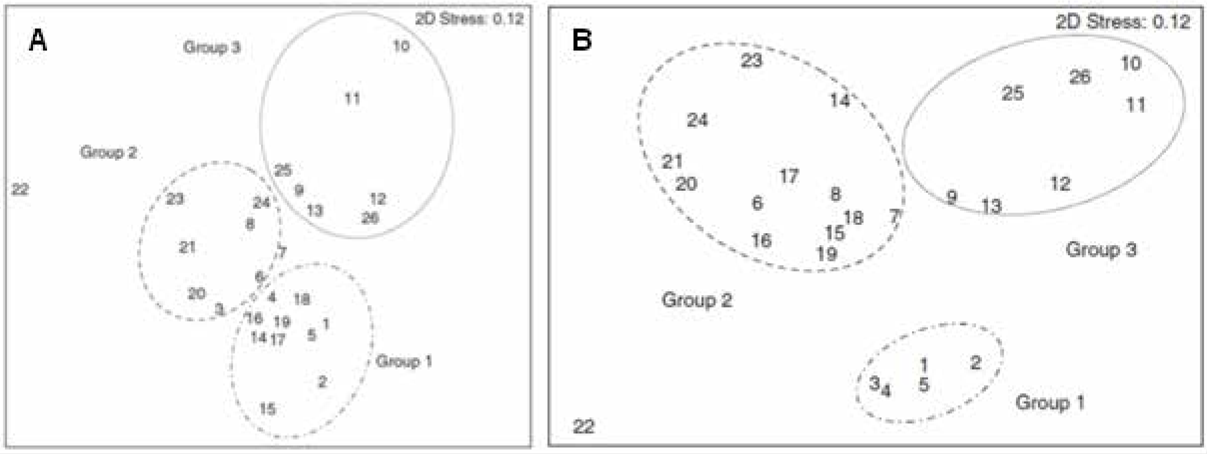

Figure 9.7. MDS of (A) fish and (B) invertebrate species assemblages in Shark Bay for the 26 sites sampled during 2002 and 2003 (Source: Kangas & Morrison 2013)

There were significant differences in the species evenness, the Shannon's diversity index and Simpson's diversity index for the trawled and untrawled sites in Group 1 fish assemblages, with higher values in the untrawled sites. Significant differences were also seen in the species richness and Shannon's diversity index for the trawled and untrawled sites within Group 3 fish assemblages, but the values were higher in the trawled sites (Figure 9.8). There were no significant differences in the diversity measures for the trawled and untrawled sites within Groups 1 and 2 for any of the invertebrate assemblages (Figure 9.9); however, there were significant differences in the species richness, the Shannon's diversity index and Simpson's diversity index for the trawled and untrawled sites within Group 3 invertebrate assemblages, with trawled sites having higher indices (Kangas & Morrison 2013).

The results of this study substantially expand the understanding of the impacts of trawling on the Shark Bay ecosystem and in particular, provide a detailed spatial and seasonal assessment of benthic communities, including areas where no trawling occurs. The latitudinal effects appeared to exert a stronger influence on community structure than the effects of trawling, although for fish it was shown that the fishing impacts were detectable with moderate to high trawl intensities and that low trawl effort sites had the highest abundance (Kangas & Morrison 2013).

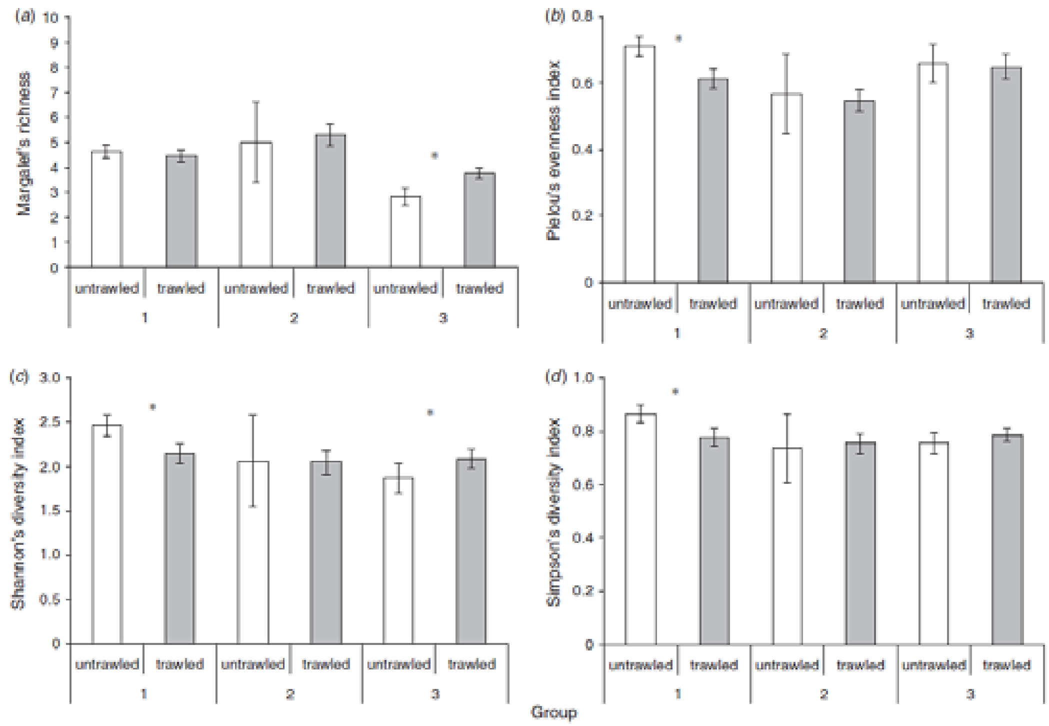

Figure 9.8. Least-squares mean of indices with 95 % confidence interval calculated for trawled and untrawled sits within groups identified from MDS for fish abundance in Shark bay. * indicates significant differences between trawled and untrawled sites within the grouping (Source: Kangas & Morrison 2013)

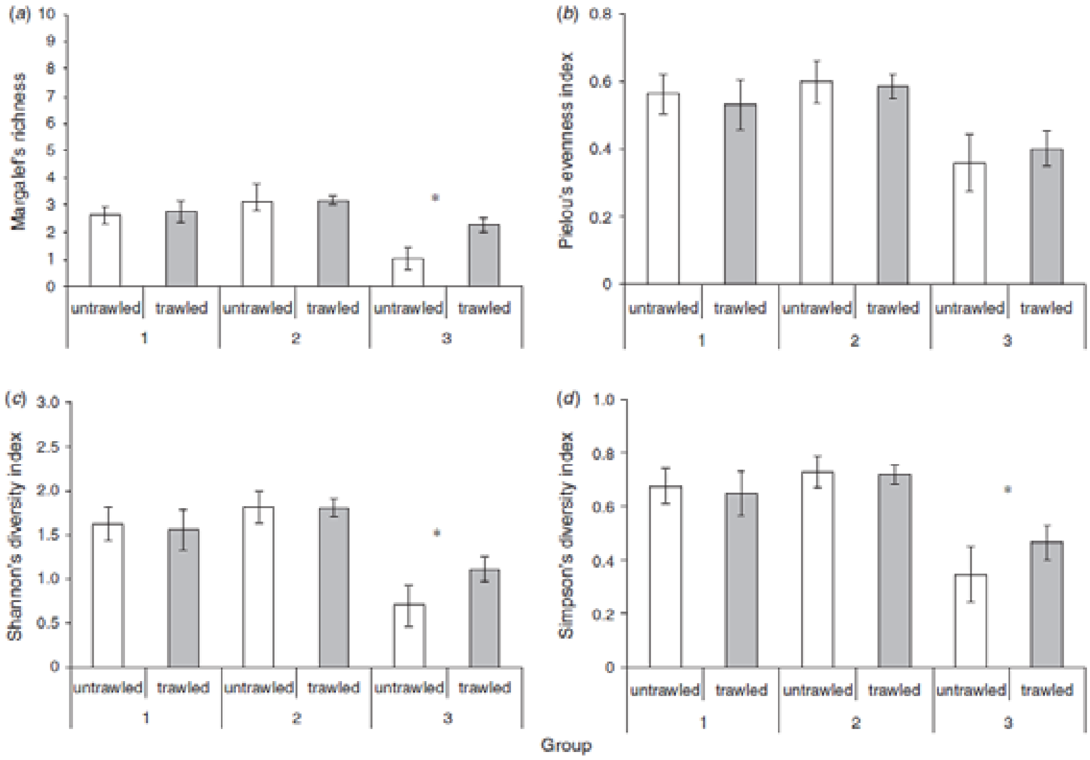

Figure 9.9. Least-squares mean of indices with 95 % confidence interval calculated for trawled and untrawled sits within groups identified from MDS for invertebrate abundance in Shark bay. * indicates significant differences between trawled and untrawled sites within the grouping (Source: Kangas & Morrison 2013)

Two depletion experiments were also undertaken in Denham Sound (sites 18 and 19) to assess bycatch species susceptibility in order to enable a comprehensive assessment for trawl impacts on bycatch species biodiversity (Kangas & Morrison 2013). At each site, the area delineated was covered by trawling north, then south with the gear overlapping the centre of the previous track so that the entire area was covered. This was repeated until all 16 sweeps were completed. Each sweep was 10 minutes in duration, and all the fish (except venomous fish in families Scorpaenidae, Plotosidae and Siganidae) and invertebrates were sorted and numbers counted after every second sweep (i.e. two sweeps sorted at a time) to even out any effects of trawling in different directions (Kangas & Morrison 2013).

For all fish species combined, the catchability was 0.23 (SE ± 0.074) per night in February and 0.06 (SE ± 0.022) in June (Figure 9.10). The low catchability overall was attributed to an increase in abundance over successive nights of the hair-finned leatherjacket (*P. choirocephalus*). When this species was removed from analysis, the catchability overall for all other 46 fish species was 0.40 (SE ± 0.058). For all invertebrates catchability was 0.11 (SE ± 0.024) per night in February, with almost no decline observed in June. The low catchability in June was attributed to an increase in abundance over successive nights of a small scallop *Annachlamys flabellata* (Lamarck, 1819), and if this was removed from the dataset, the catchability for all the other 76 invertebrate species recorded was 0.20 (SE ± 0.037; Figure 9.10).

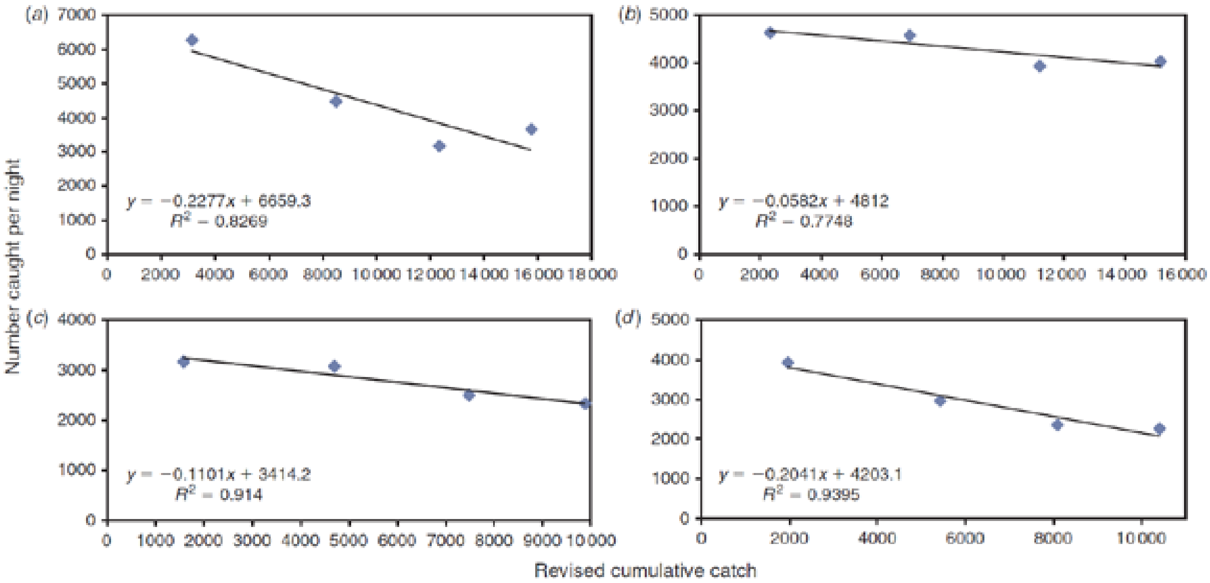

Figure 9.10. Depletion estimates of catchability of total fish and invertebrate species over four nights of trawling in Denham Sound (a) fish in February, (b) fish in June, (c) invertebrates in February and (d) all invertebrates, other than *Annachlamys flabellata* in June (Source: Kangas & Morrison 2013)

There was a significant seasonal decline in fish abundance from the period before the start of the season in February to the end of the season in November. This decline was primarily attributed to five species: *L. genivittatus*, *P. choirocephalus*, *P. quadrilineatus*, *T. pallimaculatus* and *U. asymmetricus*. This decline occurred in both trawled and untrawled sites and possibly reflects a seasonal variation in abundance and / or movement between trawled and untrawled areas. Invertebrate species abundance was only observed to decline significantly between February and June in both trawled and untrawled sites. This was attributed to the very abundant species: *A. balloti, P. latisulcatus, P. rubromarginatus* and *H. pallida*, with the first two being commercially-harvested species. As with the fish species, these four dominant invertebrate species drove the abundance patterns (Kangas & Morrison 2013).

The depletion experiment clearly indicated that some species were much more vulnerable to trawling, with catchability depending on their mobility, pattern of movement, size, physical form, burying ability, feeding mode and whether they are attracted to disturbed substrates. Susceptible species were considered to have catchability coefficients greater than 0.6 and included the invertebrates *L. maculata* (sea star) and the phylum Porifera (sponges) and the fish *P. octolineatus*, *Parupeneus chrysopleuron*, *L. genivittatus*, *S. sageneus*, *P. vitta*, *C. cephalotes* and *S. robusta* (Kangas & Morrison 2013).

Despite a clear abundance decline in some species, no obvious impact from trawling could be discerned from abundance and distribution patterns of these species, even those with high catchability coefficients. All species recorded on trawl grounds were also present in untrawled areas. Many of the moderate- to high-catchability species that are also widespread are good candidate indicator species for trend analysis (Kangas & Morrison 2013).

10. Retained (Non-Target) Species

10.1 Fishery Impacts

In addition to western king and brown tiger prawns, the SBPMF also retains small quantities of other prawn species, finfish and small invertebrates as byproduct. In 2013, catches included 123.7 t coral prawns (various species but mainly *Metapenaeopsis crassissima*), 15 t endeavour prawns (*Metapenaeus. endeavouri*), 20.9 t cuttlefish (*Sepia* spp.), 15.8 t blue swimmer crabs (*P. armatus*), 5.8 t squid, 13.2 t mixed finfish species, 3.2 t bugs (*Thenus australiensis* and *T. parindicus*) and 0.6 t octopus (Sporer et al. 2014; Table 10.1).

Table 10.1. Retained non-target species (tonnes) for the Shark Bay Prawn Managed Fishery 2003 – 2013

Species	Catches (t)										
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Endeavour Prawns	3	8	< 1	< 1	< 1	< 1	< 1	< 1	15	23	15
Coral Prawns	84.0	64.9	91.0	115.0	27.4	68.9	197.5	105.8	116.8	199.8	123.7
Blue swimmer crabs	110.5	193.9	152.0	114.3	255.6	135.2	251.2	338.2	293.0	12.5	15.8
Cuttlefish	12.0	11.1	7.8	5.7	8.6	9.5	21.5	29.3	19.9	22.6	20.9
Squid	77.5	76.6	46.6	48.0	23.1	9.5	21.1	45.3	13.9	5.1	5.8
Mixed Finfish	26.2	9.9	3.1	23.6	15.8	11.2	16.5	11.3	14.4	2.8	13.2

Bugs	0.0	0.0	0.1	1.5	0.7	1.5	2.2	13.2	0.9	2.5	3.2
Octopus	0.3	0.4	0.4	0.7	0.5	0.2	0.5	1.0	0.5	0.2	0.6

Although there is no formal stock assessment process for non-target retained species, total catch is used to assess the annual level of exploitation of each species' stock. For each species, the acceptable catch ranges have been set to reflect the historical catches of these species as follows:

- Minor prawn species (i.e. coral prawns): annual acceptable catch levels based on historical catches during the period 1989 – 1998;
- Blue swimmer crabs: as per the Shark Bay blue swimmer crab resource annual TACC; and
- All other retained non-target species: annual acceptable retention levels based on historical landings during the period 1990 – 2010. Note that retention levels for finfish species have only been identified for the current most-commonly retained species groups, i.e. whiting, flathead, mulloway and flounder, and these acceptable retention levels are still being developed. Industry has indicated that retention of non-target catch may increase in coming seasons as part of its commitment to minimising bycatch discards.

10.1.1 Risk Assessment Outcomes

10.1.1.1 Endeavour Prawns

2010 Risk Rating: Impact to breeding populations (C2 L5) **Low**

2014 PSA assessment: (2.01) **Low**

Although endeavour prawns are not targeted by the SBPMF, they are caught in reasonable numbers in some years (see Table 10.1).

Endeavour prawns (*Metapenaeus* spp.) are restricted to northern Australian waters between northern New South Wales and the Gascoyne coast of WA (Grey et al. 1983) and are found in coastal waters down to approximately 50 m in muddy or sand / mud sediment substrates. Within Shark Bay, they are generally found in the southern end of the South CPL (Kangas et al. 2006) and are thus protected from trawling for a large part of the year.

Additionally, endeavour prawns are considered to be more resilient to fishing pressure due to their smaller size (and thus lower catchability) and the lower level of targeting compared to brown tiger and western king prawns (Kangas et al. 2006).

Given no change in effort, catches of endeavour prawns should remain within the acceptable catch range of 1 – 30 t. This low level of catch should ensure that there is sufficient breeding stock to continue recruitment at levels that will replenish what is taken by fishing, predation and other environmental factors (Kangas et al. 2006).

10.1.1.2 Coral Prawns

2010 Risk Rating: Impact to breeding populations (C2 L4) **Moderate**

2014 PSA assessment: (2.01) **Low**

Coral prawns consist of a number of smaller prawn species, but in Shark Bay a large proportion of are *Metapenaeopsis crassissima*. *M. crassissima* is restricted to Australia and has been reported from South Australia, WA and north to Darwin in the Northern Territory. They most commonly occur down to 30 m over soft muddy bottoms (Grey et al. 1983). Little is known about the life history of *M. crassissima*; in Shark Bay, it appears that spawning may occur throughout the year, and it is assumed that nursery areas are inshore sheltered habitats similar to those preferred by western king and brown tiger prawn juveniles. *M. crassissima* is considered to be one of the largest species of this genus (Racek & Dall 1965), but it is still much smaller than both the western king and brown tiger prawns. Because of their small size, many pass through the cod end mesh and are therefore not captured by the fishing gear.

Coral prawn landings are highly variable due to their low value and therefore, lack of targeting by the fleet and generally low rate of retention. Landings of coral prawns tend to supplement the catch when the target species are in low abundance (Kangas et al. 2006).

Given no change in effort, catches of coral prawns should remain within the acceptable catch range of 80 – 280 t. This level of catch should ensure that there is sufficient breeding stock to continue recruitment at levels that will replenish what is taken by fishing, predation and other environmental factors (Kangas et al. 2006).

10.1.1.3 Blue Swimmer Crabs

2010 Risk Rating: Impact to breeding populations (C1 L4) **Moderate**

2014 PSA assessment: (2.01) **Low**

In WA, blue swimmer crabs are distributed from Albany to the Northern Territory border. They inhabit a wide range of inshore and continental shelf areas, from the intertidal to at least 50 m depth.

There is a comparatively limited area where blue swimmer crabs are caught by prawn trawlers in Shark Bay, and extensive refuge areas exist both north and south along the coast and in deeper waters of the continental shelf that are not generally fished.

Fishers retain crabs at a voluntary minimum size of approx. 135 mm carapace width (CW; spine to spine). This is well above the size at maturity (90 – 110 mm CW) and larger than the legislated minimum size of 127 mm CW. Fishers are also not allowed to retain egg-bearing females.

The SBPMF has historically taken only a small proportion of the total catch of blue swimmer crabs within Shark Bay; however, there has been increased retention of blue swimmer crabs in recent years. Both the trawl and trap industries voluntarily stopped fishing for blue swimmer crabs in April 2012 to facilitate stock rebuilding following a decline in abundance caused by adverse environmental conditions (see Section 5.3.2 for more details on the Shark Bay blue swimmer crab resource). Following partial stock recovery, the fishing season reopened in September 2013 with a TACC of 400 t (264 t for the trap sector and 135.2 t for the trawl sector) for the 2013/14 season.

The Shark Bay blue swimmer crab stock continues to recover from environmental impacts on recruitment as indicated by high biomass levels in February 2014 and sustained biomass levels in April 2014 (DoF unpublished data). Recovery of the stock in the deeper grounds to the west of CPL has been observed for the first time since the stock decline in late 2011. This recovery on the main trawl fishing grounds is supported by the intensity of commercial fishing in these grounds by the both trap and trawl sectors since the resumption of fishing in 2013.

10.1.1.4 Bugs[1]

2010 Risk Rating: Impact to breeding populations (C0 L5) **Negligible**

2014 PSA assessment: (2.01) **Low**

Bugs have an extensive distribution and wide geographical range and are generally caught in very low numbers by the SBPMF (e.g. 3.2 t in 2013). Under current arrangements, the fishery is considered to have only a remote likelihood of having even a minor impact on this stock resulting in a negligible risk to the stock, thus no further targeted management is required (Kangas et al. 2006).

10.1.1.5 Cephalopods

2010 Risk Rating: Impact to breeding populations (C0 L5) **Negligible**

2014 PSA assessment: (2.23) **Low**

Squid and cuttlefish are retained in moderate amounts in the SBPMF, while octopus are retained in very low amounts (generally less than one tonne annually).

Four species of cuttlefish occur in Shark Bay. All are geographically-widespread species at or near the end of their ranges in Shark Bay. Two species (*Sepia apama* and *S. novaehollandiae*) are temperate species near the northern limit of their ranges, while the other two (*S. cultrata* and *S. pharonis*) are widespread tropical species near the southern limit of their ranges. Therefore, the populations of the cuttlefish species in Shark Bay make up only a small proportion of the total ranges of these species.

Additionally, cuttlefish are most common where there are rock outcrops, seagrass beds, and other areas, which provide habitat diversity and protection. As a result, a significant proportion of the populations in Shark Bay would be unavailable to be caught by trawling operations as they do not occur in trawling areas (Dr Fred Wells [WA Museum] pers. comm.; Kangas et al. 2006).

[1] Note that bugs were included as 'other species' in the 2001, 2008 and 2010 Risk Assessments, but have been added and evaluated separately for the purpose of this document.

Given the biological characteristics (i.e. short life span, fast growth and high fecundity), population size, wide distribution, and the current catch levels of these species, the SBPMF is considered to have only a remote chance of even having a minor impact on these species' stocks resulting in a negligible risk (Kangas et al. 2006).

10.1.1.6 Mixed Finfish

2010 Risk Rating: Impact to breeding populations (C0 L5) **Negligible**

2014 PSA assessment: Whiting *Sillago* spp. (2.01) **Low**

Flounder (Family Bothidae) (2.09) **Low**

Flathead (Family Platycephalidae) (2.28) **Low**

Mulloway *Argryosomus japonicas* (2.82) **Medium**

Mixed finfish species are generally caught in very low amounts (< 1 – 15 t), with 13 t retained in 2013. This level of harvest is highly likely to be minor in comparison to the likely stock sizes of finfish species across the WA coast (Kangas et al. 2006). Further harvest control rules have been established for some mixed finfish species that are commonly retained (i.e. whiting, flounder, flathead and mulloway) (see *SBPMF Harvest Strategy 2014 – 2019* [DoF 2014a]).

10.2 Retained Species Management

There is a strategy in place to manage fishery impacts on byproduct, which utilises a number of management measures under the *Shark Bay Prawn Managed Fishery Management Plan 1993* and operational activities (as per the *SBPMF Harvest Strategy 2014 – 2019*) including:

- Limited entry;
- Gear controls;
- Seasonal closures;
- Spatial closures;
- Temporal closures; and
- Reporting.

These management measures reduce the impact of the fishery on retained non-target species' stocks by limiting the annual amount of fishing activity via seasonal, temporal and spatial closures. For example, permanent nursery closures protect non-target prawn stocks in addition to the targeted brown tiger and western king prawns. Daylight bans on trawling also reduce the potential effort on captured species (Kangas et al. 2006).

The *Shark Bay Prawn Managed Fishery Harvest Strategy 2014 – 2019* includes the long-term management objective of: *maintaining spawning stock biomass of each retained non-target species at a level where the main factor affecting recruitment is the environment*. As such, appropriate performance indicators, reference levels and control rules have been developed for all retained species in the SBPMF (DoF 2014a).

The harvest strategy includes acceptable catch levels for all retained non-target species and where a species' stocks have experienced a decline, appropriate management measures have been enacted to promote stock rebuilding. For example, fishers have not been permitted to retain scallops due to low stock abundances of this species within Shark Bay over the past few seasons. Fishers also voluntarily closed the blue swimmer crab fishery in 2012 following significant stock declines. The blue swimmer crab fishery reopened in September 2013, with a TACC in place of 400 t (combined trap and trawl sectors). The fishery is also in the process of moving to an ITQ system under a new Shark Bay Crab Managed Fishery Management Plan (expected completion mid-2015), which will incorporate the prawn trawl, scallop trawl and trap sectors.

At-sea and aerial patrols are conducted by the Department to monitor compliance with regulations. If monitoring indicates a need to reduce trawl impacts on retained non-target species in Shark Bay, this may be achieved through extending the use of current management tools, such as spatial and temporal closures, targeted harvesting strategies to optimise expenditure of effort, a reduction in overall fishing effort and the use of mechanical or other devices, such as BRDs and hoppers.

Overall evidence that the strategy is achieving its objective is provided by (1) the stable catch history of the primarily retained non-target species and (2) an experimental survey-based study that found no difference in the abundance, species richness, evenness or diversity of fish and invertebrates (including each of the main retained species) between trawled and untrawled areas in Shark Bay (Kangas et al. 2007; Kangas & Morrison 2013).

10.3 Retained Species Information and Monitoring

Research and monitoring of the SBPMF has been conducted since the commencement of the fishery in the early 1960s (see Sections 8.4 and 9). Catches of all retained species have been reported by fishers to the Department in daily logbooks since the fishery began in the 1960s (see logbook example in Appendix D). These logbooks became compulsory in the fishery in 2008 and include information on retained species, effort, ETP species interactions and fishing location (detailed shot-by-shot longitude and latitude). The information provided in logbooks is verified by processor unloads, which have been provided to the Department on a monthly basis since the fishery began. Unload data is also used to adjust daily logbook catch and effort.

The logbooks are checked by the Department's research staff on a monthly basis and any possibly erroneous entries or gaps are checked directly with skippers or the fishing company. The information provided in logbooks is considered sufficient to quantitatively estimate the outcome status of byproduct species and monitor and assess all ongoing mortalities.

Additionally, a Vessel Monitoring System (VMS) has been in place in the SBPMF since 2001. VMS enables the Department to monitor a boats location and speed with particular attention paid to the surveillance of closed areas. VMS monitoring of boats is undertaken for the entire season. Annual spatial data validation is undertaken using GIS, and random checks of data entry are made through using VMS location records.

11. Bycatch

11.1 Fishery Impacts

Bycatch levels for the SBPMF are variable, and bycatch is dominated by mixed finfish and invertebrates (see bycatch species list from 2002 – 2003 BRD trials in Appendix F). Bycatch species are returned to the water following capture; survival rates of returned fish are thought to be low, but are high for many invertebrates (e.g. crustaceans; Kangas et al. 2007). Few of the bycatch species are targeted by other sectors, with the exception of scallops and some finfish species, such as pink snapper.

Small finfish species make up approximately 70 – 80 % of the bycatch, with very few of these species subject to other fishing mortality. Along with a risk assessment for the collective group of discarded fish species (see Section 11.1.1 below), the Department has also undertaken an assessment of the risk to individual discarded fish species of the SBPMF. This was undertaken according to the same criteria developed and applied by Stobutzki et al. (2000) in the Northern Prawn Fishery (Kangas et al. 2006). Only two of the 21 most-commonly caught species, i.e. the spiny head flounder, *Engyprosopon grandisquamum,* and the heart headed flounder, *Sorsogona tuberculata,* rated highly-susceptible to trawling using the criteria; however, these species have high turnover rates and therefore the risk associated with fish bycatch is still considered to be minor. These species are also likely to be found throughout Shark Bay, with adequate areas of refuge provided in areas closed to trawling.

As part of the biodiversity study conducted by Kangas et al. (2007), highly susceptible species to trawl impacts were identified. These species included the invertebrates *L. maculata* (sea star) and the phylum Porifera (sponges) and the fish *P. octolineatus*, *Parupeneus chrysopleuron*, *L. genivittatus*, *S. sageneus*, *P. vitta*, *C. cephalotes* and *S. robusta* (Kangas & Morrison 2013). Of these identified susceptible species, all the fish species (with the exception of *P. octolineatus*) were included in the RRAMF by Evans & Molony (2010). No species scored higher than a low-moderate risk score for the cumulative impacts of fishing in the Gascoyne Coast Bioregion (Table 11.1), including any impacts from the SBPMF.

Table 11.1. Susceptible fish species and their highest risk score. Parameters listed are those that resulted in the highest risk score. Ave Score is the average score of all twelve parameter combinations assessed. D: Depth; Di: Distribution; Mo: Mortality; F: Fishing. Green shading indicates a low-moderate risk score (Adapted from Evans and Molony 2010)

Common name	Species name	Parameters	Score	Ave Score
Yellow striped goatfish	*P. chrysopleuron*	D & Mo	8.57	6.43
Threadfin emperor	*L. genivittatus*	D & Di	6.51	5.72
Netted lizardfish	*S. sageneus*	D & Mo	5.43	4.18
Striped whiptail	*P. vitta*	D & Di	6.34	5.14

Purple tuskfish	*C. cephalotes*	D & F; D & Mo	6.51	5.72
Robust whiting	*S. robusta*	D & Mo	6.86	6.10

The 2014 PSA assessment included 11 bycatch species, which were identified as species of high abundance (> 3 % of total catch) within Shark Bay during the biodiversity study undertaken in 2002 – 2003 (Kangas et al. 2007). All species were assessed as being at low risk, with individual species scores provided in Section 11.1.1 below.

The SBPMF also overlaps the spatial distribution of scallop (*Amusium balloti*) stocks within Shark Bay, with many of the SBPMF vessels also retaining scallops during the scallop season (under licences to fish in the SBSMF). When the scallop fishery and /or season is closed, however, prawn fishers are not permitted to retain scallops and all captured scallops must be discarded. The effects of trawling on scallops in Shark Bay were studied by Kangas et al. (2012) and are summarised in Section 9.3.

11.1.1 Risk Assessment Outcomes

11.1.1.1 Discarded fish

2010 Risk Rating: Impact to breeding populations (C2 L3) **Moderate**

2014 PSA assessment: Asymmetrical goatfish *Upeneus asymmetricus* (2.09) **Low**

Hair-finned leatherjacket *Paramonacanthus choirocephalus* (2.01) **Low**

Trumpeter *Pelates quadrilineatus* (2.18) **Low**

Scorpionfish *Paracentropogon vespa* (2.09) **Low**

Threadfin emperor *Lethrinus genivittatus* (2.18) **Low**

Orange-spotted toadfish *Torquigener pallimaculatus* (2.18) **Low**

Goodlad's stinkfish *Callionymus goodladi* (2.09) **Low**

Large-scaled grinner *Saurida undosquamis* (2.09) **Low**

Small non-commercial fish make up the majority of the bycatch in the SBPMF (Kangas et al. 2006). Juvenile fish caught by trawlers have a naturally high mortality rate and as such, the additional fishing mortality from the SBPMF is highly unlikely to have even a minor impact. In addition, these species are known from survey results to occur in the extensive areas where trawling does not occur (Kangas et al. 2007).

The management measures and fishing methods in place (e.g. use of grids, FEDs and hopper sorting systems, the restricted area in which fishing activities can occur) are considered to maintain individual stocks of these species well above a 0.6 virgin biomass reference point, which is considered to be a highly conservative reference point for most finfish species (Kangas et al. 2006).

11.1.1.2 Invertebrates

2010 Risk Rating: Impact to breeding populations (C0 L5) **Negligible**

2014 PSA assessment: Saucer scallop *Amusium balloti* (1.93) **Low**

Fan scallop *Annachlamys flabellata* (1.74) **Low**

Other portunid crabs *Portunus robromarginatus* (1.83) **Low**

The shallows of Shark Bay support an abundant and diverse invertebrate community, which has been attributed to the spatial isolation, high organic productivity and extensive seagrass beds and carbonate sand flats. Many of these species may reside on or in the sea floor where trawl gear operates.

The trawl gear used in the SBPMF, however, is configured in a manner that largely precludes the capture of invertebrate species living on or in the substrate (Kangas et al. 2006). There is a gap of approximately 20 cm between the ground chain and the footrope of the net, which specifically serves to minimise the capture of small immobile and slow moving benthic organisms (and inanimate objects; Kangas & Thomson 2004).

Although some large immobile organisms may be 'flicked' up into the water column by the ground chain and subsequently captured in the net, the grids in place in trawl nets have an escape opening to facilitate the removal of these organisms (Kangas & Thomson 2004).

The management measures and fishing methods in place (e.g. use of grids, FEDs and hopper sorting systems, the restricted area in which fishing activities can occur and the relatively short fishing season) are considered to maintain invertebrates species' stocks within biologically-based limits based on the distribution of these species throughout the Bay and wider Gascoyne Coast bioregion (Kangas et al. 2007).

Thus, it was considered only 'possible' that the SBPMF could have a 'negligible' impact on invertebrate populations in Shark Bay (Kangas et al. 2006).

11.1.1.3 Sharks

2010 Risk Rating: Impact to breeding populations (C0 L5) **Negligible**

Sharks have previously been retained as byproduct in the SBPMF; however, in 2007 all sharks in WA were commercially protected under the FRMA and cannot currently be retained without a permit.

The historical catch of sharks in the fishery was very low and never exceeded two tonnes in any one year, with an average take of 1.5 t each year. It is likely that the number of sharks captured and discarded in the fishery is similar to historical catch levels, with many large sharks excluded from trawl nets by grids (Kangas & Thomson 2004).

As the shark catch is comprised of more than one species, the impact on any one species is conserved to be negligible (Kangas et al. 2006).

11.2 Bycatch Management

The SBPMF has undertaken a number of management actions over the last 50 years that have contribution to reductions in bycatch in the fishery (Figure 11.1).

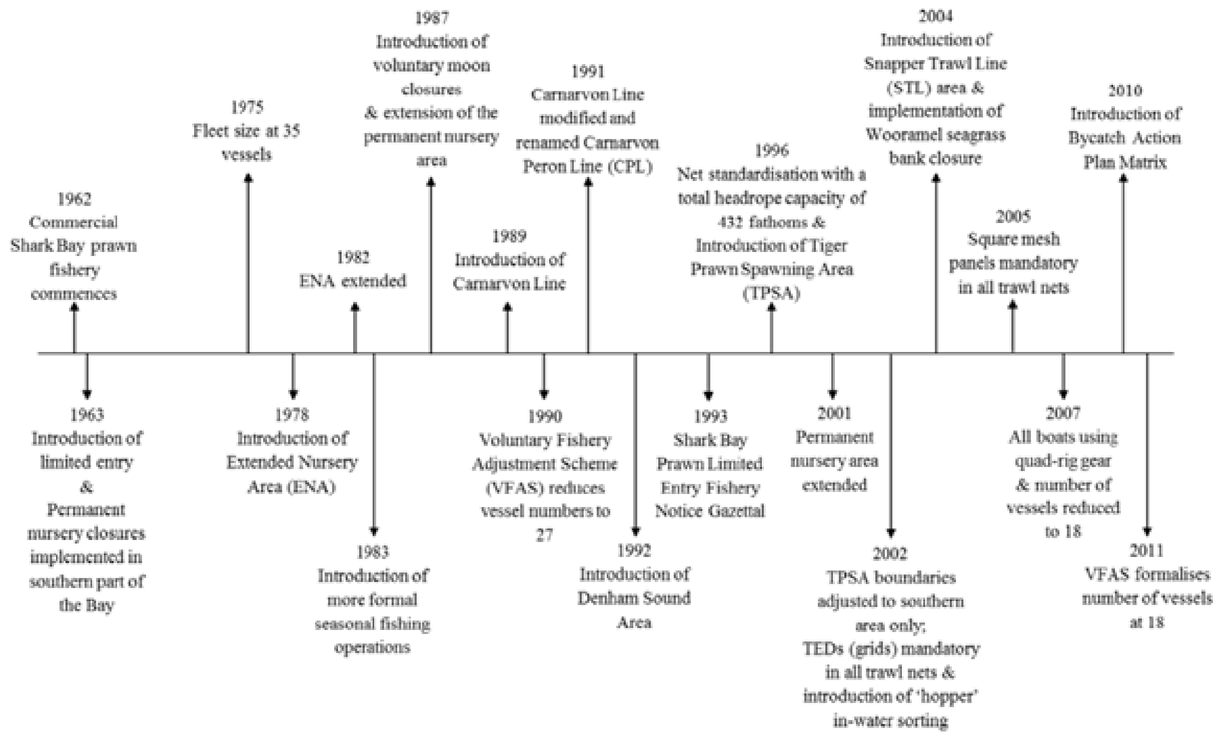

Figure 11.1 Summary of key management changes in the SBPMF that have reduced the impact of the fishery on bycatch species populations (Source: DoF 2014b)

There is a strategy in place to manage fishery impacts on bycatch species, which utilises a number of management measures under the *Shark Bay Prawn Managed Fishery Management Plan 1993* and operational activities (as per the *SBPMF Harvest Strategy 2014 – 2019*) including:

- Limited entry;
- Gear controls and the use of hopper sorting systems;
- Seasonal closures;
- Spatial closures;
- Temporal closures; and
- The use of VMS.

Not only have these measures been used successfully in similar fisheries, but testing supports high confidence that they will work in Shark Bay. The SBPMF uses a number of measures to physically reduce overall bycatch and increase the survival of bycatch through the use of gear controls including:

- a maximum ground chain link diameter (10 mm) to address the impact the chain has on benthic habitat and non-target species;
- a maximum otter board height to restrict the vertical net opening and facilitate escapement of non-target species over the top of the net;
- a maximum board length to address shoe contact with the benthic habitat and non-target species;
- the use of a drop chain arrangement to promote passage of unwanted flora and fauna underneath the net;
- the mandatory use of TEDs (grids) in all nets; and
- the mandatory use of FEDs (square mesh panels) in all nets.

The use of grids and square-mesh panels is required in all prawn trawl fisheries in WA and has been mandatory in the SBPMF since 2002 for grids and since 2005 for FEDs. Two types of grids are used in the SBPMF: the CSWA (circular, straight vertical bars, wide bar spacing and accelerator) and RSNA (rectangular, straight vertical bars, narrow bar spacing and accelerator). Some grids are still being used with a horizontal gap (up to 300 mm) in the bottom ("flounder gap") to aid the movement of weed into the codend. Overall grid dimensions are around one metre wide and 1.3 m high. Grids are sewn into the nets at an angle of 45 °, and the escape opening is generally around 780 – 800 mm wide. Bar spacing is generally 160 – 200 mm (Kangas & Thomson 2004). During BRD trials in 2000 – 2001, there was up to a 17 % reduction in overall bycatch using grids alone (Kangas & Thomson 2004). Additionally, compared to the control nets, the grid in combination with a square mesh panel also significantly reduced the weight of bycatch by 54 % (Kangas & Thomson 2004). Over a 50 % reduction in individual numbers caught was also observed for a number of fish species during FED trials in 2008 and 2009 (DoF, unpublished data).

In-water hopper sorting systems on prawn vessels add another level of protection for bycatch survival (Dell et al. 2003). Hoppers are large, water-filled tanks that receive the catch directly from the nets, thereby reducing the time the catch spends out of water. The use of hoppers makes for more-efficient sorting, and consequently, bycatch is returned to the sea more quickly (Oceanwatch 2004). The spatial and temporal measures in place are considered sufficient to minimise impacts from fishing on vulnerable species. In Shark Bay, only 20 – 40 % of the fishery area is open to trawling, and in 2013, the total area trawled was 17.2 % (Sporer et al. 2014). This ensures that more vulnerable species are protected, as the majority of species occur in both trawled and untrawled areas (Kangas et al. 2007; Kangas & Morrison 2013).

Marked seasonal differences in survival and recapture estimates of discarded *A. balloti* highlight the potential impact of past and present management strategies on the sustainability of the scallop resource in Shark Bay. The change in regulation to simultaneous openings for both the prawn and scallop fleets in 2004 reflects a positive change, where most scallops that are caught in summer are harvested. Regulatory discarding by the prawn fleet still occurs but is predominantly over winter months, when scallops exhibit higher resilience to trawl-induced stress (Kangas et al. 2012). The results support the current management strategy of both fleets fishing during the warmer pre-spawning months so that the amount of discards is less, and a spawning closure period during the cooler months, when associated discard mortality is minimal.

The *Shark Bay Prawn Managed Fishery Harvest Strategy 2014 – 2019* includes the long-term management objective to ensure *fishery impacts do not result in serious or irreversible harm to non-retained species populations*. As such, appropriate performance indicators, reference levels and control rules have been developed for bycatch species in the SBPMF (DoF 2014a). Although there is no formal stock assessment process for these species, the extent of trawling activities, BRD use and assessed risk is used to assess the impact of the SBPMF on these species' populations.

There is a continual monitoring and improvement process to minimise the impacts of the trawl gear in the SBPMF. This is facilitated through the Bycatch Action Plan (DoF 2014b), which supersedes the previous Bycatch Reduction Plan Matrix (DoF 2010) developed by the Department in 2010 for all trawl fisheries in WA. The 2014 Bycatch Action Plan lays out a commitment to a bycatch monitoring program through the application of fishery-independent surveys to collect bycatch species composition data every three years and providing validation through the introduction of a crew member observer program and / or the introduction of independent monitoring to validate crew reporting (e.g. cameras or observers).

If future monitoring indicates a need to reduce trawl impacts on bycatch species or biodiversity in Shark Bay, this may be achieved through extending the use of current management tools, such as spatial and temporal closures, targeted harvesting strategies to optimise expenditure of effort, a reduction in overall fishing effort and the use of mechanical or other devices, such as BRDs and hoppers.

11.3 Bycatch Information and Monitoring

Like most trawl fisheries, bycatch in the SBPMF comprises of a large number of taxa in low abundance, with the majority of species being uncommon or having little biological information available (Kangas & Thomson 2004). Thus, it is not practical to monitor and evaluate the sustainability of each species using traditional methods. As bycatch cannot be eliminated entirely, however, it is important to determine and monitor which species can or cannot sustain the impact of fishing and which species may be suitable as indicator species to reflect trawl impacts on the total suite of bycatch species (Kangas et al. 2007; Kangas & Morrison 2013).

Some information on the amount of bycatch in the SBPMF is available from BRD trials (see Section 9.1). Baseline data on faunal abundance and composition in Shark Bay in both trawled and untrawled areas is also available from an FRCD-funded project conducted in 2002 and 2003 (Kangas et al. 2007; Kangas & Morrison 2013).

Although logbook reporting and VMS provide information on the spatial extent of fishing activities within Shark Bay, fishers are not required to report on bycatch abundance or species composition. The lack of ongoing data collection and monitoring of bycatch in the SBPMF was identified as a potential issue for the fishery as part of the MSC pre-assessment process. In order to address this issue, the Department has developed the *SBPMF Bycatch Action Plan 2014 – 2019*, which includes an overview of bycatch issues in Shark Bay and a proposed work plan for future / ongoing monitoring and research (DoF 2014b).

12. ETP Species

12.1 Overview

Endangered, threatened and protected[1] (ETP) species in WA are protected by various international agreements and national and state legislation. International agreements include:

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

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

A number of ETP species can be found within Shark Bay, including cetaceans (whales, dolphins and porpoises), marine turtles (Families Cheloniidae and Dermochelyidae), sea snakes (Families Hydrophiidae and Laticuadidae), elasmobranchs (sharks and rays), seahorses and pipefish (Families Syngnathidae and Solenostomidae), seabirds and migratory shorebirds (see Appendix G for a comprehensive species list including CITES listing).

[1] Note that being on a protected species list does not automatically indicate that a species is either threatened or endangered.
[2] Further information on the CMS, JAMBA, CAMBA and ROKAMBA is provided at www.environment.gov.au/biodiversity/migratory/index.html

Marine Mammals

Shark Bay supports a variety of marine mammals including dugongs, whales and dolphins, with all of these species protected in Australia under the EPBC Act. The Bay supports one of the largest populations of dugongs in the world (approx. 10 000 – 12 000 individuals; DEC 2010b). These dugongs move seasonally within the Bay to stay within optimal water temperatures (Anderson 1986). Large numbers of dugongs and their young can be found on the Faure Sill and Wooramel Seagrass Bank and between Faure Island and Gladstone Bay during summer, while during winter they use the deeper water areas north of Peron Peninsula (Preen et al. 1997).

Cetaceans found within the Bay include southern right whales, Bryde's whales and Indo-Pacific and common bottlenose dolphins. Shark Bay is also an important resting area for female humpback whales and their young calves as they migrate south along the WA coast to feeding grounds in the Antarctic (Jenner & Jenner 2000). Whaling and habitat degradation have been identified as the key threats to whales, and recovery plans for these species have been developed which establish objectives and actions to ensure the ongoing recovery of these species. The most recent recovery plans for these species are available at: http://www.environment.gov.au/topics/marine/marine-species/whales-dolphins-and-porpoises/legislation.

Marine Turtles

Green turtles (*Chelonia mydas*) are the dominant marine turtle species in Shark Bay. Carnivorous when young, they become mainly herbivorous on algae and seagrass as adults. Loggerhead turtles (*Caretta caretta*) are less common in Shark Bay, but the Bay is believed to provide one of the most important breeding sites for this species in the state; approximately 70 % of loggerhead turtles in WA lay their eggs at Turtle Bay on the northern end of Dirk Hartog Island, Shelter Bay on the southern shores of the Southern Passage and the beaches of Dorre Island (Department of Envrionment 2003; DEC 2010a). Isolated individuals of hawksbill (*Eretmochelys imbricata*) and leatherback (*Dermochelys coraicea*) turtles have also been recorded in the Bay (CALM 1996). Marine turtles in Australia are protected under the EPBC Act. Threats to marine turtles have been identified as fisheries bycatch, customary harvesting, marine debris, shark control activities, boat strike, pearl farming and other aquaculture and defence activities. A recovery plan for these species has been developed by Commonwealth government and establishes objectives and actions to ensure their ongoing recovery. The most recent recovery plan for these species is available at: http://www.environment.gov.au/resource/recovery-plan-marine-turtles-australia.

Sea Snakes

Shark Bay also supports a variety of sea snakes, with seven of the 22 known WA species recorded in Shark Bay (Storr et al. 2002). All seven species are tropical, with Shark Bay being the southernmost limit of their distribution (Storr & Harold 1990). Two species, the bar-bellied sea snake (*Hydrophis elegans*) and the olive-headed sea snake (*Disteria major*), are very common throughout the Bay, and the Shark Bay sea snake (*Aipysurus pooleorum*) is endemic to Shark Bay, where it is also very common. Occasionally, individuals of the golden sea snake (*A. laevis*), the spotted sea snake (*H. ocellatus*), the southern mud snake (*Ephalophis greyae*) and the yellow-bellied sea snake (*Pelamis platura*) can also be found in Shark Bay (Storr et al. 2002). Sea snakes are slow growing and have few offspring. As air breathers, they must come to the surface to breathe; however, they can spend from 30 minutes to two hours diving between breaths (Heatwole 1999). Consequently, many may survive being captured by trawl nets when trawl shots are short, i.e. less than 2 hours (Milton et al. 2009).

A study of sea snake survival following capture in trawlers in the Gulf of Carpentaria (Northern Territory) indicated that greater than 60 % of sea snakes survived capture in trawl nets (Wassenberg et al. 1994). It is likely that sea snakes captured in the SBPMF have a similar level of survival due to the short trawl times (50 – 180 mins) in the fishery.

Seahorses and Pipefish

Protected fish found within the bay include various sea horses and pipefish and sharks and rays, which are mainly found in the deeper waters (>10 m) of oceanic salinity (Kangas and Thomson 2004; Preen et al. 1997). Various species of syngnathids are found within the Bay, along seagrass beds and detached algal communities (Kangas et al. 2006). Some syngnathid populations may be particularly susceptible to pressures because their biology is characterised by relatively low population densities, lengthy parental care combined with small brood size limiting their reproductive rate, strict monogamy, sparse distribution, generally low rates of adult mortality, strong association with preferred habitat, and low mobility and small home ranges (Foster & Vincent 2004; Vincent 1996). However, although all members of the Syngnathidae and Solenostomidae families are listed marine species under the EPBC Act no species is currently listed as threatened. In shallower waters, pipefish and seahorses are a dominant group of fish and are important predators of benthic organisms such as mysids in the zooplankton and small amphipods. (e.g. Kendrick & Hyndes 2005; Martin-Smith 2008).

Sharks and Rays

At least 28 species of shark and six ray species occur in Shark Bay.

Seabirds

Shark Bay is also an important area for seabirds. Surveys by DPaW staff have recorded 14 species breeding in Shark Bay and another 50 species occurring in the Bay (CALM 1996). Thirty-five of these species are listed in JAMBA, CAMBA and / or ROKAMBA. Shark Bay is internationally important for two species of shorebirds, the banded stilt and the eastern curlew, and is nationally important for five species of shorebirds: the wood sandpiper, the greenshank, the grey plover, the banded stilt and the eastern curlew (Watkins 1993). Areas in Shark Bay that are particularly important for seabirds and shorebirds include Faure Island, the eastern side of Dirk Hartog Island, Pelican Island and the spit on Salutation Island. Faure and

Pelican Islands and flats around them may constitute the most important area for migratory shorebirds in the Bay (Jaensch & Vervest 1990).

12.2 Fishery Impacts

Fishers in the SBPMF have reported interactions with sea snakes, marine turtles and seahorses (Table 12.1). When captured, ETP species are dealt with in an appropriate fashion, ranging from ensuring turtle are revived first before returning them to the water, to a more rapid return to the water for more sensitive species.

The level of interaction is considered to be within limits of national and international requirements for the protection of ETP species, and the SBPMF has been found the *Guidelines for the Ecologically Sustainable Management of Fisheries* (see Section 4.7). The fishery was most recently reaccredited in 2013, with export approval extended to 2018.

Table 12.1. Reported interactions with ETP species by the Shark Bay Prawn Managed Fishery 2006 – 2013. Return status indicated where known[1].

Species / Group	No. of Interactions							
	2006	2007	2008	2009	2010	2011	2012	2013
Dolphins								
Alive					1			
Dead								
Unknown							1	
Marine turtles								
Alive	14	2	10	5	9	15	6	35
Dead								1
Unknown								
Sea snakes								
Alive					47	119	387	351
Dead					17	24	44	12
Unknown	206	49	60	236	270			
Seahorses								
Alive			4		10			
Dead								
Unknown							9	

Some species-specific ETP information is available from the biodiversity surveys conducted by Kangas et al. (2007). A small number of marine turtles and sea snakes were caught in trawl nets over the sampling trips in Shark Bay. Three loggerhead turtles (*C. caretta*) were caught, two at the end of the season in October 2002 in Denham Sound (site 18) and near Point Quobba (site 11) and one at the start of the trawl season in February 2003 in Denham Sound. All turtles were in good condition and returned to the water as quickly as possible (Kangas et al. 2007).

[1] Since 2010, reporting in the SBPMF fishery has improved and has been able to provide returned status for some species.

A total of six individuals of two species of sea snakes were caught in Shark Bay. Single specimens of the bar-bellied sea snake (*Hydrophis elegans*) were recorded from site 11 in October 2002, site 16 in February 2003, site 13 in July 2003, and sites 16 and 21 in March 2004. One specimen of the Shark Bay sea snake (*Aipysurus pooleorum*) was caught in the northern prawn trawl grounds in March 2003. Three sea snakes were damaged when trapped in the mesh of the net, but those inside the net were usually in good condition and were returned to the water alive (Kangas et al. 2007).

A number of protected fish species were also caught in the trawl nets (Table 12.2). The sharks and rays were identified as soon as they were brought up and returned to the water as quickly as possible. They appeared to be in good condition. A small number of syngnathids were kept for formal identification, and the rest were quickly returned to the water. These species also appeared to be fairly resistant to trawling; however, their fate on return was unknown (Kangas et al. 2007).

Table 12.2. Shark Bay ETP fish species captured during biodiversity study (Kangas et al. 2007). DD: data deficient; LC: least concern; NT: near threatened; VUL: vulnerable; NA: not assessed.

Common name	Scientific name	Number caught	2014 IUCN status
Dusky whaler shark	*Carcharhinus obscurus*	1	NT
Sandbar shark	*Carcharhinus plumbeus*	1	NT
White-spotted shovelnose ray	*Rhynchobatus australiae*	10	NT
White-spotted eagle ray	*Aetobatus narinari*	1	NT
Western spiny seahorse	*Hippocampus angustus*	17	DD
False-eyed seahorse	*Hippocampus biocellatus*	29	NA
Flat-faced seahorse	*Hippocampus planifrons*	4	NA
Alligator pipefish	*Syngnathoides biaculeatus*	1	DD

The *Shark Bay Prawn Managed Fishery Harvest Strategy 2014 – 2019* includes the long-term management objective to ensure fishery impacts do not result in serious or irreversible harm to ETP species populations. As such, appropriate performance indicators, reference levels and control rules have been developed for ETP species in the SBPMF. Although there is no formal stock assessment process for these species, the extent of trawling activities, BRD use and assessed risk is used to assess the impact of the SBPMF on these species' populations.

12.3 Risk Assessment Outcomes

12.3.1 Marine Turtles

In 2013, fishers in the SBPMF reported interactions with 36 turtles, 35 of which were returned alive. This level of interaction is considered to be a low risk to marine turtle populations, as these species have wide distributions both within the Bay and the greater region (see species-specific risk ratings below).

12.3.1.1 Loggerhead Turtles

2010 Risk Rating (Direct Interactions): Impact on breeding population (C1 L4) **Low**

2014 PSA assessment: (3.17) **Medium**

Loggerhead turtles (*Caretta caretta)* have been caught incidentally in the SBPMF over the period of its operation. Since loggerhead turtles feed on sand-bottom dwelling crustaceans that inhabit trawling grounds turtles may be vulnerable to capture in trawl nets.

The SBPMF is considered to be a 'low risk' to loggerhead turtle populations based on:

- Reduced marine turtle interactions in the fishery since the introduction of BRDs in the fishery in 2002. The bar spacing, angle of the grid and escape hatch size have been designed and trialled to ensure that they are appropriate to exclude (with minimal injury) loggerhead turtles of the sizes found in Shark Bay (see Kangas & Thomson 2004); and
- Short shot durations in the fishery (approx. 60 mins), which minimises the chance that if a turtle is caught it will drown before it is brought to the surface and released (Kangas et al. 2006). The majority (> 95 %) of turtles captured in the SBPMF since the introduction of BRDs have been released alive.

2010 Risk Rating (Indirect Interactions[1]): Impact on breeding population (C1 L4) **Low**

2014 PSA assessment (boat strikes): (3.17) **Medium**

For the issue of possible interactions (without capture) of loggerhead turtles, it was considered 'likely' that the SBPMF would have a 'negligible' impact on the breeding populations.

Shark Bay contains the largest nesting population of loggerhead turtles in Australia, with many females nesting on Dirk Hartog Island around October and migrating to foraging grounds in the Eastern Gulf following nesting (Heithaus et al. 2002; Baldwin et al. 2003). Outside the breeding season, males have demonstrated site fidelity to small coastal foraging areas on the northern region of Peron Peninsula (Olson et al. 2012). Although loggerhead turtles move throughout the Bay following nesting season, the prawn fishing season is generally finished by this time.

The relatively low speed at which trawl vessels travel is likely to minimise the potential for any vessel interactions with loggerhead turtles. Trawlers travel at relatively slow speeds of 3 – 4 knots while trawling and up to 12 knots while steaming and as such are unlikely to hit wildlife where avoidance behaviour is not impeded.

There have been no reports of loggerhead turtles interacting with trawl vessels (e.g. being knocked by boats or nets without being captured) throughout the history of the fishery.

[1] This component addresses the issue of interaction between the fishery and a particular ETP species, which does not result in capture – in particular being hit by the hull of the vessels in the fishery and the disturbance of breeding aggregations.

12.3.1.2 Green Turtles

2010 Risk Rating (Direct Interactions): Impact on breeding population (C0 L5) **Negligible**

2014 PSA assessment: (3.04) **Medium**

In terms of the impact of the SBPMF on the green turtle (*Chelonia mydas*) breeding population, the risk assessment determined that it was 'likely' that the fishery would have a 'negligible' impact. Although investigations have shown that green turtles occur commonly in Shark Bay, there has been minimal reporting of green turtles being caught in a trawl net throughout the fishery's duration. This is probably due to the fact that green turtles prefer to reside in seagrass habitats that trawls are excluded from and / or avoid (Kangas et al. 2006).

It is possible that green turtles may occasionally be affected by trawling when vessels fish close to seagrass banks, however, with the introduction of BRDs, even in these circumstances, the majority of green turtles would be excluded from trawl nets.

Risk Rating (Indirect Interactions): Impact on breeding population (C0 L5) **Negligible**

2014 PSA assessment (boat strikes): (3.17) **Medium**

For the issue of possible interactions (without capture) of green turtles, it was considered 'likely' that the SBPMF would have a 'negligible' impact on the breeding populations, due to the following:

- Although investigations have shown that green turtles occur commonly as residents in Shark Bay, there are no major breeding sites for this species located within Shark Bay;
- There have been no reports of green turtles interacting with trawl vessels (e.g. being knocked by boats or nets without being captured);
- The relatively low speed at which trawlers travel is also likely to minimise the potential for any vessel interactions. Trawlers travel at relatively slow speeds of 3 – 4 knots while trawling and up to 12 knots while steaming, and as such are unlikely to hit wildlife where avoidance behaviour is not impeded; and
- The spatial separation of trawling activities and green turtle populations. Green turtles prefer to reside in seagrass habitats that trawls are excluded from and / or generally avoid (Kangas et al. 2006).

12.3.2 Sea Snakes

2010 Risk Rating (Direct Interactions): Impact on breeding population (C1 L2) **Low**

2014 PSA assessment: Sea snakes, general (Family Hydrophiinae) (2.74) **Medium**

Short-nosed sea snake (*Aipysurus apraefrontalis*) (2.62) **Low**

Sea snakes are the most common ETP species reported in the SBPMF. Most species of sea snakes are considered abundant or common in Shark Bay and are not known to be vulnerable. A study of sea snake survival following capture by trawlers in the Gulf of Carpentaria (within the Northern Prawn Fishery [NPF]) indicated that 60 % of sea snakes survived capture (Wassenberg et al. 1994). As the shot durations of the SBPMF are shorter than those in the NPF, it is likely that the survival of sea snakes in Shark Bay is even higher (Kangas et al. 2006).

BRDs were found to reduce the number of sea snakes caught in trawl nets in the SBPMF by 42 % (Kangas & Thomson 2004). BRDs also reduce the volume of catch in the nets, which may prevent the crushing of sea snakes among the catch in the cod end.

There has been a focus on improving monitoring of sea snake interactions, with many fishers now reporting return status when known.

12.3.3 Syngnathids

2010 Risk Rating (Direct Interactions): Impact on breeding population (C1 L2) **Low**

2014 PSA assessment: *Hippocampus* spp. (2.34) **Low**

The potential consequence of the prawn trawling operations on breeding levels of syngnathids was considered 'minor'. Anecdotal evidence from observer program results and reporting by fishers has suggested that very low numbers of syngnathids are caught by the SBPMF, in the order of one per night across the whole fleet. It is suggested that the occurrence of syngnathids appears to be area specific, and often, syngnathids may not be caught for many nights in a row (Kangas et al. 2006).

It was considered 'unlikely' that this level of consequence would result because trawling occurs over areas that are mostly unfavourable to syngnathids. Syngnathids are known to favour seagrass and detached algae communities, where trawling does not occur (Kangas et al. 2006).

12.3.4 Dugongs and Cetaceans

2010 Risk Rating (Indirect Interactions): Impact on breeding population (C1 L3) **Low**

2014 PSA assessment (capture): Dolphins, general (Family Delphinidae) (3.04) **Medium**

Dugong *Dugong dugon* (2.90) **Medium**

2014 PSA assessment (boat strikes): Cetaceans, dugongs (3.17) **Medium**

Large numbers of dugongs and their young can be found on the Faure Sill and Wooramel Seagrass Bank and between Faure Island and Gladstone Bay during the summer months (Marsh et al. 1994). These areas are all contained within a permanent trawl closure, which was implemented in the 1960s.

Research indicates that dugongs migrate seasonally within the bay to find optimal water temperatures, and as a result, their habitat usage varies extensively from summer to winter (Anderson 1986). Consequently, although trawling is physically separated from the areas used by dugongs for most of the season, there may be some overlap of trawlers and dugongs during the winter. However, there have been no reports of dugong capture or interactions over the history of the fishery.

There is a large dolphin population in Shark Bay and dolphins (particularly *Tursiops* sp.) are a popular tourist attraction at Monkey Mia. Very few dolphin interactions have been reported throughout the history of the fishery (two in the past ten years).

Humpback whales are also found within the Bay from July to October each year during their southward migration (Jenner and Jenner 2000); however, no interactions with whales have been reported in the SBPMF.

12.4 ETP Species Management

There is a strategy in place for managing the fishery's impact on ETP species that is designed to achieve national and international requirements for protection, which utilises a number of management measures under the *Shark Bay Prawn Managed Fishery Management Plan 1993* and operational activities (as per the *SBPMF Harvest Strategy 2014 – 2019*) including:

- Limited entry;
- Gear controls and sorting practices;
- Seasonal closures;
- Spatial closures;
- Temporal closures; and
- Reporting.

The impact on ETP species has been reduced as a consequence of reduced fishing effort in the SBPMF since the beginning of the fishery in 1962. Fishing effort in the SBPMF has changed dramatically since the 1960s, with 18 boats operating in 2013 compared to 35 vessels in 1975. The maximum headrope capacity introduced in 1996 further restricts fishing effort (DoF 2014b).

The SBPMF also uses a number of measures to physically reduce direct ETP species interactions and increase the survival of captured ETP species, primarily through the use of primary and secondary BRDs (i.e. grids and square mesh panels). The use of grids and square-mesh panels are required in all prawn trawl fisheries in WA, with mandatory implementation in the SBPMF in 2002 for grids and in 2005 for the use of secondary BRDs (e.g. square mesh panels). Two types of grids are used in the SBPMF: the CSWA and RSNA. Some grids are still being used with a horizontal gap (up to 300 mm) in the bottom ("flounder gap") to aid the movement of weed into the cod end. Overall grid dimensions are around one metre wide and 1.3 m high. Grids are sewn into the nets at an angle of 45 °, and the escape opening is generally around 780 – 800 mm wide. Bar spacing is generally 160 – 200 mm (Kangas & Thomson 2004).

These measures have been tested within the fishery and other similar tropical trawl fisheries in Australia and are considered to work based on trial results (see Section 9), which indicated a reduction in the incidental capture of ETP species. The grids were not found to reduce the catch levels of sea snakes, as they can pass through the gird bars and into the cod end (Kangas & Thomson 2004); however, openings in the tops of nets (i.e. FEDs) have been shown to be successful in reducing the incidental capture of sea snakes by 50 % in other fisheries (e.g. Heales et al. 2008; Milton et al. 2009). Additionally, ETP species interaction rates reported in the fishery since the implementation of BRDs continue to be very low (see Table 12.1).

The spatial and temporal measures in place are considered sufficient to minimise impacts from fishing on vulnerable species. In Shark Bay, only 20 – 40 % of the fishery area is open to trawling (Sporer et al. 2013). The limited spatial extent of fishing activities allows for adequate areas of refuge for ETP species throughout the Bay. Additionally, as trawling occurs over sand / mud substrates, the trawl nets are spatially separated from important habitats, e.g. seagrass, for many ETP species. Many of these important habitats are also protected in permanent fishery closures.

The harvest strategy includes the long-term management objective: *to ensure fishery impacts do not result in serious or irreversible harm to endangered, threatened and protected (ETP) species populations* (DoF 2014a). As such, appropriate performance indicators, reference levels and control rules have been developed for ETP species in the SBPMF (DoF 2014a). The annual extent of trawling activities, BRD use and assessed risk is used to evaluate the impact of the SBPMF on these species' populations. There is a continual monitoring and improvement process to minimise the impacts of the trawl gear in the Fishery. This is facilitated through the Bycatch Action Plan (DoF 2014b).

Compliance with management arrangement is conducted by Departmental FMOs using at-sea and landing inspections. The use of VMS also helps the Department monitor vessel location and speed, increasing compliance with spatial and temporal closures. If future monitoring indicates a need to reduce trawl impacts on ETP species in Shark Bay, this may be achieved through extending the use of current management tools, such as spatial and temporal closures, targeted harvesting strategies to optimise expenditure of effort, a reduction in overall fishing effort and the use of mechanical or other devices, such as BRDs and hoppers / handling techniques.

12.5 ETP Species Information and Monitoring

All fishers are required to report ETP interactions in daily logbooks. In order to improve reporting accuracy, fishers have been provided with a *Protected Marine Species Identification Guide* (National Heritage Trust 2005), which contains a picture and brief description of relevant protected species, specific details to include in interactions reports and current contact details for interaction reports.

Since 2010, there has been a focus on improving ETP species reporting in the fishery, with many fishers now including return status (i.e. alive, dead or unknown). This information is monitored by the Department and is considered to be sufficient to quantitatively estimate the outcome status of ETP species with a high degree of certainty.

The lack of species-specific monitoring of some ETP species in the SBPMF was identified as a potential issue for the fishery as part of the MSC pre-assessment process. In order to address this issue, the Department has developed the *SBPMF Bycatch Action Plan 2014 – 2019* (DoF 2014b), which includes an overview of the ETP species issues in Shark Bay and a proposed work plan for future / ongoing monitoring and research. In May 2015, camera equipment was obtained for on-board monitoring of bycatch diversity and quantity, as well as ETP species interactions. This equipment will be trialled on one vessel during the second half of the 2015 fishing season.

Additional ETP species information has been collected as part of the fishery-independent surveys conducted by Departmental research staff. All ETP species captured in trawl nets during these surveys have been recorded since 1999, along with the location, time, depth, weather conditions, moon phase, water temperature and gear efficiency at time of capture. Where possible, the status of the animal at capture (alive or dead) and the release procedure, if applicable, has also been recorded since 2005. Photographs have also been taken of all sea snakes and turtles captured during these surveys since August 2014. Each photo log contains shot information and species-level identification.

13. Habitats

13.1 Overview

Shark Bay is Australia's largest enclosed marine embayment (approx. 13 000 km^2) and is approximately 250 km from the northern point of Bernier Island to the southern end of Freycinet Harbour. The Bay is enclosed in the north by Bernier, Dorre and Dirk Hartog Islands, which restrict water exchange between the bay and the open ocean (Burling et al. 1999; Nahas et al. 2005).

Shark Bay is generally shallow; the average depth is nine metres, with the maximum depth of 29 m near the northern entrance. There is a series of broad gulfs, narrow inlets and basins within the Bay (Figure 13.1), which are partly cut off from the Indian Ocean. The southern half is divided by the Peron Peninsula into narrow eastern and western gulfs. Influx of oceanic water is through the northern Geographe Channel, the Naturaliste Channel and South Passage (Nahas et al. 2005).

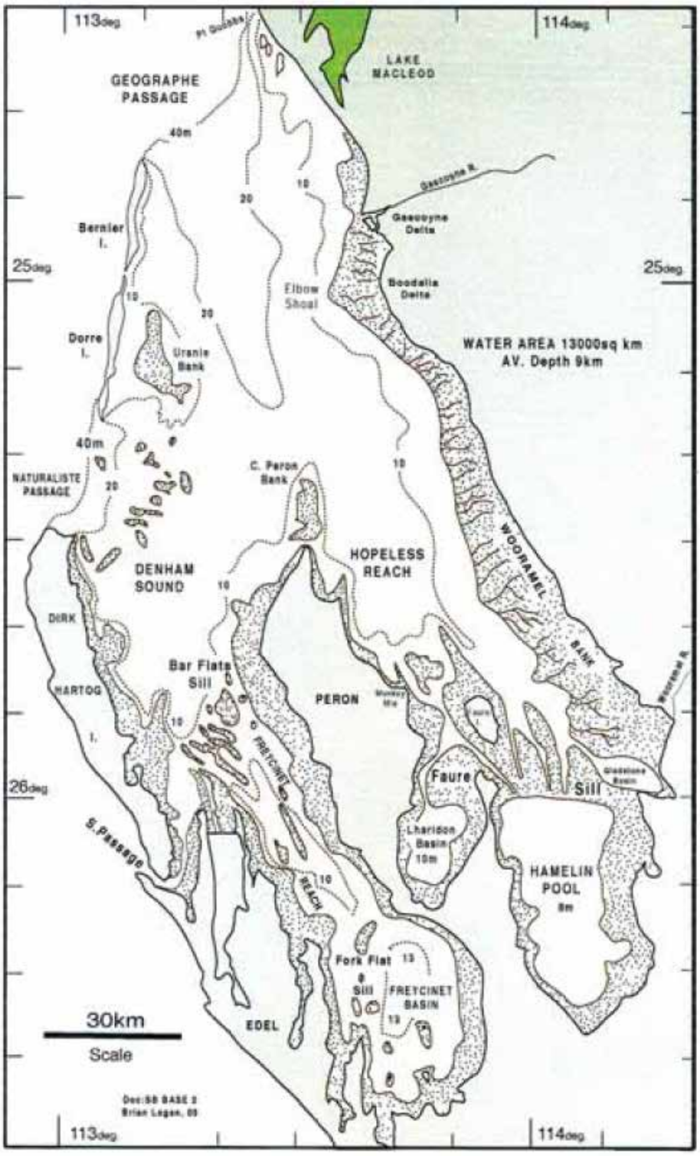

Figure 13.1. Shark Bay overview indicating basins and shoals (Source: Morrison et al. 2003)

The Bay is located near the northern limit of the transition region between temperate and tropical marine environments, making it an area of high biodiversity. Primary habitats of Shark Bay include seagrasses, microbial communities and algal mats, along with some areas of coral (Table 13.1; Figure 13.2).

Table 13.1. Primary habitats of Shark Bay (Source: EPA 2001)

Habitat	Description and Extent
Soft silt sands	The sea floor of the central northern and western parts of Shark Bay is an extensive area of soft silty sands. The seafloor supports a diverse faunal assemblage of sponges, gorgonians and other macrofauna.
Seagrass meadows, sills and banks	Seagrasses occupy nearly a third of Shark Bay, and foremost meadows include Fauré Sill and the Wooramel Seagrass Bank. There are 12 species within Shark Bay, mostly temperate species at the northern end of their distribution, although some tropical species can also be found (Walker 1989). The dense growth provides shelter and food for a variety of marine fauna and stabilises the sea bottom, channels and banks. Seagrass has also contributed to the evolution of the Bay, by modifying the physical, chemical and biological environment, as well as influencing local geology (CALM 1996). Seagrass cover decreases with increasing salinity, and very little is found within Hamelin Pool (Walker 1990).
Macroalgae	Important primary producers in Shark Bay, occurring on subtidal rock platforms, on the extensive sandflats that dominate the shallows of the bay, or as epiphytes on seagrasses, other algae or mangroves (Huisman et al. 1990).
Microbial Communities (Algal mats)	Microbial communities flourish as algal mats in the intertidal and subtidal zones of the most saline environments, particularly Hamelin Pool. These algal mats bind a variety of sediment types, including skeletal carbonate sand, ooid (small rounded accretionary mineralized bodies) sand and terrestrially-derived silt and mud. Algal mat communities are well developed south of Long Point on Wooramel Bank and become increasingly widespread southwards in the intertidal zones (Davies 1970). There are several varieties of mats, and as a primary producer, algal mats are likely to be important contributors to the food webs of Shark Bay.
Microbial Communities (Stromatolites)	Stromatolites are unusual structures that are a combination of sediment and benthic microbial communities, primarily cyanobacteria. Stromatolites are thought to be one of the earliest life forms that flourished during the Precambrian era (3500 million years ago). One of the best developments of modern stromatolites occurs on the hypersaline shores of Hamelin Pool. These stromatolites are a part of a flourishing ecosystem that provides shelter for small organisms, substrate for marine plants and a source of food for fish and crustaceans (Burne 1991). The algal mats and stromatolites are recognised as features of international significance and are listed in the nominated world heritage values (CALM 1996).
Shell beaches	Extensive beaches composed almost exclusively of shells of the small bivalve *Fragum erugatum*.
Sand beaches	There are extensive intertidal sandflats and beaches in many areas. The upper intertidal areas are generally species-poor, but diverse assemblages of invertebrates, particularly molluscs, occur on the lower intertidal shoreline.
Rocky shores	Contain a diverse range of habitats, including coral, high-energy intertidal rock platforms, large sheltered rock pools, sandy gutters, caves and deep-water habitats to about 50 m depth.
Mangroves	Only one species, *Avicennia marina*, occurs in Shark Bay, and the Bay is the southernmost location of large mangrove assemblages in Western Australia. From the Gascoyne River sub-delta southwards to Greenough Point, mangroves grow thickly and restrict the northward, longshore movement of sediment. Mangrove density declines toward the south (with increasing salinity), eventually giving way to algal mat communities.

Corals	120 species of hermatypic corals have been found in Shark Bay, along with six species of ahermatypic corals (Marsh 1990; CALM 1996). Coral reefs are not extensively developed within Shark Bay, being limited to the western areas of oceanic / metahaline salinity where light levels are high enough for photosynthesis. The eastern shores of Bernier, Dorre and Dirk Hartog Islands provide the most favourable habitats for coral growth, due to shelter and relatively stable water conditions. Some sections of these islands support prolific growth (up to 100 % cover) in both the sheltered leeward and exposed areas. The southern end of Bernier Island, near Cape Couture, has extensive coral development, and Broadhurst Reef occurs off the northwestern tip of Peron Peninsula. The occurrence of coral and associated reef communities in inshore areas of Shark Bay is considered unusual; outcrops of these communities occur within sand- and seagrass-dominated habitats in choppy, often turbid waters that are normally detrimental to corals. Inshore communities are generally small (< 4 ha) and patchy, with healthier corals occurring in the northern or leeward sections of outcrops (CALM 1996).

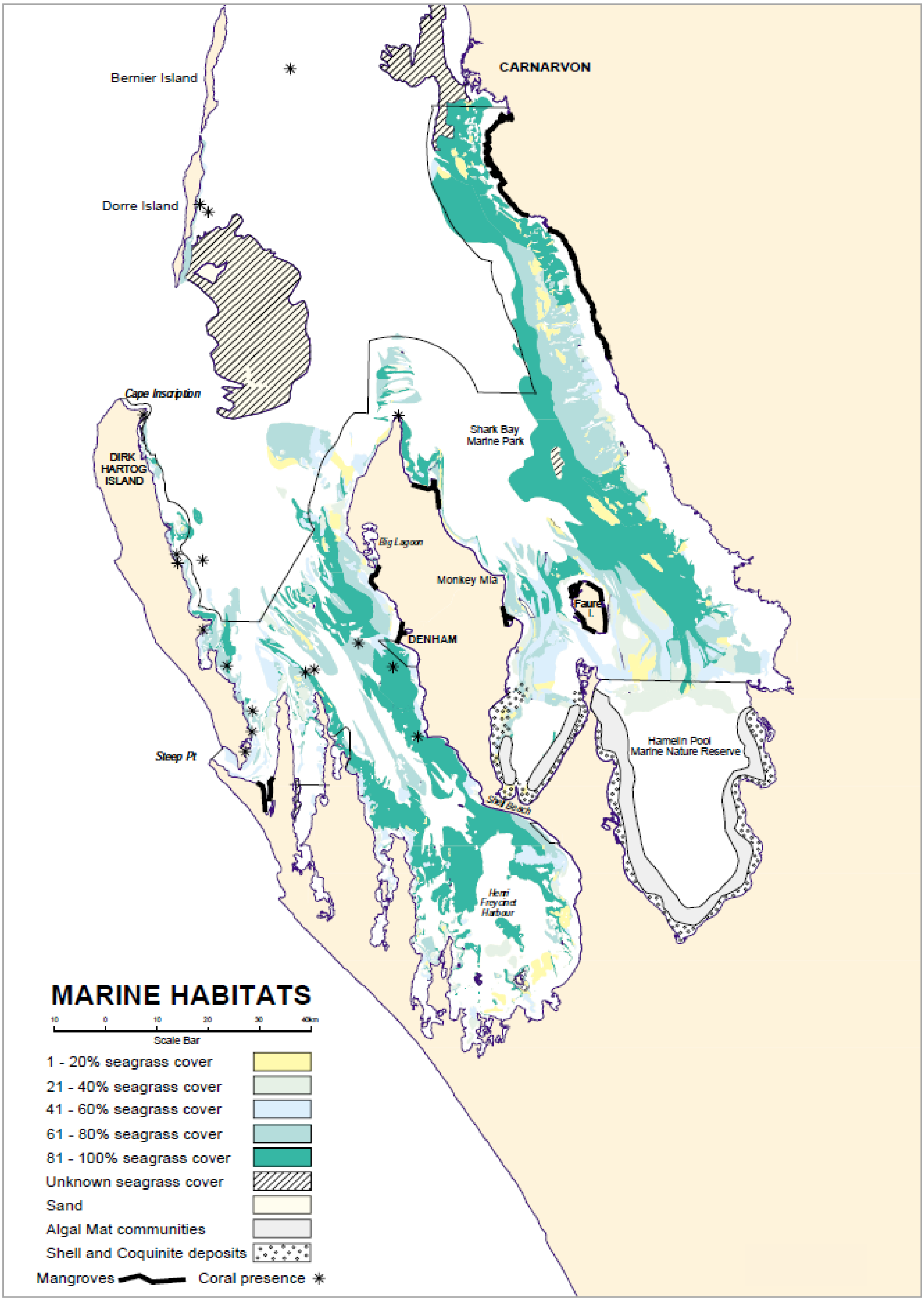

Figure 13.2. Major habitats of Shark Bay (Source: CALM 1996)

In February 2008, a field survey was undertaken by the Department of Environment and Conservation (currently DPaW) as part of an ongoing program to document the diversity and distribution of coral communities found in the Shark Bay Marine Park and Hamelin Pool Marine Nature Reserve. Marine ecological data were collected from a total of 618 sites, mainly along the east coast of Dirk Hartog Island. Coral community information is provided in Figure 13.3 (Bancroft 2009).

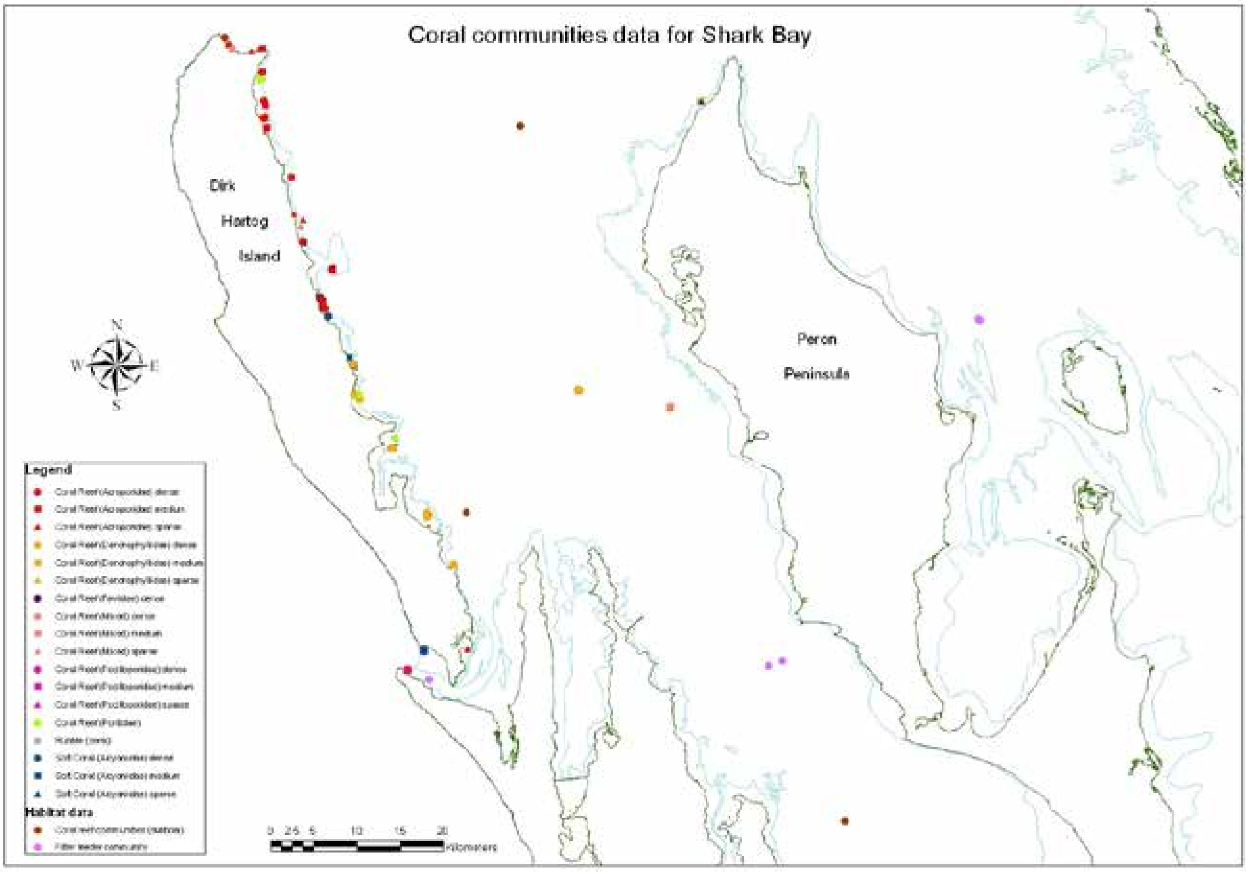

Figure 13.3. Distribution of coral communities of the Shark Bay Marine Park based on historical data and data collected during the February 2008 survey. (Source: Bancroft 2009)

13.2 Fishery Impacts

Prawn trawling in Shark Bay primarily occurs over sand / shell habitat in the deeper parts of the central Bay, north and northeast of Cape Peron and in the northern region of Denham Sound (see for example Figure 8.6). The permitted trawl area of the SBPMF is 1768 nm^2 (38 % of the inner Shark Bay area), with trawling usually occurring over a smaller area within this region (Table 13.2). In 2013, the total area trawled was 798.1 nm^2 (17.2 % of inner Shark Bay and 6.6 % of the overall fishery boundaries; Sporer et al. 2014).

Table 13.2. Annual area (nm^2) and per cent of permitted area, inner Shark Bay area and whole fishery area trawled by the Shark Bay Prawn Managed Fishery for 2006 – 2013

Year	nm^2	Percent of Permitted Area	Percent of Inner Shark Bay Area	Percent of Whole Fishery
2013	798.1	45.1	17.2	6.6
2012	746.1	42.2	16.0	6.2
2011	777.8	44.0	16.7	6.4
2010	855.5	48.4	18.4	7.1
2009	801.1	45.3	17.2	6.6
2008	745.3	42.2	16.0	6.2
2007	667.4	37.7	14.3	5.5
2006	779.2	44.0	16.7	6.4

Commercial trawling operations in Shark Bay commenced in the early 1960s. Exploratory trawls undertaken at the commencement of trawling in Shark Bay in the 1960s documented the sand and mud bottom nature of Shark Bay, indicating that trawling has not significantly altered the pre-fishing habitat. Early descriptions of the embayment's habitats reported the trawl grounds consisted predominantly of sand sediments with molluscans, echinoderms and other macrofauna and did not mention sponges or soft corals (Logan and Cebulski 1970).

Trawling does not occur over hard coral reef areas due to the likelihood of loss/damage of trawl gear and / or dangerous hook-ups of the ground chains on the coral. Most trawlers also actively avoid trawling near seagrass beds, as rolls of broken-off seagrass ('weeds') get caught in the mouth of the cod end or grid and cause the net to stop fishing (Kangas & Thomson 2004). Prawns already captured in the net also become entangled in the weed and are difficult to release (Kangas et al. 2006). The majority of sensitive habitats, i.e. hard corals, sponges and seagrass beds, are protected from fishing activities within the permanently closed nursery area (see Figure 3.1).

Evidence from video footage of trawled areas in Shark Bay suggests trawling over sand has the effect of flattening this otherwise ripple and three-dimensional substrate. This may also indirectly affect the species that inhabit this area by changing the nature of the substrate (Kangas et al. 2006). A number of studies have shown that no significant effects are caused to infaunal communities in areas of similar habitat (sand / mud) where trawling occurs (e.g. Van Dolah et al. 1991; Kaiser & Spencer 1996; Jennings and Kaiser 1998). In southwest WA, Laurenson et al. (1993) compared trawled and untrawled areas using trawl samples and underwater video. Underwater video observation of both areas before and after the completion of a depletion experiment failed to detect any visual impact on the substrate or habitat. Kangas et al. (2007) measured the biodiversity on trawled and untrawled areas in Shark Bay, Exmouth Gulf and Onslow (Area 1), and found no significant differences for pooled data with respect to fish and invertebrate abundance, species richness, evenness or diversity. Results from these studies indicate that trawling causes only minor and short-lived impacts to sand / mud habitats, and the restrictions in place within the SBPMF further limit any trawl impacts. The continuity of the fishery over the past 50 + years is also considered to be evidence that the fishery has not had any significant detrimental impacts on habitat structure or ecosystem function within the Bay.

13.2.1 Risk Assessment Outcomes

13.2.1.1 Sand / Shell Habitat

2010 Risk Rating: Impact on habitat ecology and structure (C2 L5) **Moderate**

Prawn trawling in Shark Bay occurs predominantly over sand and shell habitats. When trawling, ground chains and otter boards make contact with the sea bottom, disrupting organisms within the habitat. Evidence from video footage of trawled areas of Shark Bay suggests that trawling over sand has the effect of flattening this otherwise rippled and three-dimensional substrate (Kangas et al. 2006).

Thus, the potential impact on the sand and shell habitat of Shark Bay as a result of the prawn trawling operations was considered to have a moderate consequence due to the following:

- Of the area that is permitted to be trawled (40 % of the Bay), only around 20 % of this is actually trawled each year (due to targeting of known favourable grounds);
- A significant proportion of the Bay is permanently closed to trawling through inclusion in the permanent nursery area; and
- Studies of actual impacts from prawn trawling suggest only minimal impacts to infaunal communities (see Management Section above).

13.2.1.2 Coral / Sponge Habitat

2010 Risk Rating: Impact on habitat ecology and structure (C1 L6) **Low**

By virtue of their shape and physical structure, coral and sponge habitats are vulnerable to physical damage from trawling activities. Corals are slow to recover due to generally slow growth rates, and although sponges are faster growing and therefore more able to withstand fishing pressure, they are still vulnerable to physical damage from trawling activities (Kangas et al. 2006).

Hard corals in Shark Bay are primarily found on the eastern shores of Bernier, Dorre and Dirk Hartog Island and in the Sandy Point, Bar Flats and Egg Island areas. Soft coral and sponge habitats occur in the relatively oceanic areas inside the 20 m depth contour from Carnarvon to Quobba in the northern embayment. Sponges also occur intermittently on sandy bottoms within the Bay (Kangas et al. 2006).

Trawling is not possible over hard coral reef areas; since the nets are expensive to purchase and time consuming to repair, fishers actively avoid fishing in these areas. Soft coral and sponge habitats are also not targeted by fishers (Kangas et al. 2006), as the highest densities of prawns generally occur in sandy and muddy habitat (Hall & Penn 1979; Grady 1971; Williams 1958).

A large proportion of the known areas of hard coral growth are protected as a result of permanent nursery area closures or in sanctuary zones of the Shark Bay marine protected areas (see Section 4.5). The fishery is also managed such that no more than 20 % of the remaining coral and sponge habitat in the Bay is contained within the legally trawlable area. Assuming the worst-case scenario that all coral (soft and hard) habitats in the trawl licence area are impacted significantly, a refuge of 80 % of this habitat is considered to be precautionary (Kangas et al. 2006).

13.2.1.3 Seagrass Habitat

2010 Risk Rating: Impact on habitat ecology and structure (C0 L5) **Negligible**

Shark Bay contains the world's largest reported seagrass meadow, as well as some of the most diverse seagrass assemblages. The most common and abundant species is *Amphibolis antarctica*, which occupies over 90 % of the total seagrass area in the Bay.

As a result of the combination of the permanently closed areas under the fishery's management plan and closed areas within the Shark Bay marine protected areas, only a very small area of seagrass is contained within the trawlable area in Shark Bay.

Minor damage may occur from fishing around the edges of seagrass banks, but this activity rarely occurs. Most trawlers actively avoid trawling near seagrass areas as rolls of broken-off seagrass get caught in the mouth of the cod end or grids and reduce fishing efficiency (Kangas et al. 2006).

13.3 Habitat Management

There is a strategy in place for managing the impact of the SBPMF on benthic habitats. This strategy utilises a number of management measures under the *Shark Bay Prawn Managed Fishery Management Plan 1993* and operational activities (as per the *SBPMF Harvest Strategy 2014 – 2019*) including:

- Limited entry;
- Gear restrictions;
- Seasonal closures;
- Spatial closures;
- Temporal closures; and
- Reporting and the use of VMS.

The SBPMF uses a number of measures to reduce physical impacts of the trawl gear. Otter trawl systems, similar to those used in the SBPMF, have been demonstrated to have the least impact of all forms of trawling (Collie et al. 2000). The trawl gear is also configured in a manner that largely precludes the capture of invertebrate species living on or in the substrate. The ground chain attached to the net is designed to skim over the sand instead of digging into the seafloor, and immobile and slow-moving benthic organisms are able to avoid capture through a gap (~ 20 cm) between the ground chain and footrope. Sensitive habitats, such as corals, sponges and seagrass areas, are protected in a permanently closed nursery area along the southern regions of the Bay. These closed areas also provide protection for a portion of other habitats, such as sand / shell substrates that are widespread throughout the Bay. The input controls in place, such as limited entry, total headrope capacity, seasonal closures and the temporal restrictions of the North CPL and South CPL, further limit any impacts of trawling activities on sand / shell habitats throughout the Bay.

The *Shark Bay Prawn Managed Fishery Harvest Strategy 2014 – 2019* includes the long-term management objective to ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function. As such, appropriate performance indicators, reference levels and control rules have been developed for habitats in the SBPMF (DoF 2014a). The habitat performance indicators relate to the extent of the area trawled within inner Shark Bay and the entire fishery area. The inner Shark Bay includes a number of sensitive habitats, which are managed as part of the Shark Bay Marine Park and Shark Bay World Heritage Area. The majority of trawling has historically occurred in this area, providing reliable estimates of the extent of fishing activities from which to base a target reference level. The limit reference level relates to the extent of fishing within the entire fishery area to account for potential changes in fishing patterns.

Significant effort is put into ensuring adequate compliance with management regulations to ensure proper implementation. This includes at-sea patrols to ensure closed seasons, closed areas and operational rules are being adhered to. The use of the VMS on the vessels also provides the Department with the ability to closely monitor vessel location and speed, thus increasing compliance with closures and allowing for an assessment of the total area trawled and intensity of trawling activities throughout the Bay.

13.4 Habitat Information and Monitoring

The spatial extent and intensity of fishing activities throughout the SBPMF are monitored by the Department using VMS and daily logbooks. This information allows managers to monitor fishing activities in relation to sensitive habitats and track changes in fishing location and intensity over time and is considered sufficient to detect any increase in risk to habitat.

A project to increase habitat monitoring in Shark Bay has recently been funded by the FRDC. The outcomes of the project will include the development of a comprehensive GIS environment, with all available historical habitat and environmental data for Shark Bay and Exmouth Gulf ecosystems, and the development of new habitat maps for these regions (see Section 5.2.1).

14. Ecosystem

14.1 Overview

Shark Bay is Australia's largest enclosed marine embayment, and its unusual geomorphology has produced a diverse range of marine communities, including corals, seagrass meadows, mangroves and hypersaline communities. The bay is located near the northern limit of a transition region between temperate and tropical marine species. Of the 323 fish species recorded in Shark Bay, 83 % are tropical, with 11 % warm temperate and 6 % cool temperate species (Hutchins 1990). Shark Bay is a highly productive ecosystem and the shallows support a benthic invertebrate fauna of exceptional abundance, diversity and zoological significance. For example, two hundred and eighteen species of bivalve molluscs have been identified in the region, with 75 % with a tropical range, 10 % from a southern Australian range, and 15 % endemic to the west coast (Slack-Smith 1990). The Bay is also renowned for its marine fauna and supports large populations of dugongs, dolphins and marine turtles.

Seagrass covers approx. 4000 km^2 of the Bay, with the Wooramel Seagrass Bank the largest known structure of its kind in the world; no trawling occurs on this shallow bank. The 12 species of seagrass in the bay also make it one of the most diverse seagrass assemblages in the world. Seagrass has significantly contributed to the evolution of Shark Bay, as it has modified the physical, chemical and biological environment, as well as the geology through the development of major marine features, such as the Faure Sill (CALM 1996). 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 food chains of Shark Bay (CALM 1996). They are also important habitat and nursery areas for fish and invertebrates.

The barrier banks associated with the growth of seagrass have, in association with low rainfall, high evaporation and low tidal flushing, produced the hypersaline Hamelin Pool and L'hardion Bight. This hypersaline condition is conducive to the growth of cyanobacteria, which trap and bind sediment to produce a variety of mats and structures, such as the stromatolites found in Hamelin Pool (CALM 1996).

The subtidal seabeds in the central northern and western regions of the Bay consist of soft silty sand (DEP & URS 2001 [as cited in Morrison et al. 2003]). This substrate is populated by a diverse array of sponges, octocorals and associated invertebrates, plus infaunal species. Many crustaceans prefer this substrate, especially prawns and crabs, including western king, brown tiger, endeavour and coral prawns and some Portunid crabs (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).

Soft sediments are populated by certain echinoderm species, including brittle stars (Family Amphiuridae), echinoids (Families Temnopleuridae, Laganidae, Astriclypeidae and Loveniidae) and holothurians (*Cercodemas anceps, Colochirus crassus* and *C. quadrangularis*). Fieldnotes taken by Marsh (1975) record several species of crinoids, asteroids, ophiuroids, holothurians and echinoids from the central northern regions of Shark Bay, approx. 28 km west of Carnarvon. Few fish species have been found to live permanently in the soft, sandy substrates of Shark bay (as reported in Morrison et al. 2003).

The habitats and ecosystem of Shark Bay in relation to prawn fishing activities have been studied as part of an FRDC-funded project by Kangas et al. (2007). An overview of this project is provided in Section 9.4.

14.2 Fishery Impacts

Fisheries can potentially pose a risk of altering the benthic or demersal communities or changing prey availability through discards, such that food web dynamics shift. The main ecosystem impacts from fishing in the SBPMF would be due to the removal of the target species, brown tiger and western king prawns, as these species make up the majority of the catch. Prawns have a very high natural mortality rate, resulting in a large percentage of yearly recruits being removed naturally from the system through either death or predation. This high natural mortality rate would mask the effect of removing prawns through fishing (Kangas et al. 2006).

Other retained (byproduct) species are taken in relatively small quantities (see Section 10.1) and generally have large distribution ranges both within and outside the Bay. There are no known obligate predators in Shark Bay that are likely to be directly impacted upon by the removal of any particular species; most carnivorous predators are opportunistic and / or scavengers and therefore, are not considered dependent on any one species. A large variety of other small crustacean, invertebrate and fish species live in the Bay so it is not likely that the commercial take at of prawns or other byproduct species current levels will significantly impact on the trophic system within Shark Bay (Kangas et al. 2006).

Bycatch discards result in fish and invertebrates being made available to other organisms that would not normally have access to such a food source. This has the potential to affect the feeding behaviour of some species, particularly predators, and alter the distribution of other species through the water column and at the surface. Given the seasonal duration of the fishery (7 – 8 months), the amount of discards is very minor in terms of the overall productivity of Shark Bay. Although many studies have shown that various trophic groups feed on bycatch (e.g. Britton & Morton 1994; Poiner et al. 1999; Wassenberg and Hill 1990), few studies have found direct conclusive evidence of a resultant change in trophic structure. In Shark Bay, there is neither direct scientific evidence nor anecdotal suggestion of changes to the food web from removal of particular species / groups or from food being cycled from the bottom of the sea floor to the surface.

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. 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).

14.2.1 Risk Assessment Outcomes

14.2.1.1 Removal of Prawns and Byproduct Species

2010 Risk Rating: Impact on Trophic Structure (C2 L2) **Low**

Shark Bay is a highly productive ecosystem; an impact on the environment by removing the sum of all retained species was considered 'unlikely' to cause even a 'moderate' change to the ecosystem; hence, it was only a minor risk to the Shark Bay ecosystem based on the following information:

- The high natural mortality rate of prawns is such that a large percentage of the yearly recruits would already be removed from the system by the end of the season regardless of fishing activities. As a result, the natural variation of prawns is very high, and the effect of removing prawns through fishing would be masked.
- The take of byproduct species is relatively low and represents approx. 15 – 30 % of the total catch (over the last 10 years). This level of take is considered to have a negligible impact on the environment, as the amount of each byproduct species and the combined total amount of byproduct is likely to be less than the background variance in abundance.
- There are no known obligate predators of prawns or byproduct species that are likely to be directly impacted upon by the removal of these species. A variety of other small crustacean, invertebrate and fish species live within Shark Bay and would be able to fulfil the roles of the removed species.
- Management arrangements ensure that an adequate spawning stock of all prawn species survive to reproduce recruits for the subsequent season through the use of closed areas and seasons. The spatial and temporal closures in place also provide refuge from fishing activities for byproduct species populations.
- Research in this and similar fisheries that have indicated similar species diversity and abundance in both trawled and untrawled areas (e.g. Kangas et al. 2007; Kangas & Morrison 2013; Harris & Poiner 1991; Jennings & Kaiser 1998).

14.2.1.2 Discarding Bycatch

2010 Risk Rating: Impact on the environment (C2 L3) **Moderate**

Discarding bycatch results in fish and, to a lesser extent, crustaceans being made available to others organisms that would normally not have access to such a food source. This has the potential to affect the feeding behaviour of some species, particularly predators, and alter the distribution of other species throughout the water column and at the surface. For example, dead fish that sink to the seafloor become available to benthic scavengers, such as crabs. These fish would normally be only available, in that level of abundance, to pelagic predators.

Studies on the fate of discards through trophic structure have been examined in other similar fisheries, but not in the SBPMF specifically. A number of studies have shown that various trophic groups feed on bycatch:

- In the Great Barrier Reef Trawl Fishery, a study showed that the majority of discards were fish and about 40 % of the fish floated on return to the water. Most of these fish were taken by birds, dolphins and sharks. The discards that sank were considered to be dispersed over the seabed, without causing a measurable impact (Poiner et al. 1999).
- In Moreton Bay, Queensland, Wassenberg and Hill (1987) found that crabs were a dominant scavenger of bycatch from the local prawn trawl fishery, with 30 % of their diet coming from this source. A further study in Moreton Bay also found that trawl discards became the principle food source for three species of seabirds (Wassenberg and Hill 1990).
- In South Australia, the most common scavengers on prawn trawl bycatch were dolphins and sea birds (Svane 2005). Four surveys were undertaken in which skippers recorded the numbers of seabirds and dolphins feeding on discarded bycatch. The mean number of dolphins per boat and observation varied between seasons, with 0.5 – 1.3 dolphins per boat per observation. The occurrence of seabirds varied between sites but not between season and time of night. The largest mean number of seabirds observed on one site was 2.8 seabirds per observation. It was concluded that an estimated 18 – 183 t of discards were consumed per year by dolphins, constituting 0.3 – 2.6 % of the discarded bycatch, while seabirds potentially consumed less than 0.3 % of the discarded bycatch (Svane 2005).

Based on results from the observer program during BRD trials, the ratio of discards to retained species in the SBPMF is about 4 – 8:1. Of this, about 50 % of the fish are dead and sink, therefore becoming available to bottom feeders. Most of the crustaceans sink but have a relatively high survival rate. The impact of provisioning as a result of discarding bycatch in the SBPMF was considered be a 'moderate' risk as a result of the following factors:

- Although many studies have shown that various trophic groups prey upon bycatch species, few studies have found direct conclusive evidence of a resultant change in trophic structure (see above).
- In Shark Bay, there is neither direct scientific evidence nor any anecdotal suggestion of changes to the food web from the removal of particular groups or species, or from food being cycled from the bottom of the sea floor to the surface.
- The area over which organisms are discarded is large, and therefore any impacts would be diffused (approx. five tonnes of discards per square kilometre[14]). Additionally, a considerable proportion of the bycatch is crustaceans and elasmobranchs, which have a high survival rate and therefore do not contribute to the provisioning. Furthermore, the discards from this fishery are seasonal, as the fishery only operates for eight months of the year.

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[14] Based on average prawn (western king, brown tiger, coral and endeavour) landings of ~1500 – 1800 t, with bycatch considered to be approx. six times the prawn catch (i.e. 9000 – 11000 t of bycatch) and discarding occurring over the functional trawl fishery area (i.e. 2150 km^2).

- However, trawling is considered to provide some benefits to seabird populations by aggregating food items normally at low densities in the water column. It has been suggested that pied cormorants in Shark Bay have increased in abundance as a result of discards from trawl fisheries (N. Dunlop, pers. comm.; Kangas et al. 2006).
- While dolphins have been known to follow the prawn vessels for discards, the amount of discards that result in this fishery is not significant. Due to the seasonality of the fishery, dolphins are still reliant on their normal feeding habits to sustain them throughout the year.

14.3 Ecosystem Management

There is a strategy in place that contains measures to address all main impacts of the fishery on the ecosystem. This strategy utilises management measures implemented under the *Shark Bay Prawn Managed Fishery Management Plan 1993* and operational activities (as per the *SBPMF Harvest Strategy 2014 – 2019*) including:

- Limited entry;
- Gear restrictions;
- Seasonal closures;
- Spatial closures;
- Temporal closures; and
- Reporting and the use of VMS.

This strategy focuses on minimising impacts on ecosystem through maintaining significant biomass levels of prawn and other byproduct species in order to minimise the potential for trophic perturbations. Other arrangements, such as gear restrictions, spatial and seasonal closures and a limited number of vessels further minimise the potential for ecosystem impacts through reducing potential impacts on the ecosystem components (i.e. byproduct, bycatch, ETP species and habitats).

The *Shark Bay Prawn Managed Fishery Harvest Strategy 2014 – 2019* includes the long-term ecosystem management objective: *to ensure the effects of fishing do not result in serious or irreversible harm to ecological processes*. As such, appropriate performance indicators, reference levels and control rules have been developed for the Shark Bay ecosystem(s) (DoF 2014a). The ecosystem performance indicators related to risk assessment outcomes for each ecosystem component and the ecosystem as a whole, the extent of the area trawled in Shark Bay and the annual catch of all retained species.

Within Shark Bay, there is direct evidence that the fish and invertebrate species on the trawl groups have not been significantly affected compared to those species on the non-trawl grounds (Kangas et al. 2007). This is clear evidence that the ecosystem has not been affected to any measurable degree, with the closed areas providing protection to those species more vulnerable to trawling. Furthermore, the continuity of the fishery over the past 50 + years is also considered to be evidence that the strategy works, is being implemented successfully and is achieving its objective.

Compliance with the management arrangements is monitored by the Department using at-sea and aerial patrols to ensure closed seasons, closed areas and operational rules are being adhered to. VMS monitoring also ensures compliance with closed areas. If future studies or monitoring indicate that further management is required, this may be achieved through extending the use of current management tools, such as spatial and temporal closures, targeted harvesting strategies to optimise expenditure of effort, a reduction in overall fishing effort and the use of mechanical or other devices, such as BRDs and hoppers / handling techniques.

14.4 Ecosystem Information and Monitoring

Information continues to be collected on the impacts of the fishery on each of the key ecosystem components at a sufficient level to detect any increased risk. Fishers are required to report retained species catches, effort, any ETP species interactions and fishing location in daily logbooks. Fishing activities (location and intensity) are also monitored by the Department via VMS. Further monitoring activities are provided in the *SBPMF Bycatch Action Plan 2014 – 2019* (DoF 2014b).

The long time series of data available, along with biodiversity research (i.e. Kangas et al. 2007) in Shark Bay, support the conclusion that the ecosystem has not been unacceptably impacted by the fishery during the 50 + years of its operation.

MSC Principle 3

MSC Principle 3 relates to the effective management of the fishery under assessment. Within this context, the fishery must demonstrate that it meets all local, national and international laws and must have a management system in place to respond to changing circumstances and maintain sustainability (MSC 2013).

15. Governance and Policy

The governance and policy section captures the broad, high-level context of the fishery management system within which the SBPMF is found. This section therefore includes information on:

- The legal and/or customary framework that overarches the fishery, including relevant international treaties, national environmental legislation, national cooperative arrangements, jurisdictional arrangements between the WA State and Commonwealth Governments and the system of governance in WA, including relevant fisheries legislation;
- Consultation processes and policies, as well as the roles and responsibilities of people and organisations within the overarching fishery management system;
- The long-term fishery management objectives; and
- A description of the incentives in place for sustainable fishing within the SBPMF.

15.1 Legal and / or Customary Framework

The management system for the SBPMF exists within an appropriate legal and / or customary framework which ensures that it:

- Is capable of delivering sustainable fisheries in accordance with MSC Principles 1 and 2;
- Observes the legal rights created explicitly or established by custom of people dependent on fishing for food or livelihood; and
- Incorporates an appropriate dispute resolution framework.

15.1.1 Compatibility of Laws with Effective Management

The governance system in place for all WA commercial fisheries, including the SBPMF, is subject to a number of international, national and local (state-level) treaties, policies and pieces of legislation.

15.1.1.1 International Fisheries Jurisdiction and Treaties

On 1 August 1994, the Commonwealth of Australia declared an Exclusive Economic Zone (EEZ) extending from 12 nautical miles to 200 nautical miles from its coastline[15]. Within its EEZ, Australia has sovereign rights to explore and exploit, conserve and manage the natural

[15] http://www.daff.gov.au/fisheries/domestic/zone

resources—both living (such as fisheries and genetic material) and non-living (such as oil, gas, minerals).

Australia is a signatory to a number of international agreements and conventions (which is applied within its EEZ) such as —

- *United Nations Convention on the Law of the Sea* (regulation of ocean space);
- *Convention on Biological Diversity* and Agenda 21 (sustainable development and ecosystem based fisheries management);
- *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (protection of ETP species);
- *Code of Conduct for Responsible Fisheries* (standards of behaviour for responsible practices regarding sustainable development);
- United Nations *Fish Stocks Agreement*; and
- State Member of the *International Union for Conservation of Nature*.

15.1.1.2 National Environmental Legislation

The EPBC Act[16] is the Australian Government's (hereafter referred to as the 'Commonwealth Government') central piece of environmental legislation. The EPBC Act is administered by the Commonwealth Government's Department of the Environment (DotE) and provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as matters of national environmental significance. The DotE is responsible for acting on international obligations on a national level, by enacting policy and/or legislation to implement strategies to address those obligations.

The Commonwealth DotE, through the Commonwealth Minister, has a legislative responsibility to ensure that:

- All Commonwealth managed fisheries undergo strategic environmental impact assessment before new management arrangements are brought into effect; and
- All fisheries in Australia from which product is exported undergo assessment to determine the extent to which management arrangements will ensure the fishery is managed in an ecologically sustainable way in the long term.

WA fisheries legislation and policy conforms to overarching Commonwealth Government fisheries and environmental law, including the EPBC Act. Western Australia's commercial export fisheries, including the SBPMF, have been assessed using the Australian National ESD Framework for Fisheries[17], in particular, the *Guidelines for the Ecologically Sustainable Management of Fisheries* (the Guidelines).[18]

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[16] http://www.austlii.edu.au/au/legis/cth/consol_act/epabca1999588/

[17] http://www.fisheries-esd.com

[18] http://www.environment.gov.au/coasts/fisheries/publications/guidelines.html)

15.1.1.3 State and Commonwealth Fisheries Jurisdictional Arrangements

There are three different statutory entities responsible for the control and management of fisheries off the coast of Western Australia –

- the WA State Government;
- the WA Fisheries Joint Authority; and
- the Commonwealth Australian Fisheries Management Authority[19] (AFMA).

The WA State Government and WA Fisheries Joint Authority managed fish resources that fall under the jurisdiction of the *Fish Resources Management Act 1994* (FRMA) are described in a formal agreement between the Commonwealth and State Governments known as the *Offshore Constitutional Settlement 1995* (OCS)[20]. Commonwealth fisheries are managed by AFMA under the Commonwealth *Fisheries Management Act 1991*[21].

The OCS sets out that the State will manage all trawling on the landward side of the 200 metre isobath in WA, and the Commonwealth will manage all deep water trawling. The SBPMF is managed by the State pursuant to the OCS, and its western boundary is the 200 metre isobath. There are no migratory or straddling stock management requirements associated with this fishery.

15.1.1.4 System of Government in WA and Relevant Fisheries Legislation

The Government of WA operates under the Westminster system, and an important tenant of this system is that the responsible Minister makes executive decisions. Insofar as the administration of fisheries in Western Australia is concerned the relevant executive decision maker is the Minister for Fisheries.

The WA Department of Fisheries is established and governed under the State *Public Sector Management Act 1994*[22] (PSM Act) which is administered by the Western Australian Public Sector Commission[23] under the Department of Premier and Cabinet. Departmental staff must act in accordance with the PSM Act and any allegations of official corruption by Departmental staff are handled by the WA Corruption and Crime Commission[24]. The Department is required to report on its performance annually via its *Annual Report to State Parliament* (*Annual Report*).[25]

The Department is principally responsible for assisting the Minister for Fisheries in administering the following Acts and Regulations[26] that apply to the aquatic resources (excluding pearling) in WA:

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[19] http://www.afma.gov.au/
[20] http://www.fish.wa.gov.au/Documents/management_papers/fmp077.pdf.
[21] http://www.austlii.edu.au/au/legis/cth/consol_act/fma1991193/
[22] http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_771_homepage.html.
[23] http://www.publicsector.wa.gov.au/
[24] http://www.ccc.wa.gov.au/Pages/default.aspx
[25] http://www.fish.wa.gov.au/Documents/annual_reports/annual_report_2012-13.pdf

[26] http://www.slp.wa.gov.au/statutes/subsiduary.nsf/fishlegis?OpenPage

- FRMA;
- *FRMR*;
- *Fisheries Adjustment Schemes Act 1987*; and
- *Fishing and Related Industries Compensation (Marine Reserves) Act 1997.*

The FRMA adheres to arrangements established under relevant Australian laws as set out in sections 3 and 4A:

Section 3 of the FRMA —

"The objects of this Act are

(a) to develop and manage fisheries and aquaculture in a sustainable way; and

(b) to share and conserve the State's fish and other aquatic resources and their habitats for the benefit of present and future generations."

Section 4A of the FRMA precautionary principle, effect of, states-

"In the performance or exercise of a function or power under this Act, lack of full scientific certainty must not be used as a reason for postponing cost-effective measures to ensure the sustainability of fish stocks or the aquatic environment."

The FRMA deals with broad principles, the provision of head powers and high level overarching matters; the FRMR and other subsidiary legislation, such as commercial fishery management plans, deal with the details needed to put these matters into practice.

In many cases, the FRMA will specifically require some matters to be dealt with by subsidiary legislation. Subsidiary legislation cannot be inconsistent with the provisions of the FRMA, under which it was made, and must be permitted to be made by a head of power in the empowering Act.

15.1.1.5 New WA Aquatic Resources Management Act

In 2010, the Minister for Fisheries directed the Department to investigate and scope the requirements for a new Western Australian Act of Parliament to ensure the sustainable development and conservation of the State's aquatic biological resources into the future.

This review recognised the need for the establishment of a clear statutory basis for commercial and recreational fishing access rights as a component in improving the overall robustness of sustainable fisheries management and improving security of resource access for all fisheries sectors.

A new *Aquatic Resources Management Act* (ARMA) has been drafted to replace the FRMA and is expected to be passed by Parliament during 2015. Importantly, the ARMA's proposed framework includes provision for a rights-based management approach for all fishing sectors in the context of aquatic resource management strategies and sectoral harvest plans.

An overview of the proposed new ARMA and the objectives of sustainable fisheries and aquatic management policy and how they relate to national and international fisheries law and policy are published in *A Sea Change for Aquatic Sustainability – Meeting the Challenge of Fish Resource and Aquatic Sustainability in the 21st Century.*[27]

The guiding principles for the proposed ARMA are that it:

- Provides an integrated aquatic resource management framework which incorporates ESD and biodiversity conservation goals;
- Incorporates the precautionary principle more explicitly;
- Broadens the base of the Act to include aquatic ecosystem issues in the management prescriptions;
- Provides a basis for simplifying subsidiary legislation where possible;
- Provides for greater devolution of decision making and delegation where suitable;
- Provides flexibility for more cost-effective management based on more explicit risk assessment;
- Provides explicit head powers to achieve biological and allocation outcomes across all harvest sectors as required; and
- Provides improved security of access for all resource users.

Importantly, the proposed ARMA includes objects to:

"*(a) ensure the ecological sustainability of the State's aquatic resources and aquatic ecosystems for the benefit of present and future generations; and (b) to ensure that the State's aquatic resources are managed, developed and used having regard to the economic, social and other benefits that the aquatic resources may provide.*"

15.1.2 Resolution of Legal Disputes

There are well established mechanisms for administrative and legal appeals of decisions taken in respect of fisheries which are prescribed in Part 14 of the FRMA. Most decisions made by the Chief Executive Officer of the Department and disputes regarding the implementation and administration of fisheries legislation can be taken to the Western Australian State Administrative Tribunal (SAT)[28] for review or the WA (and Commonwealth) Court System[29].

These mechanisms have been used and tested across several fisheries. The decisions of the SAT and the Courts are binding on the Department (for details of decisions see

[27] http://www.fish.wa.gov.au/Documents/occasional_publications/fop079.pdf.

[28] http://www.sat.justice.wa.gov.au
[29] http://www.courts.dotag.wa.gov.au/C/courts_history.aspx

http://decisions.justice.wa.gov.au/SAT/SATdcsn.nsf). All SAT decisions must be carried out by the Department (section 29(5) of the *State Administrative Tribunal Act 2004*[30]).

Criminal offences against the FRMA are dealt with by the Magistrates Courts and a commercial operator or recreational fisher is either found guilty or not guilty.

All changes to, or new, fisheries legislation, including subsidiary legislation such as management plans and orders, are potentially subject to review through the disallowance process of State Parliament.

All subsidiary legislation is also reviewed by the Joint Standing Committee on Delegated Legislation who may seek further advice on the reasons for the legislation, and potentially, move to disallow. In this way there is Parliamentary and public scrutiny of fisheries legislation. Fisheries legislation is "passed and enacted" when it is gazetted.

This framework applies to the SBPMF. It should be noted that the consultative, educative and partnership approach to management, which is inclusive of all stakeholders, provides informal but effective mechanisms to minimise opportunities for disputes.

15.1.3 Respect for Rights

15.1.3.1 Commonwealth Statutory Native Title Rights

Statutory aboriginal native title rights are managed under the Commonwealth *Native Title Act 1993*[31] (NTA). A registered native title claim is an application where a decision about native title is yet to be made. A determination of native title is a decision that native title does or does not exist in a particular area of land and/or waters (the determination area). The National Native Title Tribunal[32] facilitates the negotiation of indigenous land use agreements following a claim or determination and is required to keep registers of approved native title determination and native title claims.

A key aspect of the legislation is that proposed developments or activities (including fisheries where a registered claim or determination extends into State waters) that may affect native title are classed as 'future acts'[33]. This requirement has been in place since 1993.

In 1999, the Department obtained a 'Report for Fisheries Western Australia' in respect of the interaction between fisheries/pearling legislation and the *Native Title Act 1993*. That Report advised that:

> 1. The very wide scope of what can be done under a management plan means that they do have the potential to affect native title. As a result, a new management plan would be considered a 'future act' for the purpose of the *Native Title Act 1993.*

[30] http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_918_homepage.html
[31] http://www.comlaw.gov.au/Series/C2004A04665
[32] http://www.nntt.gov.au/au/Pages/default.aspx
[33] http://www.dpc.wa.gov.au/lantu/FutureActs/Pages/Default.aspx

2. Because the new management plan would be covered by *Native Title Act* s24HA, it can be validly made without the need for any specific native title notification or comment procedure.

3. While specific notification is not required, it would however be prudent for comment to be sought from any native title parties likely to be affected by the new management plan under the provisions of the FRMA section 64(2).

4. The granting of licences and permits under management plans will not be future acts in their own right and they can therefore be granted without the need for any native title procedure or notification requirement.

In accordance with point 3 above, the Department provides any native title party, or parties, with an opportunity to comment on the development of a proposed fishery. There is a registered Native title claim that includes the waters of Shark Bay (WAD6236/1998)[34] by the Malgana Shark Bay people.

A recent Australian High Court decision related to the application of State fisheries law to native title holders fishing for abalone in their local area in South Australia.[35] The decision concluded that the State Fisheries Law did not extinguish native title rights to fish and the section 211 NTA defence was applicable. It is therefore unlikely that fisheries legislation in Western Australia has the effect of extinguishing native title rights to fish and that the defence provided by section 211 NTA will apply to most cases where the right being exercised is for a traditional, non-commercial purpose and where the person is in fact, an Aboriginal person.

15.1.3.2 Customary Fishing in Western Australia

There are relatively large Aboriginal communities within the Gascoyne Coast Bioregion, and fishing is a popular activity. People of Aboriginal descent do not need a recreational fishing licence if fishing using traditional methods.

The WA Government and the Department are committed to working with the customary fishing sector to recognise customary rights. Section 6 of the FRMA acknowledges the rights of Aboriginal persons fishing for a customary purpose —

6. Aboriginal persons, application of Act to

An Aboriginal person is not required to hold a recreational fishing licence to the extent that the person takes fish from any waters in accordance with continuing Aboriginal tradition if the fish are taken for the purposes of the person or his or her family and not for a commercial purpose.

The FRMA defines customary fishing as:

fishing by an Aboriginal person that —

[34] http://www.nntt.gov.au/searchRegApps/NativeTitleRegisters/Pages/RNTC_details.aspx?NNTT_Fileno=WC1998/017
[35] http://www.hcourt.gov.au/assets/publications/judgment-summaries/2013/hca47-2013-11-06.pdf

(a) is in accordance with the Aboriginal customary law and tradition of the area being fished; and

(b) is for the purpose of satisfying personal, domestic, ceremonial, educational or non-commercial communal needs.

The FRMA also provides the power to make regulations to manage customary fishing.

The Department released a policy position statement in 2009 relating to customary fishing in Western Australia[36] which states that customary fishing applies, within a sustainable fisheries management framework, to persons of Aboriginal descent who are fishing in accordance with the traditional law and custom of the area being fished and fishing for the purpose of satisfying personal, domestic, ceremonial, educational or non-commercial communal needs.

Further details regarding social aspects of customary fishing in Western Australia can be found in Fisheries Management Paper 168 (2003) *Aboriginal Fishing Strategy - Recognising the Past, Fishing for the Future*[37].

To date, the only survey designed to document the Indigenous catch was the National Recreational and Indigenous Fishing Survey carried out in 2000/01 (Henry and Lyle 2003[38]). While this survey did not present data separately for regional Western Australia, what is clear from this report is that the vast majority of the Indigenous catch is from inland and coastal waterways.

Under the proposed ARMA, a quantity of a specified aquatic resource[39] will be reserved for conservation and reproductive purposes, then setting a sustainable allowable harvest level for use by the fishing sectors. The quantity "reserved" also includes an allowance for Customary fishing and public benefit purposes such as scientific research. This means that a specific share does not have to be allocated to the Customary sector, as that share is set aside prior to setting an allowable harvest level for the resource and Customary fishing can continue in accordance with existing Customary fishing arrangements.

Integrated Fisheries Management (IFM) is a Government initiative adopted in 2004 aimed at making sure that Western Australia's fish resources continue to be managed in a sustainable way in the future. IFM recognises the rights of customary fishers of Aboriginal descent who are fishing for cultural needs. Given there is no evidence of Indigenous (or recreational) fishing for prawns in Shark Bay, there is no requirement to implement IFM to manage the catch share of prawns between sectors in Shark Bay; however the customary fishing framework still applies.

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[36] http://www.fish.wa.gov.au/Documents/customary_fishing/customary_fishing_policy.pdf.
[37] http://www.fish.wa.gov.au/Documents/management_papers/fmp168.pdf
[38] http://daff.gov.au/__data/assets/pdf_file/0011/23501/final_recsurvey_report.pdf
[39] In this context "aquatic biological resource" may refer to a single species of fish, or a number of species or species groups. The resource may also be defined by area. Several "fisheries" and sectors may operate on a resource.

15.2 Consultation, Roles and Responsibilities

The management system has effective consultation processes that are open to interested and affected parties. The roles and responsibilities of organisations and individuals who are involved in the management process are clear and understood by all relevant parties.

15.2.1 Roles and Responsibilities

One of the first steps in the consultation process is identifying the key and other interested stakeholders relevant to a fishery. The number and type of stakeholders vary depending on the type of fishery, target species, the area of operation and whether or not the fishery contains a significant recreational or customary fishing component.

15.2.1.1 Department of Fisheries

There is explicit definition of the roles and responsibilities of the Commonwealth's DotE as discussed above. The role and responsibilities of the state of WA in fisheries management in explicitly outlined in the *Western Australian Government Fisheries Policy Statement March 2012*[40] and in the Offshore Constitutional Settlement arrangements particularly in relation to the management of trawl fisheries.

The members of the Department's Corporate Executive and an organisational chart are published in the Department's *Annual Report*. With respect to the SBPMF, key personnel to whom the responsibility of ensuring management, research and compliance outcomes, including proper prioritization of Departmental funding, include:

- Gascoyne / Northern Bioregion Program Manager (Aquatic Management Division);
- Gascoyne / Northern Bioregion Principal Management Officers (Aquatic Management Division);
- Gascoyne / Northern Bioregion Fisheries Management Officers (Aquatic Management Division);
- Supervising Scientist – Invertebrates (Research Division);
- Senior Scientist – Invertebrates (Research Division);
- Gascoyne Bioregion Compliance Manager (Regional Services); and
- Gascoyne Bioregion Regional Manager (Regional Services).

Planning and prioritisation is done in conjunction with the Chief Executive Officers of the peak sector bodies for the commercial and recreational sectors (where relevant) in Western Australia:

- the Chief Executive Officer of the WAFIC and
- the Chief Executive Officer of Recfishwest.

[40] http://www.fish.wa.gov.au/Documents/corporate_publications/wa_govt_fisheries_policy_statement.pdf.

The Department or Minister is responsible for advising licensees and WAFIC of Ministerial / Department decisions which are the subject of a consultation process.

Responsibilities of the Department in formal consultation arrangements with WAFIC include that it:

- provides annual funding to WAFIC equivalent to 0.5 % of Western Australian commercial fishing gross value of product (based on a three year average) plus a pro rata amount equivalent to 10% of water access fees paid by aquaculture and pearling operators. Payments to WAFIC are made by 6 monthly instalments each year (see Section 15.3 for further information around the funding model);
- works with WAFIC in a manner consistent with WAFIC's role as the peak body representing commercial fishing interests in Western Australia; and
- engages with WAFIC, sector bodies and commercial fishing interests according to WAFIC Operational Principles contained in Table 15.1.

The Department or Minister is also responsible for ensuring that the recreational fishing sector, through Recfishwest, is formally consulted on proposed changes to recreational fisheries management and is advised of Ministerial / Department decisions which are the subject of a consultation process. The Minister is responsible for providing Recfishwest with a proportion of the income generated from annual recreational fishing licence fees to undertake it role as the peak body representing recreational fishing interests in Western Australia.

15.2.1.2 Peak Sector Bodies

The Western Australian Government formally recognises[41] WAFIC and Recfishwest as the key sources of coordinated industry advice for the commercial and recreational sectors, respectively.

15.2.1.2.1 WAFIC

WAFIC[42] is the peak industry body representing professional fishing, pearling and aquaculture enterprises, as well as processors and exporters, in WA. It is an incorporated association that was created by industry more than 40 years ago to work in partnership with Government to set the directions for the management of commercial fisheries in WA. WAFIC aims to secure a sustainable industry that is confident of:

- Resource sustainability and security of access to a fair share of the resource;
- Cost-effective fisheries management;
- That its business can be operated in a safe, environmentally-responsible and profitable way; and

  That investment in industry research and development is valued and promoted.

[41] http://www.fish.wa.gov.au/Documents/corporate_publications/wa_govt_fisheries_policy_statement.pdf.
[42] More information about WAFIC is available on their website: www.wafic.org.au/

WAFIC provides a monthly newsletter[43] to subscribers and publishes annual reports and financial information[44].

WAFIC's responsibilities include coordinating Government funding for industry representation and taking on a leadership role for matters that involve or impact on or across a number of fisheries or are of an industry-wide or generic nature. WAFIC also represents those commercial fishing sectors that do not have capability for self-representation.

WAFIC's responsibilities can be summarised as:

- Providing effective professional representation of commercial fishing interests and the commercial fishing sector to Government, industry, other relevant organisations and the community. This includes engaging, facilitating and consulting, as necessary in order to meet this responsibility;
- Providing professional advice to the Government and industry members on issues affecting commercial fishing;
- Engaging, facilitating and consulting as necessary in order to deliver the above; Providing representation of commercial fishing interests on fisheries management and Ministerial committees, as required;
- Documenting priority issues for commercial fishing interests (by 30 March) each year to the Department;
- Providing feedback to the Department on proposed deliverables and budget priorities for expenditure of the Fisheries Research and Development account;
- Engaging with RFW and other appropriate parties with a view to identifying joint priorities and solutions to issues of shared concern;
- Engaging in promotion, education and awareness of key sustainability messages consistent with best practice fisheries management and objects of the FRMA; and
- Conducting agreed activities that are consistent with the FRMA as it relates to the provision of assistance to, or promotion of, the fishing industry (i.e. s238(5)(1) of the FRMA).

WAFIC's Operational Principles (Table 15.1) outline consultation responsibilities of the organisation in dealing with policy issues that could affect, as a whole, the commercial fishing, aquaculture, and pearling industries; issues which primarily affect one sector, but could have broader industry implications; and issues that affect only one specific industry group.

43 http://www.wafic.org.au/images/stories/WAFIC_Mar_2014_Newsletter.pdf
44 http://www.wafic.org.au/about-wafic/publications/annual-reports

Table 15.1. WAFIC's Operational Principles for consultation

Principle	Responsible Body	Example
On generic policy issues that could affect, as a whole, the commercial fishing, aquaculture, and pearling industries	WAFIC	Bioregional marine planning; safety, education and training; research and development policy and biosecurity
On policy issues that currently primarily affect one sector but which could have implications for the broader industry	WAFIC will nominate the relevant sector body, and WAFIC and that body will jointly represent industry.	WAFIC would represent industry on marina and port access issues, which may primarily initially impact on the fishing industry in regard to certain locations but have precedents for the rest of the industry for other locations, and on animal welfare.
On issues which affect only one specific industry group.	The relevant sector association would represent itself, but WAFIC would be kept informed and may have a statutory consultation role.	Regulation of gear design or compliance (WAFIC and specific industry associations)

15.2.1.2.2 Recfishwest

Similar roles and responsibilities exist with Recfishwest[45] as the peak body for the recreational sector. Recfishwest is an incorporated association and receives 15 % of the revenue raised from recreational fishing licence fees (see Section 15.3) to advocate for, and represent, the recreational fishing sector. Key roles undertaken by Recfishwest include consultation on management reforms, advocating for the sector on issues of significance, education and oversee recreational fishing initiatives.

Recfishwest's monthly electronic newsletter reaches over 50 000 recreational fishers, keeping subscribers up to date with recreational fishing initiatives, research results and issues affecting the recreational fishing sector.

15.2.1.3 Licensees / Sector Associations

The licence holders in the fisheries have a responsibility to make themselves aware of the fisheries legislation that relates to their activities as it changes from time to time. In order to fulfil this responsibility, the Department assists licence holders by explicitly reminding them in writing of where they can access the latest legislation. This information can be found on every licence (e.g. MFLs, CFLs and FBLs).

15.2.1.4 Other interests

The prawn resources targeted by the SBPMF are not taken in any major numbers by recreational or customary fishers; however, other interested stakeholders are recognised on the basis that the fishery:

- has the potential to impact on ecosystem components including ETP species and habitat;

[45] http://www.recfishwest.org.au/

- targets a species susceptible to changes in environmental conditions;
- currently has a Native title claim within its boundaries;
- has the potential to interact with other marine users in Shark Bay; and
- provides an iconic seafood product to retailers and consumers both locally and overseas.

Based on these characteristics, other stakeholders relevant to the SBPMF include:

- Organisations/institutions undertaking research relevant to Shark Bay and environmental factors[46] (e.g. WAMSI[47], universities and CSIRO[48]);
- Local Government and State Government agencies (e.g. Department of Parks and Wildlife[49]);
- conservation sector representatives (e.g. Conservation Council of WA[50]);
- Native Title claimant and their representatives;
- Local government (Shire of Shark Bay);
- investors, banking representatives, boat brokers etc.;
- retailers and consumers; and
- the wider community.

15.2.2 Consultation Processes

The management system includes consultation processes that regularly seek and accept relevant information, including local knowledge, and the system demonstrates consideration of information and explains how it is used or not used.

The WA Government's commitment to consultation with stakeholders is set out in the *WA Government's Fisheries Policy Statement* of 2012[51]. The broad consultation framework (Figure 15.1) was developed following the outcome of a 2009 review of consultation arrangements between the fishing sector and Government that incorporated the following objectives:

1. Enhanced efficiency, cost effectiveness and flexibility.
2. Clarification with respect to:
    a. fishing sector representation;
    b. expertise based advice to the Department; and

[46] http://www.fish.wa.gov.au/Documents/research_reports/frr250.pdf
[47] http://www.wamsi.org.au/
[48] http://www.csiro.au/
[49] http://www.dpaw.wa.gov.au/
[50] http://ccwa.org.au/
[51] Western Australian Government Fisheries Policy Statement, March 2012, Department of Fisheries, page 10, at http://www.fish.wa.gov.au/Documents/corporate_publications/wa_govt_fisheries_policy_statement.pdf.

c. the Department as the primary source of management advice to the Minister for Fisheries.

3. Enhancement of the Department's engagement with industry, stakeholders and the public.

The review process resulted in[52] —

- Recognition of WAFIC as the peak body representing the commercial fishing sector (including pearling and aquaculture) and RFW as the peak body representing the recreational fishing sector, with funding provided by Government to each peak body to support these roles;

- Capacity for these peak bodies to perform consultation functions on behalf of the Minister. In this regard, the Department has entered into a Service Level Agreement (SLA) with WAFIC for the provision of specified consultation services with the commercial sector;

- The replacement of Management Advisory Committees (MACs) with two key sources of advice: (1) the Department, as the key source of Government advice on fisheries management, and (2) WAFIC and RFW, as the key sources of coordinated industry advice for the commercial and recreational sectors, respectively;

- Establishment of an Aquatic Advisory Committee (AAC) to provide independent advice to the Minister or the Department on high-level strategic matters;

- The establishment by the Minister (or Department) of tasked working groups to provide advice on specific fisheries or operational matters. Tasked working groups differ to MACs in that they are expertise-based and operate on the basis of a written referral on a specific matter. Tasked working groups have been established to provide advice on matters such as water access (lease) fees, strengthening of access rights in the fisheries legislation, development of a Government fisheries policy statement and determining catch shares among sectors.

- Capacity for peak bodies to perform consultation functions on behalf of the Minister. In this regard, the Department has entered into a SLA with WAFIC for the provision of specified consultation services with the commercial sector. Figure 15.1 provides a diagrammatical representation of the broad consultation framework for fisheries management in WA that resulted from the review.

[52] See Report of the Consultation Working Group at-
http://www.fish.wa.gov.au/Documents/occasional_publications/fop073.pdf

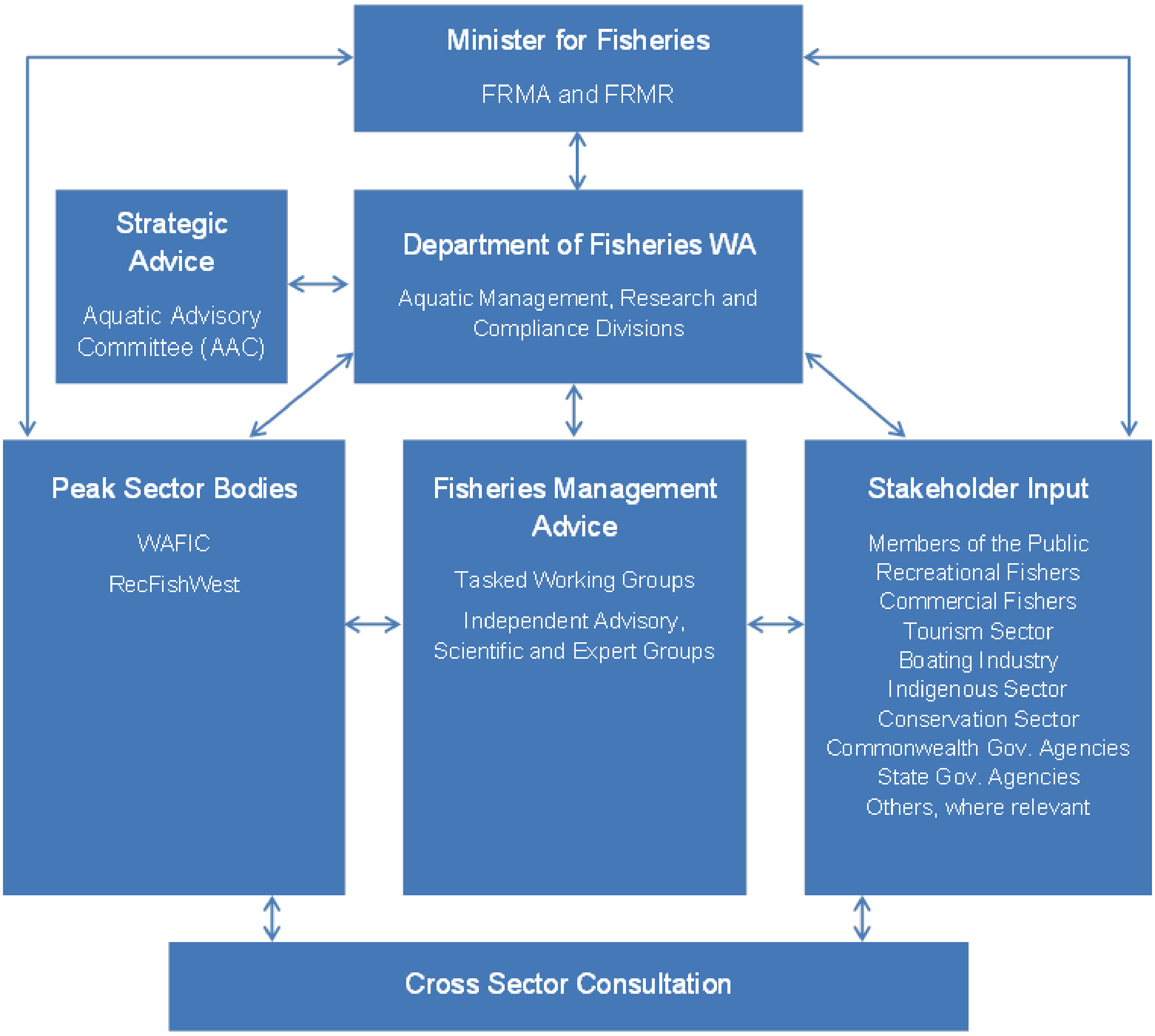

Figure 15.1. Broad fisheries management consultation framework in WA.

15.2.2.1 Statutory Consultation

Given the commercial aspects of fishing access rights and the potential for amendments to management arrangements to adversely affect these interests, it is fundamental that the interest holders are consulted, have the opportunity to respond to any proposed amendments by the Minister / Department and have these responses genuinely considered by the Minister prior to the final decision.

Most management changes and fishing arrangements in the SBPMF are facilitated through amendments to the fishery's management plan and by notices determined by the Department's Director General (DG; also referred to as the CEO under the FRMA); however, other arrangements can be implemented via section 43 orders, licence conditions and (section 7) exemptions, as required. The Minster is the final decision-maker in determining or amending legislation. The Department generally undertakes consultation work on the Minister's behalf; however, the statutory consultation function is presently conducted by WAFIC on behalf of the Department under a SLA.

Amendments to a fishery management plan cannot be undertaken without addressing statutory consultation requirements pursuant to section 65 of the FRMA[53], with each fishery management plan explicitly identifying the key stakeholders for the fishery that the Minster must consult with prior to making an amendment. It should be noted that, since there is no longer a Joint Trawl Management Advisory Committee as a result of the consultation review detailed in the Consultation Processes section above, the key stakeholder in the SBPMF defaults to the licence holders in the fishery.

The SBPMF is opened annually pursuant to clause 10 of the Management Plan. The Department consults with the licensees prior to providing advice to the Chief Executive Officer who must provide notice of his decision to the licensee in writing. For the implementation of other statutory fishing management tools, such as section 43 orders or section 7 exemptions, statutory provisions are silent as to procedural consultation requirements; nevertheless, the Minister must have regard for common law principles to afford natural justice to the licence holder. The Department has a series of formal decision-making delegations for licensing decisions and exemptions from legislation. Most Departmental decisions (excluding Ministerial decisions) are subject to review by the State Administrative Tribunal.

15.2.2.2 Obtaining Information

The Department / Minster may seek advice from a number of sources, including external expert advice and internal management advice, when considering policy or management changes. Collaborative research projects using expert advice on data and other information is often sought and underpins management changes.

The Department / Minister may also seek and provide advice directly through the peak sector bodies (WAFIC and Recfishwest) and / or other sector associations. For example, WAFIC and Recfishwest have direct input into the annual planning and priority-setting process used to determine management, compliance, research and other priorities for the Department.

15.2.2.2.1 Strategic Advice

An Aquatic Advisory Committee (AAC) provides independent advice to the Minster / Department on high-level strategic matters. This committee consists of members who have strong backgrounds in governance and policy.

15.2.2.2.2 Fisheries Management Advice

Fisheries management advice may be provided by tasked working groups and / or independent advisory, scientific and expert groups. Tasked working groups and panels can be established by the DG or the Minister to provide independent, expert advice relating to a range of fisheries management matters. Working groups are highly flexible and work to specific terms of reference within a particular timeframe. They are usually provided with a

[53] Note that section 65(4) of the FRMA provides for the Minister to amend a management plan without consultation if, in the Minister's opinion, the amendment is required urgently or is of a minor nature (but must provide advice following the amendment of the plan). This might include the need for amendments for emergency sustainability reasons.

specified task, such as addressing resource access (e.g. closures and compensation) and allocation (e.g. IFM) or reviewing research, management or Government policy.

15.2.2.2.3 Stakeholder Input

The Department / Minister is responsible for advising licensees and WAFIC of management decisions that are the subject of a consultation process. In carrying out the consultation functions on matters referred to the organisation by the Minister or the Department, WAFIC must:

- Distribute proposed changes to management arrangements that include the Minister's / Department's reasoning for the proposal(s) and the information on which the proposal(s) is based to all licence holders in the relevant fishery;
- Describe the method by which licence holders may provide their views; this may be by way of inviting written responses, or it may involve additional processes, such as the establishment of appropriate forums in which licence holders can discuss and deliberate on the merits of proposed changes prior to putting forward individual views as well as collective views, where appropriate;
- Ensure that licence holders have a reasonable period in which to consider their position and respond; and
- Ensure the decision maker is fully aware of the views being put forward, in order to ensure the decision maker gives proper and genuine consideration to the views being put forward.

The Department has a general practice of holding regular (often annual) management meetings with fishery licensees to discuss research, management, compliance and other specific issues affecting the fishery (e.g. marine park planning). These management meetings underpin the decision-making process at the fishery-specific level. These meetings are generally coordinated by WAFIC (under the SLA), with the location, timing and priority of the annual management meeting determined by the WAFIC Industry Consultation Unit (ICU) in liaison with relevant Departmental resource managers. The meeting can occur at any time of year but is usually held either before the start of a licencing year or at the end of a fishing year, in accordance with the schedule agreed upon by WAFIC and the Department.

The meetings are attended by Departmental personnel, WAFIC and licence holders, but can also be open to other stakeholder groups, e.g. Recfishwest, processors, universities, other Government departments, the conservation sector and the general public, following appropriate consultation with industry.

The annual management meetings are widely recognised by the commercial licence holders as a mechanism for receiving the most up-to-date scientific advice on the status of the fishery, facilitating information exchange between stakeholders and decision-makers and for discussing new and ongoing management issues. The invaluable information licensees provide to the Department at these forums is considered when making research, management and compliance decisions.

For detail on the types of meetings held, the issues discussed and stakeholders in attendance during 2013/14 for the SBPMF please refer to Appendix H.

15.2.2.3 Other Consultation Processes

The Department may also hold meetings, workshops or consult in writing with stakeholders on an "as needs" basis on a range of fisheries management matters including:

- Updates on the implementation of the ARMA;
- Ministerial decisions regarding the SBPMF or wider commercial fisheries' policy and management;
- Risk assessment workshops;
- ESD accreditation, including conditions and reassessments;
- Intra and inter-sectoral access, allocation and conflict issues;
- Impacts of other State Department policies (e.g. marine park planning or mining activities);
- Implementation of new initiatives (e.g. MSC accreditation, new mobile applications);
- Expert review workshops;
- FRDC project steering committee representation[54];
- Published research results;
- Release of discussion papers that seek stakeholder input; and
- Implementation of IFM, where relevant.

When specific issues arise that involve particular stakeholder groups, there is consultation with them. For example, since 2004 no trawling has been allowed in southern areas of Denham Sound (below the 'Snapper Trawl Line' [STL]) in order to minimise potential impact on juvenile pink snapper. The potential for prawn fishing south of the STL was raised by the Shark Bay Prawn Trawler Operators Association in 2012. Research advice was presented to the Gascoyne Development Commission, Recfishwest and the Shire of Shark Bay as part of the consultation process. The outcome was to allow limited trawling in the area subject to appropriate conditions and this was relayed to interested stakeholders via a media release[55].

The SBPMF is unique in that a co-operative real-time management framework exists which underpins some of the decision making. To ensure interested stakeholders understand this process both the annual and in-season consultation processes for the SBPMF have been documented in the fishery's Harvest Strategy, which is available on the Department's website (DoF 2014a).

[54] http://www.fish.wa.gov.au/Documents/research_reports/frr160.pdf
[55] http://www.fish.wa.gov.au/About-Us/Media-releases/Pages/Shark-Bay-prawn-fishers-get-a-new-opportunity.aspx

15.2.3 Participation

The existing system for consultation includes both statutory and non-statutory opportunities for interested stakeholders to be involved in the management system.

The consultation processes undertaken by the Department ensures that stakeholders and the broader community have an increased awareness of and access to relevant information regarding fisheries management decisions. The Department encourages input from stakeholders and the broader community in the management process and facilitates their involvement by making all relevant information available and providing for discussion and the exchange of ideas.

WAFIC and Recfishwest are also responsible for seeking advice from their sector members during consultation periods and providing consolidated advice to the Department. Both organisations provide a monthly newsletter to subscribers, keeping them up-to-date with new initiatives, research results and issues. News and other relevant information is also publically-available on their WAFIC and Recfishwest websites (www.wafic.org.au and www.recfishwest.org.au, respectively).

Before making a decision around aquatic resource policy, the Minister must demonstrate that he has asked for, and taken into account, interested and affected parties' submissions on policy proposals. The release of Fisheries Management Papers (FMPs; discussion papers) for public comment are the most common way the Department undertakes wider consultation with the public and other interested stakeholders and invites stakeholder engagement on fisheries management proposals. Published FMPs detail the recommended management approach arising out of the expert review process and seeks public comment on those recommendations. The Minster is required to take these comments into account before a decision is made in respect to future management.

The Department encourages stakeholder comment in regard to any proposed management recommendations and publicises the release of new FMPs. The Department uses a variety of processes to ensure coverage and engagement with stakeholders and the wider community during the consultation period, including:

- direct consultation in writing;
- press releases;
- newspaper, radio and television interviews;
- dissemination of information via the Department's website; and
- Invitations for stakeholders to sit on tasked working groups or participate in scientific reviews / workshops, formal risk assessment processes and management reviews.

For example, an initial Shark Bay Prawn and Scallop Review Draft Report (Fisheries Management Paper No. 222) was released in April 2006 and invited submissions. Five written submissions were received and these submissions along with those received prior to the draft review paper being published were attached as annexes to the final report (Fisheries

Management Paper No. 235[56]). The report provided for consideration of future management arrangements and research directions.

These processes ensure that stakeholders and the community more generally have an increased awareness and access to relevant information. Making information available and providing for a discussion and exchange of ideas encourages input from stakeholders and the community in the management process.

15.3 Long-Term Objectives

The fisheries management legislation and policy in WA has clear long-term objectives to guide decision-making that are consistent with MSC Principles and Criteria and incorporate the precautionary approach.

The WA Government has set a long-term overarching objective that is underpinned by the principle of social and environmental responsibility *to ensure that economic activity associated with aquatic resources is managed in a socially and environmentally responsible manner for the long-term benefit of the State*. These objectives are explicit in both fisheries legislation and management policy, as described below.

15.3.1 Western Australian Fisheries Legislation

Sections 3 and 4 of the FRMA set out the overarching long-term sustainability strategy (including a precautionary approach) for fisheries and the aquatic environment in WA. The broad scope of the legislation ensures that it —

- Manages all factors associated with fishing (incorporating ESD and EBFM);
- Provides a clear basis for management of a whole biological resource (as opposed to just one sector);
- Gives effect to IFM by
  - Creating head powers that can establish management strategies with clear biological outcomes for all sectors, as required;
  - Establishing formal harvest allocations where these have been made; or
  - Describes the basis of informal allocations where these operate.
- Clearly distinguishes between managed aquatic resources and fisheries with biological targets and socially-regulated fisheries.

As set out in section 3, the objects of the FMRA are to:

"(a) to develop and manage fisheries and aquaculture in a sustainable way and (b) to share and conserve the State's fish and other aquatic resources and their habitats for the benefit of present and future generations."

The FRMA outlines the following means to achieve these objectives, including:

[56] http://www.fish.wa.gov.au/Documents/management_papers/fmp235.pdf

- *"Conserving fish and protecting their environment;*
- *Ensuring that the impact of fishing and aquaculture on aquatic fauna and their habitats is ecologically-sustainable and that the use of all aquatic resources is carried out in a sustainable manner;*
- *Enabling the management of fishing, aquaculture, tourism that is reliant on fishing, aquatic eco-tourism and associated non-extractive activities that are reliant of fish and the aquatic environment;*
- *Fostering the sustainable development of commercial and recreational fishing and aquaculture, including the establishment and management of aquaculture facilities for community or commercial purposes;*
- *Achieving the optimum economic, social and other benefits from the use of the fish resources;*
- *Enabling the allocation of fish resources between users of those resources, their reallocation between users from time to time and the management of users in relation to their respective allocations;*
- *Providing for the control of foreign interests in fishing, aquaculture and associated industries; and*
- *Enabling the management of fish habitat protection areas and the Abrolhos Islands reserve."*

Additionally, section 4a of the FRMA outlines the use of the precautionary principle in fisheries management:

"*In the performance or exercise of a function or power under this Act, lack of full scientific certainty must not be used as a reason for postponing cost-effective measure to ensure the sustainability of fish stocks or the aquatic environment.*"

The proposed ARMA more-explicitly incorporates broader ESD and biodiversity conservation goals, with objects to:

"(a) ensure the ecological sustainability of the State's aquatic resources and aquatic ecosystems for the benefit of present and future generations; and (b) to ensure that the State's aquatic resources are managed, developed and used having regard to the economic, social and other benefits that the aquatic resources may provide."

In order to effectively deal with community expectations for aquatic resource management, these legislative objectives have been translated into clearly-defined operational arrangements and procedures for each resource / fishery in the form of a fishery- or resource-specific harvest strategy. The harvest strategy is used to implement adaptive and precautionary approaches to fisheries management and includes the identification of harvesting approaches, the establishment of precautionary reference points and harvest decision and control rules that describe how fishing exploitation should be adjusted as a function of changes in spawning potential or stock size (DoF in press).

The *SBPMF Harvest Strategy* (DoF 2014a) includes fishery-specific objectives that align with those prescribed under the FRMA (and proposed ARMA), as well as clear and specifically-articulated performance levels and the associated management actions designed to achieve these objectives.

15.3.1.1 Efficiency Indicators

Government's desired outcome for the Department is the conservation and sustainable development of the State's fish resources. The Department has developed effectiveness and efficiency indicators to show the extent to which the Department achieved its goal of conserving and sustainably developing the State's aquatic resources. Performance against these indicators is reported annually in the Department's *Annual Report*.[57]

The Internal Audit Committee maintains and manages the Department's internal audit function on behalf of the Director General. The committee assists the Director General to identify and quantify risks that have the potential to impede the Department in achieving its goals, and to guide the development and implementation of risk-mitigation strategies.

15.3.2 Strategic Plan 2009 - 2018

The Department's *Strategic Plan 2009 – 2018* (currently in Phase 3 [2013 – 2015]) sets out clear and explicit long-term biological, ecological, social and economic objectives, which include:

- Sustainability: To ensure WA's fisheries and aquatic resources are sustainable and to provide services based on risk to ensure fish for the future and support the maintenance of healthy aquatic ecosystems;
- Community Outcomes: to achieve an optimum balance between economic development and social amenity in accordance with a framework to achieve sustainability;
- Partnerships: to promote effective strategic alliances and community stewardship; and
- Agency Management: deliver services on behalf of Government in accordance with the Department's statutory requirements to achieve effective and efficient use of resources to support the delivery of our strategy.

The *Strategic Plan 2009 - 2018* also sets out the strategies and key deliverables and divisions of the Department that are responsible for delivery and is reviewed on a regular basis.

The Research Division of the Department has established a Research Strategic Plan that is focused on achieving research outcomes against the objectives listed above. Further information on the Research Strategic Plan is provided in Section 16.5.

[57] http://www.fish.wa.gov.au/Documents/annual_reports/annual_report_2012-13.pdf

15.3.3 Fisheries Policy Statement 2012

The Government's fisheries and aquatic resource policy is set out in broad terms in *Western Australian Government Fisheries Policy Statement March 2012*.[58] The Policy Statement focuses on the Government's approach to sustainable resource management, fisheries and aquaculture development and growth, and appropriate structures and processes to ensure good governance is achieved in:

- aquatic resource management;
- aquatic resource access and allocation;
- aquatic environmental management
- marine planning;
- development and growth; and
- structures and processes (e.g. administration).

15.3.4 Improving Access Rights

In June 2010, the Minister for Fisheries announced that he would be establishing a working group to provide him with advice on elements of policy that related to the improvement of commercial fishing access rights. The Access Rights Working Group's report to the Minister is published in Fisheries Occasional Publication 102 (November 2011): *Improving Commercial Fishing Access Rights in Western Australia - Access Rights Working Group Report to the Hon Norman Moore, MLC Minister for Fisheries*[59].

The Access Rights Working Group proposed that the ARMA should be structured around the concept of rights-based fisheries management and make specific provision for establishing and managing these rights in a robust and integrated manner. It also recommended that a new system for the creation, trading and administration of fishing access rights (fishery shares) discrete from fishing activity (fishing permits) should be created.

The FRMA was amended in 2011 to incorporate some short term changes to existing legislation and administrative practice which provided some immediate improvements to the trading aspects of fishing rights created under Part 6 (Management Plans) of the FRMA. Specifically, the amendments improved the transferability, security and duration characteristics of fishing access rights created under the FRMA within the existing rights management approach.

15.3.5 Resourcing the Ability to Meet Long-Term Objectives

The costs of managing the aquatic resources, including conducting research, are met from a variety of sources. In particular, significant contributions can come from:

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[58] http://www.fish.wa.gov.au/Documents/corporate_publications/wa_govt_fisheries_policy_statement.pdf.

[59] http://www.fish.wa.gov.au/Documents/occasional_publications/fop102.pdf

- commercial fishing licence fees;
- State Government Consolidated Revenue;
- the Fisheries Research and Development Corporation;
- the Recreational Fishing Account (from recreational fishing licence fees);
- the National Heritage Trust;
- the Western Australian Marine Science Institution;
- Australian Research Council linkage grants;
- the Natural Resource Management Rangelands Catchment Coordinating Group;
- the Commonwealth Scientific and Industrial Research Organisation (CSIRO); and
- Commonwealth World Heritage Funding.

There is a commitment from the Department to meet the cost of:

- development and implementation of management outcomes; and
- ensuring adequate compliance by fishers with new and existing management initiatives.

Government consolidated revenue provided $ 48.4 million of the Department's income in 2012/13.[60]

From 1 July 2010, managed commercial fisheries were subject to a new funding model[61] which replaced a cost recovery system. The new funding model aimed at improving flexibility for resourcing priority management needs, equity in how much licensees pay in access fees and greater certainty of funding and access rights. This involves managed commercial fisheries in WA paying an access fee equivalent to 5.75% of the gross value of production (GVP) of the respective fishery. Commercial fishery access fees contributed $ 16.2 million to the Department's income in 2012/13.

As part of these arrangements, Government also agreed to contribute the equivalent of 0.5 % of managed commercial fishery GVP to WAFIC, to support its role as the peak body, and the equivalent of 0.25 % of GVP to the Fisheries Research and Development Corporation (FRDC).[62]

The recreational fishing sector also contributes to the cost of managing recreational fishing through recreational fishing licence fees (via a Recreational Fishing Account established under the FRMA).[63] The Recreational Fishing Account is used to address management,

[60] http://www.fish.wa.gov.au/About-Us/Publications/Pages/Annual-Report.aspx

[61] For further information on the new access fees see http://www.fish.wa.gov.au/sec/com/lic/index.php?0205.
[62] See http://www.fish.wa.gov.au/sec/com/lic/index.php?0205 for details of commercial fisheries fees that are used to fund research, management, compliance, community education etc.
[63] See http://www.fish.wa.gov.au/docs/media/index.php?0000&mr=793 for media update and http://www.fish.wa.gov.au/docs/pub/rfl/index.php?00 for details of licensing arrangements.

compliance, and research relevant to recreational fishing, and where appropriate, co-funds programs which deal broadly with issues which can cross sectors. Recreational fishing licence fees contributed over $ 6 million in 2012/13.

The Department also receives revenue from sources other than access fees that can be used to meet the cost of fisheries or more general ecosystem research. In particular, the FRDC is a significant source of funds for many research projects in Western Australia. Other sources of funding are the Western Australian Marine Science Institution (WAMSI), Australian Research Council linkage grants with a university partner (University of Western Australia, Murdoch University, Edith Cowan University or Curtin University) and the National Heritage Trust. Where funding is sought from outside sources, such as FRDC, the Department cannot ensure that applications will be accepted and that funding will be secured. Grants and other income from outside sources contributed $ 6.4 million of the Department's income in 2012/13.

As part of the Department's Ecosystem Based Fisheries Management framework, the Department monitors the environmental system (ecosystems and aquatic resources) of the Gascoyne Coast Bioregion, including Shark Bay. Actions to be undertaken to achieve outcomes (e.g. key target species' stock assessment and modelling, observer programs, managing ETP species interactions, habitat mapping, understanding environmental and external factors etc.) are funded through the prioritised spending of the 5 % GVP commercial fisheries access fee and by accessing funds from FRDC and other outside funding sources.

15.3.6 Key Policies for Meeting Long-Term Objectives

15.3.6.1.1 Ecologically Sustainable Development

The WA Government is committed to the concept of ESD which seeks to integrate short and long-term economic, social and environmental effects in to all decision-making. The key principles of ESD are implicitly contained in the objectives of the FRMA, and the Department's ESD Policy.[64]

The Department was one of the first fisheries agencies in the world to articulate how to demonstrate, in a practical manner, whether ESD requirements were being achieved. Each of WA's main commercial fisheries[65] has now been assessed using the Australian National ESD Framework for Fisheries,[66] as developed by the Fisheries Research and Development Corporation ESD Subprogram, and it is now an integral part of the stock sustainability assessment process for all fisheries in WA. The report for the Shark Bay Prawn Managed Fishery is available from the ESD subprogram website: http://www.fish.wa.gov.au/About-Us/Publications/Pages/Ecologically-sustainable-development.aspx

For the purposes of the wildlife trade provisions of Part 13A of the Commonwealth Government's EPBC Act, i.e. to be exempt from export controls for native species harvested in a fishery, management agencies must demonstrate that fisheries management regimes

[64] http://www.fish.wa.gov.au/Documents/management_papers/fmp157.pdf
[65] http://www.environment.gov.au/coasts/fisheries/index.html
[66] http://www.fisheries-esd.com

comply with the objectives of ecologically sustainable development. The Commonwealth Government DotE has prepared publicly available guidelines, *Guidelines for the Ecologically Sustainable Management of Fisheries* (Commonwealth Guidelines, 2007 current version)[67] on which management agencies are required to base their submissions for export approval. The submissions are released for public comment, which ensures rigorous and transparent assessments are conducted with input from Commonwealth and State fisheries agencies, the fishing industry and the wider community. All documents pertaining to the submissions and assessments, including the Commonwealth Minister's decisions and any conditions that are set on the fishery, are publicly available on the Commonwealth DotE's website.[68]

WA fisheries assessments are conducted against the Commonwealth Guidelines which outline specific principles and objectives designed to ensure a strategic and transparent way of evaluating the ecological sustainability of fishery management arrangements. Adequate performance of fishing in relation to the Commonwealth Guidelines will see that the management arrangements demonstrate a precautionary approach, particularly in the absence of information. A precautionary approach should be used in all stages of fishery management, from planning through to assessment, enforcement and then re-evaluation.

A precautionary approach requires managers to utilise the best scientific evidence available when designing a management regime. It also requires that a minimum level of information be available before a fishery is established. Thus information collection and ongoing research is of significant importance and may be inversely proportional to the level of precaution that is taken in setting management measures for a fishery. Sources of uncertainty within the data should be identified and where possible quantified. Until research on the specific stock provides information, a precautionary approach should set conservative limits to account for the unknown level of uncertainty.

To satisfy the Commonwealth Government requirements for a demonstrably ecologically sustainable fishery, the fishery or fisheries (if a species is caught in more than one fishery), must operate under a management regime that meets Principles 1 and 2 of the Commonwealth Guidelines. The management regime must take into account arrangements in other jurisdictions and adhere to arrangements established under Australian laws and international agreements.

Under the Commonwealth Guidelines, the management regime does not have to be a formal statutory fishery management plan as such, and may include non-statutory management arrangements or management policies and programs. The regime should —

- be documented, publicly available and transparent;
- be developed through a consultative process providing opportunity to all interested and affected parties, including the general public;

[67]http://www.environment.gov.au/resource/guidelines-ecologically-sustainable-management-fisheries
[68] http://www.environment.gov.au/coasts/fisheries/index.html

- ensure that a range of expertise and community interests are involved in individual fishery management committees and during the stock assessment process;
- be strategic, containing objectives and performance criteria by which the effectiveness of the management arrangements are measured;
- be capable of controlling the level of harvest in the fishery using input and/or output controls;
- contain the means of enforcing critical aspects of the management arrangements;
- provide for the periodic review of the performance of the fishery management arrangements and the management strategies, objectives and criteria;
- be capable of assessing, monitoring and avoiding, remedying or mitigating any adverse impacts on the wider marine ecosystem in which the target species lives and the fishery operates; and
- require compliance with relevant threat abatement plans, recovery plans, the National Policy on Fisheries Bycatch, and bycatch action strategies developed under that policy.

The steps to apply this 'ecosystem type of approach' to individual fisheries are based on the adoption of international standards for risk management (Australian Standards/New Zealand Standards 4360 2009)[69], reflecting that fisheries management is a specific form of risk management. These steps have also now been routinely applied elsewhere in Australia and internationally.

The Australian National ESD Framework for Fisheries includes an ESD reporting framework for fisheries outlined within a series of reports, making the completion of ESD reports as efficient and effective as possible. There are four main processes needed to complete an ESD report.[70] These include: identifying issues; determining the importance of each of these issues using risk assessment; completing suitably detailed reports; and compiling sufficient background material to put these reports into context.

Sections of the Australian National ESD Framework *How to Guide*[71] outline in detail how to complete each of these major elements by providing detailed descriptions of the methodology, examples of outputs from case studies and, where necessary, the theoretical foundations to the methods used.

Further information regarding the SBPMF export approval under the EPBC Act is provided in Section 16.1.

A high level summary of the process required to complete an ESD report is provided in Figure 15.2.

[69] Standards Australia website-
http://www.standards.org.au/Pages/default.aspx
[70] These elements are equivalent to completing a standard risk analysis process.
[71] http://www.fisheries-esd.com/a/pdf/WildCaptureFisheries_V1_01.pdf

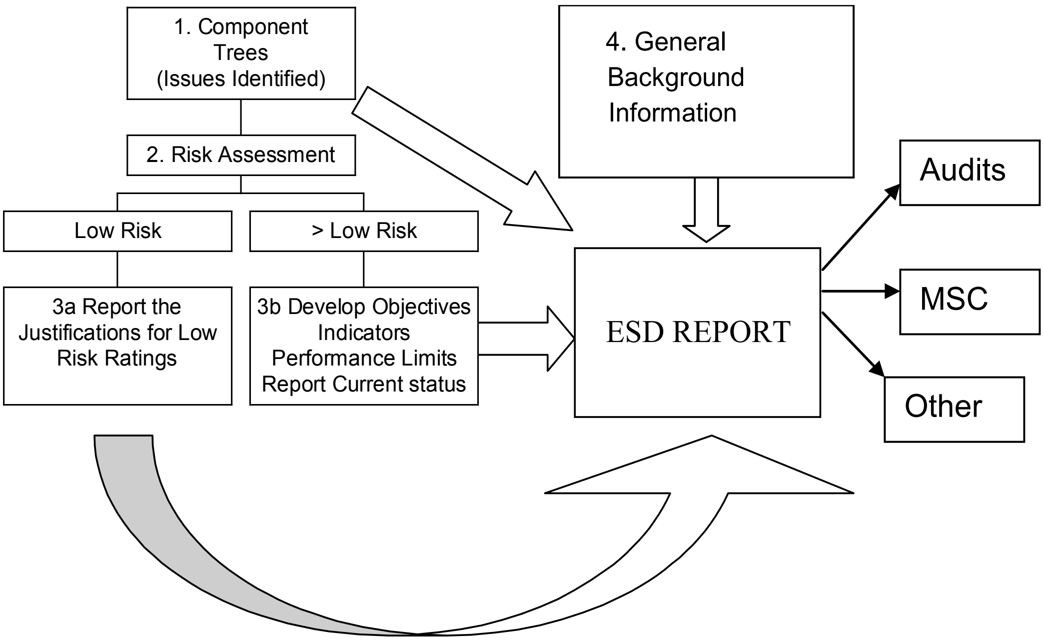

Figure 15.2. Process required to complete an ESD report.

15.3.6.1.2 Ecosystem Based Fisheries Management

Following the success of the ESD framework for individual fisheries, a practical, risk based framework for use with regional level management of marine resources was developed by the Department to enable cross/multiple fishery management at the bioregional level to fully implement Ecosystem Based Fisheries Management (EBFM). This was designed to replace the previous, disjointed fishery level, planning systems, with a single, coordinated risk based system to generate efficiencies for the use of Departmental (government) resources. The simple set of steps developed has enabled adoption of a fully regional, 'ecosystem based' approach in WA without material increases in funding.

The Department has met best practice international sustainability benchmarks by being one of the first fisheries agencies in the world to introduce EBFM across all aquatic resources. EBFM recognises that ecosystems work at a regional level, and fits better with the global shift towards holistic, regional-based natural resource management.

EBFM takes into account the impacts of all aquatic resource use on species targeted by fishing, as well as non-target species and the environment – all of which are regarded as ecological assets – and the social and economic impacts of the resource use. It recognises that while fishing activity affects ecosystems, providing the impacts are risk-assessed and managed, fishing can also create social and economic benefits.

Annual EBFM risk assessment outcomes for each bioregion in Western Australia are published in the annual *Status Reports of the Fisheries and Aquatic Resources of Western Australia* (State of the Fisheries)[72].

[72]http://www.fish.wa.gov.au/About-Us/Publications/Pages/State-of-the-Fisheries-report.aspx

EBFM is based on using the best global standard for risk assessment and risk management. The levels of risk are used as a key input to the Department's Risk Register which, combined with the assessment of the economic and social values and risks associated with these assets, is an integral component of the annual planning cycle for assigning activity priorities (e.g. management, research, compliance, education, etc.) across each Bioregion.

A summary of the Department's risk-based planning annual cycle that is delivering EBFM in the long term is provided in Figure 15.3.

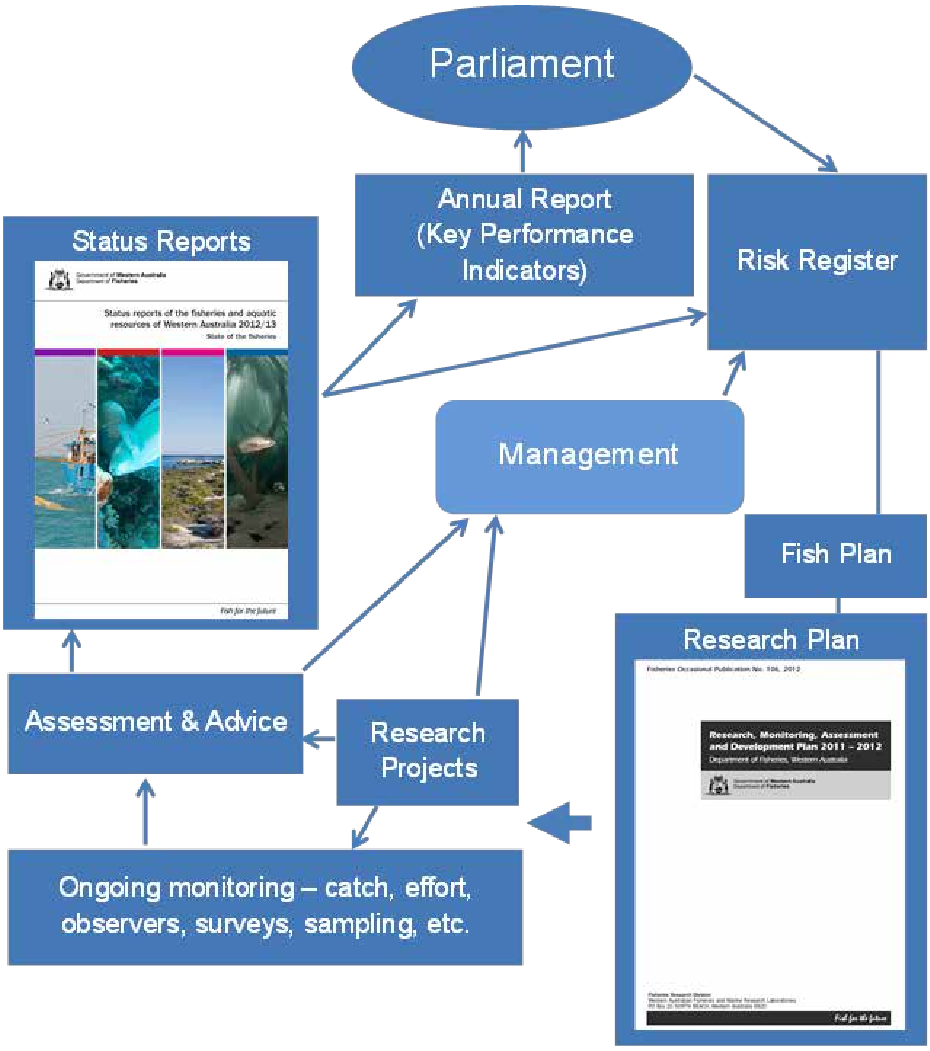

Figure 15.3. An outline of the risk based planning cycle used for determining Departmental priorities and activities.

The Risk Register informs Fish Plan (current version 2011/12 – 2015/16) which sets out baseline management activities over a five year period. The extent to which the Department is effective in achieving its Agency Level Outcome is measured by the Department's Key Performance Indicators (KPIs) which are published in the Department's *Annual Report* to Parliament. Fish Plan assists the Department in achieving its desired Agency Level Outcome by providing a planned and structured approach to management of capture fishery resources (assets) including review of management arrangements for fish stocks, assessment and monitoring of fish stocks and compliance planning. This process provides the Department with a basis or framework for allocating resources to individual capture fishery assets and to provide greater certainty to peak bodies and industry participants on the timelines for management reviews etc.

Fish Plan in turn informs the Research, Monitoring, Assessment and Development Plan 2011/12 – 2015/16[73] (RMAD Plan) which sets out associated research projects over a five year period. The research projects and activities address ongoing monitoring requirements, as well as generating assessments and advice, which then drive reporting and management activities. The SBPMF is included in the RMAD and discussed more in Section 12.4.

EBFM has been applied to the ecological assets recognised in each of the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) (Version 4, 2006)[74] regions within each bioregion in Western Australia. Those ecological assets include:

- Ecosystem structure and biodiversity (on a meso-scale basis);
- Captured fish species;
- Protected species (direct impact – capture or interaction);
- Benthic habitats; and
- External impacts.

The SBPMF has been assessed[75] pursuant to the EBFM framework and strategies, partial strategies and measures have been implemented based on risk assessment. The results of the risk assessment for the SBPMF are published in the *Status Reports of the Fisheries and Aquatic Resources of Western Australia* (State of the Fisheries)[76].

It is important to note that the levels of knowledge needed for each of the impacts only need to be appropriate to the risk and the level of precaution adopted by management. Implementing EBFM does not, therefore, automatically generate the need to collect more ecological, social or economic data or require the development of complex 'ecosystem' models, it only requires the consideration of each of these elements to determine which (if any) required direct management to achieve acceptable performance.

Further detailed information on the EBFM policy can be found at:

- Fisheries Research Report 194 - *Conceptual models for Ecosystem Based Fisheries Management (EBFM) in Western Australia*. Department of Fisheries (2009)[77]; and,

[73] http://www.fish.wa.gov.au/Documents/occasional_publications/fop106.pdf
[74] http://www.environment.gov.au/resource/guide-integrated-marine-and-coastal-regionalisation-australia-version-40-june-2006-imcra
[75] ESD Report can be found here: http://www.fish.wa.gov.au/Documents/esd_reports/esd003.pdf
[76] http://www.fish.wa.gov.au/About-Us/Publications/Pages/State-of-the-Fisheries-report.aspx
[77] http://www.fish.wa.gov.au/Documents/research_reports/frr194.pdf

- Fletcher, W.J., Shaw, J., Metcalf, S.J. and Gaughan, D.J. (2010) An Ecosystem Based Fisheries Management framework: the efficient, regional-level planning tool for management agencies. *Marine Policy 34* (2010) 1226-1238[78].

As part of ensuring it was implementing EBFM effectively, the Department undertook a study to:

- Test the robustness of statistical procedures to identify impacts of multi-sector fishing on community composition using existing fishery data.
- Assess the level of change in community composition in each bioregion of WA during the previous 30 years.
- Identify key data to which ecosystem structure and management strategies are most sensitive and which should be collected in the future.
- Identify critical changes in exploitation and/or environment that would impact marine systems markedly.
- Identify areas where more detailed research and/or monitoring are needed.

The results from the study are published in Fisheries Research Report Number 215 (2011) *Development of an ecosystem management approach to the monitoring and management of Western Australian Fisheries*[79] and have influenced the monitoring and reporting of the management of the SBPMF against the principles of EBFM.

A description of how the general legislation integrates with the fisheries policy framework to achieve the long term sustainability objectives of EBFM is published in Fisheries Occasional paper 79 (2010) *A Sea Change for Aquatic Sustainability – Meeting the Challenge of Fish Resource and Aquatic Sustainability in the 21st Century.*[80]

15.3.6.1.3 Harvest Strategy Policy

A broad, high level *Harvest Strategy Policy* has been developed (DoF in press). The policy articulates all performance levels and the management actions designed to achieve agreed objectives. These objectives articulate what is to be achieved, and why, both for the resource and the relevant fisheries. This policy is aimed at ensuring target species' sustainability in the long term.

Where a harvest strategy is required, the core elements are:

- Articulation, at an operational level, of what is to be achieved, and why, both for the resource and the relevant fisheries (operational objectives);
- Determination of performance indicators to be used to measure performance against operational objectives;

[78] http://ac.els-cdn.com/S0308597X10000849/1-s2.0-S0308597X10000849-main.pdf?_tid=bf282dea-7c03-11e3-b1dc-00000aab0f01&acdnat=1389584308_7fe8a2af9082316b5a6cb7c4ea86af47
[79] http://www.fish.wa.gov.au/Documents/research_reports/frr215.pdf
[80] http://www.fish.wa.gov.au/Documents/occasional_publications/fop079.pdf.

- Based on achieving acceptable risk levels, establishment of appropriate reference points/levels for each performance indicator;
- The selection of:
    1. the most appropriate Harvesting Approach (e.g. constant harvest/exploitation, constant escapement/stock size, constant catch);
    2. the associated Harvest Control Rules which articulate pre-defined, specific management actions based on current status designed to maintain target levels and avoid breaching thresholds or limits; and
    3. the Acceptable Catch/Effort Tolerance which is used to evaluate the effectiveness of the management actions in delivering the specific catch/effort as determined by the Harvest Control Rules and IFM allocation decisions;
- Monitoring and assessment procedures for the collection and analysis of all the data needed to underpin the harvest strategy and determine stock status and fishery performance against operational objectives; and
- The timetable and frequency for review of the harvest strategy elements.

The SBPMF is subject to an industry-agreed and published harvest strategy under this framework.

15.3.6.2 Aquatic Biodiversity Policy

The Department is currently drafting an overarching *Aquatic Biodiversity Policy* that describes the Department's role, responsibilities and jurisdiction in the management of the State's aquatic biodiversity assets, and the key principles applicable in this management area. By focusing on five key asset areas (retained fish species, non-retained fish species, ETP species, fish habitats and ecosystem processes) and seven key threats imposed upon these asset areas (habitat loss, invasive pests, unsustainable harvest, external drivers, lack of information, governance and cumulative impacts), a practical framework for the management of aquatic biodiversity will be described.

15.4 Incentives for Sustainable Fishing

WA fisheries legislation, including that governing the SBPMF, has policies and principles that provide social and economic incentives to fishers to fish sustainably and encourage a sense of stewardship towards the resource. These incentives include policies that provide stability and / or security for fishers by:

- Providing strategic or statutory management planning to give certainty about rules and goals of management; for example, the Department has a general practice of holding regular (often annual) management meetings with fishery licencees to discuss fishery research, management, compliance and other fishery-specific issues as they arise. These meetings are attended by Department officers, WAFIC and licence holders and are recognised by licence holders as a mechanism for receiving the most up-to-date scientific advice on the status of the fishery, facilitating information exchange and discussing new and ongoing management issues;

- Providing for the clarification of roles, rights and responsibilities of the various stakeholders; for example, WAFIC is recognised by the WA Government as the key source of coordinated industry advice for the commercial fishing sector. WAFIC's responsibilities include coordinating Government funding for industry representation and taking a leadership role for matters that involve or impact on a number of fisheries or are of an industry-wide or generic nature;
- Providing for a participatory approach to management, research and other relevant processes. The SBPMF has well-defined management processes, which are enshrined in legislation, policy and practice; for example, the recently-published *Harvest Strategy 2014 – 2019* and the *Bycatch Action Plan 2014 – 2019* were developed following multiple internal workshops, correspondence and face-to-face consultation with the licensees;
- Providing rights of exclusion (limited entry); the number of managed fishery licences (MFLs) in the SBPMF is limited to 18. The 18 MFLs in the SBPMF are owned by six different entities. These access rights engender a sense of ownership of the resource and a commitment to long-term sustainability to protect their investment;
- Providing industry the opportunity to optimise economic returns within a sustainable fishery framework. Fishing effort controls work towards maximum economic yield, which evens out inter-annual and intra-annual catch variations, thereby making the fisheries more economically-stable and viable. This provides industry with a more-secure investment environment (e.g. when borrowing from financial institutions); and
- Including features that encourage collective action while allowing for individual choice, such that individual decisions are steered towards the public good; for example, non-statutory rolling spatial closures occur throughout the fishing season to contain and direct overall fleet effort and protect small (pre-spawning) prawns. These closures occur through a co-operative arrangement[81] with the licensees, with skippers voluntarily complying with boundaries in order to maximise economic returns.

There is high acceptance by the commercial fishing sector that well-managed and sustainable fisheries result in positive social and economic outcomes for individual fishers, the sector as a whole and the broader community. This acceptance also drives sustainable and compliant fishing behaviour. Positive social and economic incentives that drive sustainable fishing practices in the commercial fishing industry include:

- An opportunity to support regional communities through the provision of employment and demand for services and supplies;

[81] Note, however, if VMS or compliance monitoring indicated that there were repeated incursions into in-season voluntary closed areas, the Director General may close specific areas to fishing pursuant to clause 10 of the Management Plan.

- The operation of commercially-viable fisheries that result in both profit and lifestyle benefits; and
- A general understanding by the WA community that the commercial fishing industry acts with integrity and respect.

15.4.1 Review Process

There are no incentives for the fishers to fish unsustainably in the SBPMF. Commercial fishers understand that management measures are in place to minimise fishery impacts in order to ensure the stock and environment continue to be managed sustainably and thus, fished profitably. Research, management and compliance monitor adherence to sustainable fishing arrangements and make adjustments to them if necessary.

16. Fishery-Specific Management System

This section focuses on the management system directly applied to the SBPMF and includes:

- Fishery-specific management objectives;
- The decision-making process used in the Fishery;
- The compliance and enforcement system and its implementation;
- Research planning and monitoring for the SBPMF; and
- An evaluation of the performance of the management system in meeting the fishery's objectives.

16.1 Fishery-Specific Objectives

The SBPMF has clear, specific objectives designed to achieve the outcomes expressed by MSC's Principles 1 and 2.

Explicit, well-defined and measurable short- and long-term specific management objectives have been applied to the management of prawn resources and associated ecosystem impacts of commercial fishing for prawns in Shark Bay, and the fishery-specific management system contains a range of strategies that are monitored to ensure these objectives are being met in the long term. The management objectives are contained in the *SBPMF Harvest Strategy* (DoF 2014a), which is publically-available on the Department's website.

The annual performance of the fishery is measured by undertaking a post-season evaluation of each performance indicators against the reference levels set out in the harvest strategy. Along with the long-term management objectives, as described below, there is a short-term operational objective to maintain annual performance above the threshold reference level (and as close to the target reference level as possible) for each component of the fishery.

16.1.1 Target Species Stock (P1) Objectives

The SBPMF has a long-term management objective, which is demonstrably consistent with achieving outcomes expressed by MSC Principle 1: *to maintain spawning stock biomass of* *each target species (brown tiger and western king prawns) at a level where the main factor affecting recruitment is the environment.*

There is strong evidence to suggest that this management objective is being met in the long-term (see Section 6.1). As part of the SBPMF harvest strategy, a review of the season arrangements and monitoring system is triggered if the annual performance measure (spawning stock index) is below the target level. This ensures that potential issues are recognised and addressed prior to the following fishing season to ensure the long term management objective relevant to MSC Principle 1 continues to be met.

16.1.2 Ecosystem (P2) Objectives

The long term management objectives for the SBPMF which are demonstrably consistent with achieving the outcomes expressed by MSC Principle 2 are:

- *To maintain spawning stock biomass of each retained species at a level where the main factor affecting recruitment is the environment.*
- *To ensure fishery impacts do not result in serious or irreversible harm to bycatch species populations*
- *To ensure fishery impacts do not result in serious or irreversible harm to ETP species populations*
- *To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function; and*
- *To ensure the effects of fishing do not result in serious or irreversible harm to ecosystem processes.*

There is strong evidence to suggest that each of the long term management objectives listed above are being met in the long term. More detailed information about the fishery's impacts, management of those impacts, information and monitoring and risk assessment is provided in the MSC Principle 2 section of this document in Sections 9 – 14.

16.1.3 Economic Management Objective

The economic objective for the SBPMF is:

To provide industry the opportunity to optimise the economic returns generated by the SBPMF within a sustainable fishery framework.

There is strong evidence to suggest that the economic management objective to provide industry with the opportunity to optimise the economic returns generated by the SBPMF within a sustainable fishery framework is being met over the long term.

By implementing an effective harvesting approach that achieves ecosystem based fisheries management outcomes, the sustainable exploitation of prawn resources in Shark Bay and management of ecosystem impacts results in positive economic consequences for both key stakeholders (e.g. the licensees) and indirect stakeholders (e.g. the local communities within the Shire of Shark Bay, the restaurants and retail sector in WA, consumers and the wider Western Australian community).

The Department has implemented a flexible management framework for the SBPMF that is not overly regulated and which provides the ability for the fishery to achieve optimum economic efficiency. The Department is prepared to consider proposals to improve economic efficiency that do not adversely affect meeting the ecological objectives. The co-operative framework allows the Department and the licensees to collaborate the timing and extent of in-season openings and closing of areas (other than those implemented for sustainability purposes) to optimise catch rates, as well as prawn size and condition.

The licensee and skippers continue to work with the Department under the co-operative management framework and there are no indications that the licensees are dissatisfied with the current arrangements.

While not directly used as a measure of performance against the economic management objective, there are ways that the economic efficiency of the fishery can be measured. This includes the evaluation of:

- commercial catch rates;
- target prawn price per kg;
- gross annual returns; and
- employment levels.

These data are reported annually in *State of the Fisheries* and the long term trend for these data indicates that the management framework is providing the fishery with the opportunity to operate efficiently and viably within a sustainable fishery framework.

16.2 Decision-Making Processes

The fishery specific management system includes effective decision-making processes that result in measures and strategies to achieve the objectives and has an appropriate approach to actual disputes in the fishery under assessment.

16.2.1 Established Processes

There are established decision making processes in the SBPMF that are fully understood by stakeholders and underpinned by explicit and transparent consultation. The fishery specific decision making process for the SBPMF consists of three components:

- annual and in-season consultation and decision-making that may result in measures to meet short term (operational) objectives (driven by the control rules contained in the current *SBPMF Harvest Strategy*);
- in-season consultation and decision-making that is designed to meet the economic objective to provide the fishery with the opportunity to optimise economic returns (cooperative framework); and

- longer-term consultation and decision-making that results in new measures and strategies to achieve the long-term fishery-specific management objectives (i.e. changes to the management framework).

16.2.1.1 Harvest Strategy Consultation and Decision-Making

An overview of the annual and in-season consultation and decision-making processes to achieve short term operational objectives under the current management framework are described below and are outlined in the *SBPMF Harvest Strategy*. In addition, the harvest strategy control rules guide the management response in the event that the operational objective (i.e. to maintain the performance indicator above the threshold reference level) is not met. In these cases, the decision-making processes may result in measures to achieve fishery-specific objectives.

16.2.1.1.1 Annual Processes

Post-season report / Pre-season briefing to the licensees

The Department's Research staff undertake a post season evaluation and develop a written report for all licensees (see Appendix I). This report, together with a research summary presentation is provided at the annual management meeting (AMM) held in December when the season is closed. The report includes the results from the recruitment and spawning surveys which inform the stock assessment, seasonal catch and effort data and an assessment against the performance measures for the fishery (including bycatch and ETP species interactions). A management and compliance update is also provided at the AMM.

It is at this stage that any issues arising from the annual evaluation of the operational objectives in the Harvest Strategy are discussed. These discussions can include preliminary investigation of reasons why target reference levels were not met (if this was the case). Such reasons can be stock related or effort related and may include environmental influences, low effort due to changes in fishing behaviour, market forces, etc. If sustainability is considered to be at risk, changes to fishing arrangements are discussed with the licensee and implemented for the following fishing season (e.g. a delay to the commencement of fishing to reduce effort).

Consultation between the Department and licensees also occurs at this stage to decide on the statutory season opening date (usually after the full moon in March) and closing date, the in-season survey schedule and the extent of moon closures. The next season's arrangements are finalised by formal signing off from the Industry Association representative.

Advice to management and the Director General regarding the opening / closing of the fishing season

Following consultation with licensees, a written briefing is provided to the Director General recommending the statutory opening and closing dates for the coming fishing season. The

Director General (as the Chief Executive Officer[82]) determines the opening and closing dates for the fishery by making a Determination pursuant to clause 10 of the Management Plan, a copy of which is provided to licensees in writing. The notice is then made publically available on the State Law Publisher's website[83]. This notice statutorily caps the overall fishing effort (fishing days) for the season at an acceptable level (i.e. a maximum of 175 fishing days). Clause 10 of the Management Plan provides the power for the Director General to statutorily set the annual fishing season without the need for an amendment to the Management Plan. The Director General also approves the boundaries of the management areas in the Determination.

Pre-season skippers' briefing

The Department's Research staff develop an information package (see Appendix J) and provide a briefing to the fleet skippers for the coming season, usually in March. Skippers are also provided with a presentation of the outcomes of the previous fishing season and compliance requirements are discussed. The skippers' briefing provides a feedback loop to the Department on the proposed seasonal arrangements for the coming season.

16.2.1.1.2 In season Processes

The key in-season decision-making process is undertaken pursuant to the control rules designed to achieve the in-season operational objectives in the Harvest Strategy (i.e. to achieve above the threshold reference levels).

Consultation is undertaken by the Department's Research staff directly with licensees and the SBPTOA around the timing and extent of fishing in the management areas. In-season decision-making is informed by a combination of the recruitment and spawning stock survey regime (catch rates and prawn size composition), knowledge of prawn biology (spawning and movement patterns of brown tiger and western king prawns) and daily monitoring of commercial catch rates. The resulting decisions are communicated to skippers, as well as to the Department's management and compliance (including VMS) staff.

The annual in-season fishing arrangements designed to achieve the in-season operational objectives in the Harvest Strategy are implemented on a non-statutory basis. However they are monitored by VMS and, if it is identified that an area of the fishery may need to be closed statutorily, this can be achieved quickly (within 24 hours) via a notice pursuant to clause 10 of the Management Plan. There has been no evidence arising from compliance monitoring that has required in-season closures to be legislated.

Cooperative Management Framework

Once requirements have been addressed in line with the Harvest Strategy, an in-season cooperative consultation and decision-making process is used to provide licensees with the

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[82] Note that annual notices made pursuant to clause 10 of the Management Plan are signed by the Director General as 'Chief Executive Officer' transitioned from the 'Executive Director' pursuant to section 242 of the *Machinery of Government (Miscellaneous Amendments) Act 2006*

[83] http://www.slp.wa.gov.au/statutes/subsiduary.nsf/0/D33E12BC49B263F448257D3C00170ECE/$file/shark+bay+prawn+-+determination+no.+3+of+2014+-+22.08.14.pdf

opportunity to optimise economic returns from the target prawn species within a sustainable fishing framework.

Decisions around optimising economic returns are informed by prawn size composition information arising from both Department and industry surveys and real-time monitoring of daily commercial catch data. The consultation and decision-making process that is aimed at optimising economic returns is undertaken between the Department's Research staff and the Shark Bay Prawn Trawler Operators' Association (SBPTOA) and is communicated to fleet skippers (through VMS messaging) compliance and VMS staff.

The fishing arrangements (i.e. timing and extent of fishing) resulting from the cooperative framework are non-statutory because they are not in place for stock sustainability reasons, however; they are monitored by VMS staff.

As an example of the flexibility and complexity of the cooperative decision-making framework, ten separate closures and openings of all or parts of the management areas were implemented during the 2013 season. These decisions were made according to the harvest strategy decision rules and based on in-season spawning stock survey results (CPUE and prawn size composition) and real-time fleet CPUE and catches (which can be monitored daily). In-season closures or reduced fishing areas may occur when the threshold is reached, but may also be influenced by prawn biology (spawning and movement patterns) and prawn size (both sustainability and economic indicators).

Following the re-opening of management areas or parts of management areas later in the fishing season, the fleet CPUE is monitored daily to ensure fishing ceases before the limit reference point is reached (or the season finishes).

A description of the cooperative framework is provided in a report entitled *Co-management in the Exmouth Gulf Prawn Fishery with comparison to the Shark Bay Prawn Fishery*[84] which was published as part of FAO Fisheries Technical Paper 504 (2008) *Case Studies in Fisheries Self-governance.*[85]

16.2.1.2 Management System

There is an established fishery-specific management system decision-making process in place that results in measures and strategies to ensure the fishery-specific management objectives continue to be met in the longer term.

The fishery specific management system decision-making process is triggered primarily as a result of analysing longer term patterns or trends resulting from annual monitoring of the success of the existing management regime. Variations in the operating environment caused by other factors (e.g. environmental conditions, market conditions, fishing behaviour, conflicts with other marine users, determination of native title, marine planning etc.) can also trigger investigation and discussion that may lead to a change to the management system.

[84] ftp://ftp.fao.org/docrep/fao/010/a1497e/a1497e21.pdf
[85] http://www.fao.org/docrep/010/a1497e/a1497e00.htm

Changes to the management system as a result of implementing new measures and strategies tend to be more permanent (i.e. lasting for more than one season) and are often implemented in legislation. Depending on the issue and stakeholders affected consultation can occur through the following mechanisms-

- directly in writing;
- at licensee meetings and skipper's briefings;
- establishment of a tasked working group;
- external/expert workshops (e.g. ecological risk assessments);
- internal workshops (e.g. harvest strategy development, ecological and compliance risk assessments).

These forums are used to work through options for addressing emerging issues, consider both key and other interested stakeholder advice and take into account the broader implications of those options. Following the consultation process, any new proposed management measures and strategies that require changes to legislation or publication must be provided to the statutory decision maker (usually the Director General or the Minister for Fisheries). The Department must set out evidence of consultation and the results of the decision-making process during this process.

Recent examples of the fishery specific management system decision-making process that resulted in new strategies include the development of the current Harvest Strategy and BAP for the SBPMF, both of which were developed following multiple internal workshops and face -to- face consultation with Industry.

Figure 16.1 shows the consultation and decision-making process as it relates to the SBPMF management system.

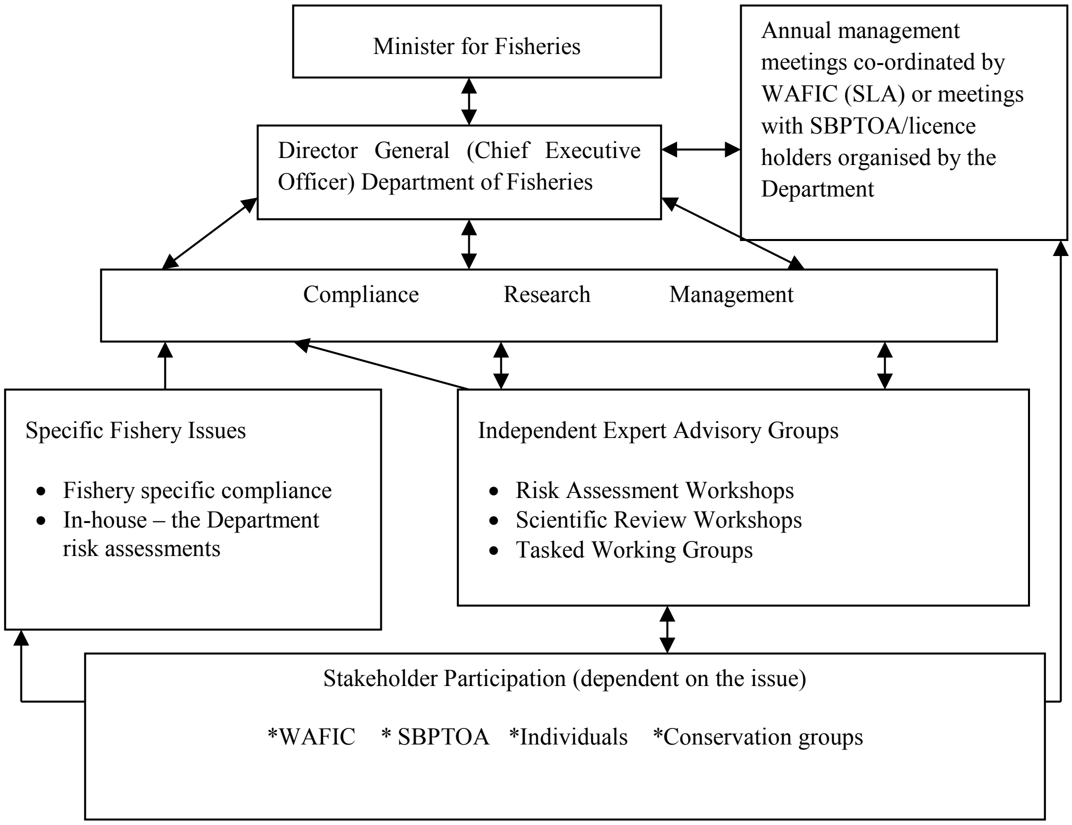

Figure 16.1. Fishery specific consultation and decision making framework for the SBPMF management system

16.2.2 Responsiveness of Decision-Making Processes

The transparent decision making processes allows for a timely response in instances where management changes need to be applied to alleviate unacceptable risks to stocks. The timing of provision of scientific advice on the status of prawn stocks is immediate given the real time monitoring regime.

The annual and in-season control rules contained in the current Harvest Strategy are applied consistently and are informed by both real-time monitoring of fishery-independent and dependent catch rates (for decisions implemented in-season) and annual evaluation (for decisions implemented in the following fishing season). During the season, the real time management system enables a reactive process between Industry and the Department that accommodates the high spatial and temporal variability in prawn abundance from year to year. Management of this fishery has a history of reacting appropriately to threats to sustainability by constantly changing spatial and temporal controls on effort (i.e. delay the commencement of fishing to protect small size prawns).

The research surveys and application of the decision rules to the survey results are explicitly documented in the season arrangements (see Appendix 2 of DoF 2014a). For example, in April, recruitment surveys to determine prawn abundance and size on the Carnarvon-Peron line are conducted with a commitment to having the survey results analysed within 2 days of survey completion. Application of decision rules to survey results then determine the extent of area of Carnarvon-Peron Line to open and for what period.

More permanent changes to the management system tend to result from internal and external reviews of the management/monitoring/stock assessment/compliance regime, an unacceptable change in risk level detected by an updated risk assessment, results of research, requests from licensees to optimise efficiency, fishery certification requirements etc. (see Section 16.5).

The urgency of consultation and decision-making processes relevant to more permanent changes to the management system is based on risk and tend to be implemented by way of changes to legislative instruments. For example, actions to close areas of the fishery (or the entire fishery), reduce fishing days/hours (temporal effort management) or change management area boundaries (spatial effort management) can be implemented almost immediately by the Director General pursuant to clause 10 of the Management Plan.

Changes to other existing arrangements (such as headrope limits and gear specifications) can also be applied very quickly (within days or weeks), depending on urgency. Once a decision is made, the approval and implementation of such changes is undertaken by amendment to the relevant legislative instrument in a transparent and accountable way and in line with statutory requirements where necessary.

For example, the Minister for Fisheries must consult with the licensees before approving an amendment to the Management Plan (section 65 of the FRMA). While the Director General can impose, delete or vary an MFL condition, this decision is subject to a formal appeals process (section 147 of the FRMA). There are no statutory provisions as to the consultation requirements relating to section 7 instruments of exemption or section 43 orders (noting that section 43 orders can be disallowed in State Parliament). However; in the absence of any statute specifying consultative procedures, the Department has regard for common law principles to afford natural justice to the licensees. As such, the Department will formally consult with licensees when making changes to management arrangements via an instrument of exemption or an order.

The outcomes of the decision-making process and implementation of statutory arrangements is always formally communicated to licensees in writing and available publically on the State Law Publishers website.

The decision-making process also allows for the consideration of the wider implications of decisions, particularly where proposed longer term management actions may result in adverse unintended consequences to other management components. It is important to note that all ecological objectives must be met prior to considering responses to achieve economic objectives. For example, the move to a quad-rigged net configuration by 2007 improved fishing efficiency for commercial purposes, however; a maximum headrope length for the fishery was imposed for sustainability purposes.

16.2.3 Use of Precautionary Approach

The decision-making processes for the SBPMF described above uses the precautionary approach and are based on the best available information.

The established decision-making processes are highly responsive to the most recent data obtained through regular monitoring and assessment. The SBPMF is managed based on a constant escapement harvesting approach. The management activities related to this approach has been developed over time based on a comprehensive understanding of the biology of brown tiger and western king prawns in Shark Bay, together with a long-term annual and in-season monitoring and assessment regime. Based on this information, the decision-making processes have led to the implementation of a sustainable management framework over time. Furthermore, the reference levels are considered appropriate as they are demonstrably achieving the fishery specific management objectives.

The control rules incorporate a precautionary approach to the decision-making process by requiring a review when the target reference level is not met. This ensures that any warning signs are recognised and investigated/addressed in their early stages. The frequency of evaluation (both annually and in-season) and review means that management action to investigate and, where required, alleviate adverse impacts on stocks is always taken before the performance indicators reach the limit reference level.

The commercial catch rates of brown tiger and western king prawns for the 2014 fishing season are closely monitored against the catch prediction arising from the recruitment surveys. The brown tiger prawn spawning stock surveys undertaken in August and September 2014 and assessment of commercial catch rates of western king prawns will provide the most up to date information as to the current status of both stocks.

Sources of uncertainty within the data and data gaps have been identified, particularly where they relate to obtaining a more quantified and up-to-date assessment of the risk posed by the fishery to bycatch and ETP species' populations. This will be addressed in the current Bycatch Action Plan and may result in management actions, should the existing management system prove to be posing an unacceptable risk.

The decision-making processes have resulted in the existing management regime being set at a precautionary level until further research on environmental changes and risk to bycatch and ETP species' populations provides further information.

16.2.4 Accountability and Transparency

16.2.4.1 Key Stakeholders

Formal and regular reporting to key stakeholders relating to information on fishery performance and management actions and how the management system responded to findings and relevant recommendations emerging from research, monitoring, evaluation and review activity is primarily provided at the annual meeting between the Department and the licensees. This reporting consists of presentations and the provision of the annual season report for the fishery.

Key stakeholders are also formally briefed on the outcomes of research prior to publication. Such meetings and briefings are also used as a forum to discuss relevant recommendations and proposed management actions. Recommendations and final decisions that result in new measures or strategies are often published by the Department as fisheries management papers, research reports or in State of the Fisheries. For example, the current harvest strategy and bycatch action plan for the SBPMF was developed directly in consultation with licensees (DoF 2014a, 2014b). These strategies are published and available on the Department's website.

16.2.4.2 Other Interested Stakeholders

There are several other interested stakeholders relevant to the SBPMF as discussed in *PI 3.1.2 Consultation, Roles and Responsibilities*.

Formal/direct reporting to other interested stakeholders to provide information on the performance and management of the SBPMF is undertaken on a case-by-case basis. For example, formal/direct reporting is provided to other interested stakeholders that are involved in consultation and decision-making processes such as tasked working groups, external risk assessments or external reviews of the SBPMF management system.

Notwithstanding this, comprehensive information on fishery performance and management actions, and how the management system responded to findings and relevant recommendations emerging from research, monitoring, evaluation and review activity is compiled on a regular basis and publically available in documents published on the Department's website including:

- *State of the Fisheries*[86];
- SBPMF Management Plan[87] (available on the State Law Publisher's website via a link from the Department's website);
- CEO notices regarding opening and closing the fishery[88];
- *SBPMF Harvest Strategy 2014 – 2019;*
- *Research, Monitoring, Assessment and Development Plan 2011-12*[89], which provides information on all completed and proposed research relating to the SBPMF and the associated ecosystem;
- *SBPMF Bycatch Action Plan 2014 – 2019*;
- Outcomes of management decisions, research and studies (e.g. Fisheries Management Papers, Fisheries Research Reports and Occasional Papers)[90].

[86] http://www.fish.wa.gov.au/Documents/sofar/status_reports_of_the_fisheries_2012-13_gascoyne_coast_bioregion.pdf
[87] http://www.slp.wa.gov.au/statutes/subsidiary.nsf/FisheriesT?openpage
[88] http://www.slp.wa.gov.au/statutes/subsidiary.nsf/Fisheriesexec?openpage
[89] http://www.fish.wa.gov.au/Documents/occasional_publications/fop106.pdf
[90] http://www.fish.wa.gov.au/Documents/research_reports/frr160.pdf

Other mediums for communication with other interested stakeholders can include media releases[91] and the Shark Bay Prawn Producers website[92] also provides information targeted at consumers.

16.2.5 Approach to Disputes

The SBPMF consultation and decision making processes proactively avoid legal disputes through the inclusion of stakeholders during consultation on key management matters. This allows for all impacts of proposed management actions to be considered, conflicts to be addressed and negotiation and compromise to be reached. In addition the close collaboration and regular communication between the Department, the SBPTOA and skippers has resulted in a mutual and in-depth understanding of industry operations and the fishery management system.

As described in Section 15.1, there are well established mechanisms for administrative and legal appeals of decisions which are prescribed in Part 14 of the FRMA. Should they arise, disputes regarding statutory validity are dealt with by the Courts. These decisions are publically available. Examples of these cases include:

Shine Fisheries Pty Ltd vs Minister for Fisheries (2002) at:

> http://decisions.justice.wa.gov.au/supreme/supdcsn.nsf/judgment.xsp?documentId=89CBEA251EC082BB48256B5A000C1635&action=openDocument.
>
> This judgement has been put into effect in practice, by allowing the nominated operator of a vessel to be changed.

Edgemere Pty Ltd vs Minister for Fisheries & Anor (1997) at:

> http://decisions.justice.wa.gov.au/supreme/supdcsn.nsf/judgment.xsp?documentId=E2B71DECD36F4C1B48256497004CD3F9&action=openDocument.

The decisions of the SAT and the Courts are binding on the Department (for details of decisions see http://decisions.justice.wa.gov.au/SAT/SATdcsn.nsf). All SAT decisions must be carried out by the Department (section 29(5), page 20 of the *State Administrative Tribunal Act 2004*[93]).

16.3 Compliance and Enforcement

In order to optimally utilise compliance resources, enforcement effort is designed to maximise the potential for fishers to voluntarily comply with fishery rules, while at the same time provide a reasonable threat of detection, successful prosecution and significant penalties for those who do not comply. This is achieved through a range of strategies, including effective monitoring and surveillance, appropriately trained staff, suitable deterrents in the forms of fines and administrative penalties and targeted educative campaigns.

[91] http://www.fish.wa.gov.au/About-Us/Media-releases/Pages/Prawn-fisheries-seek-sustainability-certification.aspx
[92] http://sharkbayprawns.com/
[93] State Law Publishers website- http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_918_homepage.html

The Department's Regional Services Division (RSD) delivers the Department's compliance and educational services, with the support of the Communications and Education Branch, and the RSD also provides licensing facilities at the regional offices, as well as online renewal and payment. There is approximately 170 RSD staff across the State, spread throughout regional and district offices. Regional operational areas are supported by the Regional Services Branch's Perth-based Central Support Services and Strategic Policy sections.

Key compliance programs in place throughout the State include:

- Recreational fishing;
- Commercial fishing;
- Biosecurity;
- Pearling and Aquaculture;
- Marine parks (State and Commonwealth);
- Fish Habitat Protection Areas (FHPAs);
- Marine Safety; and
- Organised, unlicensed fisheries crime.

Compliance and community education services in the Gascoyne Coast Bioregion (GCB), which includes Shark Bay and Exmouth Gulf, are delivered by Fisheries and Marine Officers (FMOs), Community Education Officers and associated management and administrative support staff based at the District Offices in Denham, Carnarvon and Exmouth. During 2012/13, the three district offices supported a total of ten FMO positions allocated to deliver services to several client groups including commercial and recreational fisheries, marine parks, pearling and aquaculture operations and FHPAs. Most Fisheries Officers are permanently located in the main population centres with access to appropriate platforms to allow them to undertake patrols up and down the entire WA coastline. A small number of Officers are also specifically employed to undertake mobile patrols to conduct 'surprise' inspections, an activity that is particularly important in smaller towns where fishers can quite easily learn the movement patterns of local Officers (Green and McKinley 2009).

A significant aspect of the region's compliance work is the provision of compliance services to the State's Marine Parks. The GCB has two of WA's most iconic and significant Marine Parks, Ningaloo Marine Park (and the associated Commonwealth Ningaloo Marine Park) and the Shark Bay Marine Park and associated World Heritage Area. These two Marine Parks occupy just over 70 % of the GCB. In partnership with the Department of Parks and Wildlife (DPaW), FMOs monitor and deliver compliance and education programs covering some 30 Sanctuary Zones, Marine Managed Areas and other protected areas.

FMOs undertake regular land, air and sea patrols using a compliance delivery model supported by a risk assessment process and associated operational planning framework. Throughout the bioregion, they employ specially equipped four-wheel-drive vehicles, quad bikes and small towable vessels. They also make use of sophisticated surveillance, mapping and GPS equipment to assist in evidence gathering. This includes high-powered telescopes and photographic mapping technology. A high-visibility Recreational Fishing Mobile Patrol has been added to the Gascoyne pool of resources. This dedicated education and enforcement unit patrols the coast from Onslow through to Kalbarri.

FMOs at Exmouth make extensive use of the 13-metre Patrol Vessel (PV) the PV *Edwards* to conduct compliance activities throughout the GCB, while FMOs in Carnarvon and Denham use an 8-metre rigid inflatable boat and a 7.3-metre rigid inflatable boat, respectively. Both vessels are used to conduct at-sea inspections in Shark Bay and within the southern aspects of the Ningaloo Marine Park and Commonwealth Ningaloo Marine Park. In all three Districts, FMOs spend approximately 90 days a year at sea on patrol duties. Historically, large patrol vessels (greater than 20 m in length) have assisted FMOs at various times of the year for offshore patrols, especially in the SBPMF. FMOs conduct patrols the length of the GCB and target offenders in all of the recreational and commercial fisheries based on intelligence gathered, as well as conduct aerial surveillance, at-sea and on-land licence, gear and marine safety inspections and attend community events and school education programs.

16.3.1 Monitoring, Control and Surveillance Systems

Monitoring, control and surveillance (MCS) mechanisms ensure a fishery's management measures are enforced and complied with. There is a comprehensive MCS system implemented in the SBPMF that has demonstrated a consistent ability to enforce relevant management measures, strategies and / or rules. The MCS system is administered by the Department's RSD through a fishery-specific Operational Compliance Plan (OCP).

A fishery's OCP provides clear and unambiguous direction and guidance to FMOs for the yearly delivery of compliance-related activities in the fishery. The development of fishery-specific OCPs and compliance strategies continues to provide the most effective and efficient method for a planned and measureable approach to compliance delivery.

16.3.1.1 Implementation

16.3.1.1.1 Compliance Risk Assessments

Fishers and other stakeholder groups may be directly involved in setting compliance priorities through compliance risk assessments. The Department conducts compliance risk assessments every 1 – 2 years in major fisheries (e.g. the SBPMF) or those perceived to be at high risk and every 3 – 5 years in minor fisheries. The risk assessment process can also be triggered by the introduction of new supporting legislation[94] in a fishery / resource or the identification of any new major issues that would require RSD managers to assess their compliance program including (but not limited to):

- A sectoral complaint;
- Ministerial or Parliamentary enquiry;
- Management framework issues;

[94] 'Supporting legislation' refers to any legislation that would allow non-compliance with the management framework to be detected and prosecuted with a reasonable chance of securing a conviction.

- Public complaint or sustained media interest;
- Intelligence; or an
- Upward trend in non-compliance.

The risk assessment process involves the participation of managers, field-based FMOs, researchers, commercial and recreational fishers, fish processors and representatives from other interested stakeholder groups, where relevant. There are two tiers in the risk assessment process — the first tier is the formal transparent process involving industry and other stakeholders, and the second tier is internal, utilising researchers, fishery managers and compliance personnel. The second process feeds into the fishery's OCP[95], which provides the formal framework for the delivery of specific compliance services that remove or mitigate the identified risks.

The compliance risk assessment process identifies modes of offending, compliance countermeasures and risks and relies on a weight-of-evidence approach, considering information available from specialist units, trends and issues identified by local staff and Departmental priorities set by the Aquatic Management Division through Fish Plan.

16.3.1.1.2 Operational Compliance Plan

An OCP provides a formal and transparent process for staff to carry out defined compliance activities in order to monitor, inspect and regulate the compliance risks to each specific high-risk activity in a fishery, and in turn confirm they are at an acceptable and manageable level. This is supported by measurable reporting methods defined under the OCP to demonstrate compliance activities being undertaken are having a direct and significant impact on reducing identified risks.

The development of an OCP consists of identifying and applying tailored compliance strategies for each identified risk. In the case of the SBPMF, this includes strategies that may deal with higher identified risks related to seasonal considerations, spatial considerations, environmental considerations and identified persons or groups of interest.

OCPs have been operating for several years now in the SBPMF and other major commercial fisheries in the GCB and for the management of the Ningaloo Marine Park, Shark Bay Marine Park and Commonwealth Ningaloo Marine Park. Each OCP is reviewed following a compliance risk assessment. Additionally, by regularly reviewing the OCPs for all fisheries in a particular location, rational, accountable decisions can be made about deploying compliance resources and ensuring that resources are available to mitigate risks to an acceptable level.

Following a formal review of a fishery's OCP and associated compliance strategies, compliance activities are prioritized in accordance with risk, budget and resourcing considerations. All existing OCPs were reviewed and updated during the 2012/13 year using this model.

[95] By their nature, OCPs contain sensitive information and are only made available to authorised compliance personnel.

Annual planning meetings are held for OCPs, with regular specific planning of day-to-day targeted and non-targeted patrols linked to the OCP based on resources and competing priorities.

16.3.1.1.3 Resourcing Compliance Operations

Gascoyne regional staff co-ordinate the allocation and prioritisation of existing resources across all programs in the region based on the risk assessments and related OCPs. Compliance planning meetings are held regularly to ensure staffing requirements are adequate for scheduled compliance activities.

Available compliance resources are allocated based on the risk assessment outcomes and the contacts and compliance statistics which are captured, reported on and reviewed at the end of each year. The allocated resources and compliance strategies (i.e. monitoring, surveillance and education activities) are outlined in the OCP, which specifies planned hours and staff allocated to key compliance tasks and duties. This planning and delivery process allows for more-targeted, effective and relevant compliance service in terms of both cost and activities.

There is also flexibility within the region to allocate additional resources to respond to changes, such as the need for a planned tactical operation in response to fresh intelligence. This may be achieved by redirecting existing resources or seeking additional resources from other areas or units. Similarly, changing priorities and resourcing on a local level can involve reducing planned delivery of compliance services to ensure resources are directed to where they are most needed.

16.3.1.1.3.1 Key Compliance Personnel in the Gascoyne Coast Bioregion

The Regional Office of the Department relevant to the SBPMF is located in Carnarvon and supported by district offices located at Exmouth, Carnarvon and Denham. Staff located at these offices provide on-ground compliance and educative delivery for these fisheries. Key compliance and enforcement personnel located in the region and their responsibilities include:

1. Compliance Managers
    - Overall responsibility for OCPs and compliance strategies, including their development, review and ensuring outcomes are delivered;
    - Responsible for providing sufficient and appropriate resources to achieve compliance outcomes;
    - Ensuring FMO safety is considered at all times and the Region's occupational health and safety requirements are met;
    - Monitoring the progress of the OCPs and strategies during their execution;
    - Consulting with all key stakeholders when reviewing the OCPs and strategies; and
    - Reporting outcomes.

2. Supervising Fisheries and Marine Officers

    - Field responsibility for OCPs and strategies, including reporting any deficiencies and reporting the outcomes as they are delivered or achieved;
    - Supervision of staff performance;
    - Ensuring officer safety is considered at all times and the district's occupational health and safety requirements are met;
    - Provide briefings and de-briefings as required;
    - Ensuring all equipment required to execute the OCPs and strategies is serviced, operational and available; and
    - Liaising with staff from other agencies operating in a joint servicing arrangement.

3. Fisheries and Marine Officers (FMOs):

    - Day-to-day responsibility for the execution of the OCPs and strategies in their interaction with users of the Fishery;
    - Ensuring FMO safety is considered at all times and individual occupational health and safety requirements are met;
    - Reporting any deficiencies and outcomes in a timely and accurate manner; and
    - Complying with the *Standard Operating Procedures*, *Prosecution Guidelines*[96], the Department's *Code of Conduct* and promoting the vision and mission statement of the Department and its joint-servicing partners.

    FMOs are formally appointed pursuant to the FRMA, which clearly sets out their powers to enforce fisheries legislation, enter and search premises, obtain information and inspect catches. FMOs are highly trained; they must have a thorough knowledge of the legislation they are responsible for enforcing and follow a strict protocol for undertaking their duties in accordance with the FRMA and in recording information relating to the number and type of contacts, offences detected and sanctions applied.

In addition to regional compliance staff there are a number of units within the Department that support the delivery of compliance outcomes, including:

1. Patrol Boat Business Unit

    - Provides large oceangoing patrol vessels for Statewide offshore compliance operations and education activities.

2. Vessel Monitoring System Unit

    - Operates the Department's vessel monitoring system (VMS) to help manage the State's commercial fisheries.

[96] The *Prosecution Guidelines* is a confidential guide used by FMOs that provide a tiered framework for dealing with fishery offences, thus it is not a publically-available document.

3. Serious Offences Unit
    - Undertakes covert operations and deals with connections to organised crime;
    - Conducts major investigations and initiates proactive intelligence-driven operations;
    - Targets any serious and organised criminal activity within the fishing sector;
    - Provides specialist investigative training; and
    - Provides technical assistance in relation to covert surveillance.
4. Fisheries Intelligence Unit
    - Responsible for providing intelligence reports to support strategic, operational and tactical needs of compliance programs; and
    - Collects and analyses compliance data.
5. Compliance Statistics Unit
    - Develop monitoring and sampling programmes to support compliance delivery;
    - Collects and analyses compliance data to identify trends; and
    - Provides compliance statistics to help target enforcement activities.
6. Prosecutions Unit
    - Manage the electronic system used to issue infringement notices or commence prosecution processes when offences are detected; and
    - Custodians of information relating to detected offences which can be used for official reporting purposes.
7. Strategic Policy Section of the Regional Services Branch
    - Develops and implements strategic compliance policy and standards;
    - Provides compliance risk assessments for fisheries;
    - Provides review and implementation of fisheries management and compliance legislation;
    - Oversees collection and analysis of compliance data;
    - Oversees compliance research projects;
    - Develops occupational health and safety standards for FMOs; and
    - Provides recruitment and training of new and existing FMOs.

16.3.1.2 Formal MCS Systems

Compliance staff utilise a number of formal monitoring and surveillance activities and control mechanisms in the SBPMF.

16.3.1.2.1 Monitoring Activities

VMS is a mandatory requirement for real-time monitoring to ensure fishers are operating within the legislated permitted fishing areas. All vessels operating in the SBPMF are required to install an Automatic Location Communicator[97] (ALC) pursuant to the fishery's Management Plan. The ALC tracks the location of the boat and transmits information such as the geographical position, course and speed of the boat via a satellite link to a VMS database at the Department's Marine Operations Centre in Fremantle, with authorised Departmental officers able to access VMS data in real-time. This monitoring reduces incentives to break the law due to a high level of certainty that an offence would be detected.

The licensee and / or the master of every licenced fishing boat is required (under regulation 64 of the FRMR) to submit accurate and complete catch and effort returns on forms approved by the Department. Daily[98] Trawl Logbook Sheets (see Appendices) have been completed by all skippers in the fisheries since 1962/63 and have been compulsory since 2008. On each logbook sheet, fishers are required to report the starting position (longitude and latitude), start time, duration, mean depth and catches of each retained species for each trawl shot, as well as daily records of all ETP species interactions and environmental data (i.e. water temperature and moon phase).

This fishery operates using a constant escapement approach, with catch and effort monitored by the research branch and used to inform in-season control rules related to the rolling opening/closure of management areas throughout the Fishery. As part of the control rules, once the catch rates in an area fall below the limit reference levels, the area is closed to fishing activity (for a specified period of time or for the remainder of the season depending on the area). Thus, there is an incentive for fishers not to under-report catches, as this will generate a lower catch rate and thus, the potential closure of an area to fishing activity.

16.3.1.2.2 Control Mechanisms

Fisheries legislation forms the main component of the control system for commercial fisheries in WA, along with conditions applied on an MFL. The SBPMF are subject to controls under:

- The EPBC Act (export exemptions);
- The FRMA;
- The FRMR;
- The *SBPMF Management Plan*; and
- MFL conditions;

A description of the control measures in place are provided in Table 16.1.

[97] Statutory approved directions are gazetted and readily-available to regulate the installation, use, servicing and testing of approved ALCs.
[98] Shot-by-shot information provided since 1998

Table 16.1. Description of the control measures and instruments of implementation in the SBPMF

Measure	Description	Instrument
Limited Entry	A limited number of Managed Fishery Licenses (18) are permitted to operate in the SBPMF.	SBPMF Management Plan 1993
Effort Restrictions	The fishery currently operates under a maximum headrope capacity restriction of 724 metres (396 fathoms).	SBPMF Management Plan 1993 FRMA (Section 7 Exemptions)
Gear Controls	Include controls on mesh size (≤ 60 mm) of nets, boat length, size of the ground chain (≤ 10 mm diameter) and the dimensions of the otter boards, including metal shoes.	SBPMF Management Plan 1993 FRMA (Section 7 Exemptions)
Bycatch Reduction Devices (BRDs)	The fleet is required to have BRDs in the forms of grids and fish exclusion devices (FEDs), such as square mesh panels, in all standard nets.	MFL Condition
Annual Closed Season & Cap on Fishing Days	The fishery is closed to fishing between November and March each year, with the aim of a maximum of 175 total fishing days each year.	SBPMF Management Plan 1993 (clause 10 determination)
Spatial Closures	Parts of Shark Bay are permanently closed to trawling activities to preserve seagrass and other sensitive habitats that are essential nursery areas for prawns and other species. There are also two Port Area Closures in place within three nautical miles of Carnarvon and Denham.	SBPMF Management Plan 1993
	The waters of Hamelin Bay are also permanently closed to trawling as part of the Shark Bay Marine Park.	Section 43 order (Shark Bay Marine Park)
	A combination of statutory and voluntary rolling spatial closures of a number of areas are used throughout the season to contain and direct overall fleet effort, control effort on brown tiger prawns and provide industry the opportunity to maximise economic returns.	SBPMF Management Plan 1993 (clause 10 determination); Co-operative Agreement
Temporal Closures	Fishing is only permitted at night, as prawns are nocturnal.	SBPMF Management Plan 1993 (clause 10 determination)
	Fishing closures also occur around each full moon.	Co-operative Agreement
Reporting	Fishers are required to report all retained (target and non-target) species catches, effort, ETP species interactions and fishing location in statutory daily logbooks.	FRMR
	Fishing activities are also monitored via the satellite Vessel Monitoring System (VMS) and the master must submit a nomination of intention to enter the fishery via VMS.	SBPMF Management Plan 1993

16.3.1.2.3 Surveillance Activities

FMOs deliver compliance activities directed at commercial fisheries through pre-season briefings with the masters of the licenced fishing boats and pre-season inspections, as well as at-sea inspections and investigations resulting from suspected breaches detected via the VMS and intelligence-led operations.

FMO's follow a variety of established Standard Operating Procedures (SOPs) when undertaking patrol and inspection work. This procedure ensures that inspections are carried out safely, efficiently, correctly and with due regard to relevant policies. SOPs also ensure consistency in the delivery of compliance services and the ability to quickly familiarise new staff to the specifics of important compliance elements in a fishery.

The majority of surveillance activities in the SBPMF are undertaken by FMOs during field-based patrols. Compliance activities undertaken during patrols are recorded and reported by FMOs using a daily patrol contact (DPC) form. The purpose of these forms is to record and classify contacts and time spent in the field for each FMO. These forms provide managers with information about:

- The number of field contacts made, which provides a context for the number of offences detected. This includes random contacts and offences from random inspections;
- The number of targeted[99] contacts made, which provides information on the effectiveness of the intelligence gathering capacity at identifying 'targets';
- The number of face-to-face contacts outside of a compliance context (referred to as 'A/L/E' contacts) made, which provides information on the educative effort of FMOs in a fishery; and
- Other routine information that can be used to help managers report on where and on which fisheries FMOs have undertaken patrols. This information is also used in patrol planning and risk assessments and ensures accountability of the compliance program.

A 'contact' occurs when an FMO has a chance of detecting illegal activity being undertaken by a fisher and includes personal contact (face-to-face), covert activities (e.g. deliberate, intensive surveillance), unattended gear checks (e.g. checking BRDs on a trawl net) and A/L/E contacts. VMS vessel days are also considered commercial compliance contacts. VMS vessel days are a proxy for fleet size and compliance coverage, representing each day that a vessel has an ALC operational (whether fishing or not) and therefore, a day that FMOs can assess whether it is complying with statutory spatial closures. In addition, VMS allows for a more targeted and cost effective on-ground compliance delivery.

The DPC form also includes a section to record details of individual commercial vessel inspections / checks. These inspections may involve:

- Inspection of all nets, BRD's, otter boards, VMS and other gear;

[99] A targeted contact is one that is initiated because available information indicates that an offence may have been committed or may be more likely to have been committed.

- Inspection of all authorizations; and
- Inspection of freezers and fish on board the boat.

Compliance field activity undertaken by FMOs operating from large (> 20 m) patrol vessels are reported and captured in the patrol vessel database (PVDB), which is available for use by compliance managers and other patrol vessels as needed.

The Department has also implemented an initiative called Fishwatch[100], whereby the community can report instances of suspected illegal fishing. The Fishwatch phone line provides a confidential quick and easy way to report any suspicious activity to Departmental compliance staff.

16.3.1.3 Additional Monitoring

Although compliance with the rolling opening / closing of various areas throughout the fishery is voluntary, the Department's VMS compliance team also monitor and report on VMS incursions annually. Information from these reports is used to assess general compliance levels in the fishery and inform the OCP and associated compliance activities for the following seasons.

16.3.2 Applying Sanctions

As described in Section 15.4, the SBPMF management system provides a number of incentives to fish both lawfully and sustainably. These incentives, combined with explicit penalties and comprehensive MCS systems, provide a robust framework for ensuring that licensed commercial fishers comply with the management arrangements.

There is an explicit and statutory sanction framework that is applied should a person contravene legislation relevant to the SBPMF. Sanctions applicable to the FRMA or FRMR are generally specific to each section or regulation. For example, section 74 of the FMRA sets out the sanctions applied when a clause of the *SBPMF Management Plan* is contravened[101], while section 77 sets out the sanctions applied should a condition of the MFL (e.g. the requirement to install prescribed bycatch reduction devices) be contravened.

Breaches in fishery rules may occur for a variety of reasons, and FMOs undertake every opportunity to provide education, awareness and advice to fishers; however, all offences detected in the fishery are considered to be of significant concern and are addressed by FMOs via the prosecution process outlined in the Department's *Prosecution Guidelines* and rules set out in the FRMA and FRMR. When an FMO detects a breach of the FRMA, the officer determines if the matter is prosecutable (according to the Department's *Prosecution Guidelines*) and where it is, a prosecution brief is prepared by the FMO and submitted to their supervisor. Based on the *Prosecution Guidelines*, there are four tiers of enforcement measures applied by FMOs when an offence is detected in the fishery including:

[100] http://www.fish.wa.gov.au/About-Us/Contact-Us/Pages/Fish-watch.aspx
[101] Note that clause 19A of the Management Plan (offences and major provisions) is redundant as section 75 of the FRMA was revoked and replaced with section 74, which applies across all Fishery Management Plans

- Infringement warnings: These are written warnings issued for minor fisher offences. They do not incur a fine, but are a written record of a minor offence that may be referred to by Fishery Officers in the future. A certain number of infringement warnings for similar offences in a designated period may result in an infringement notice;

- Infringement notices: These are written notifications to pay a monetary penalty for an observed offence. Fishers issued infringement notices may choose to defend the matter in court; however, most fishers simply choose to pay the fine. The Department may initiate a prosecution brief for those fishers who appear to be habitual offenders;

- Letters of warning: A letter of warning (LOW) is an available sanction that achieves a formal record of a commercial offence where a prosecution may be unduly harsh under the circumstances. A LOW may be issued where an offence may have been committed but detected outside of the 45-day period where an infringement can be issued. There may not be a public interest in prosecution, but this still formally records the detected offence. A LOW formally advises the offender of their actions and seeks future 'voluntary' compliance.; and

- Prosecutions: These are offences of serious nature (prescribed in the FRMA) that immediately proceed to formal, legal prosecution. Such matters often incur hefty fines or can even result in incarceration, and matters brought before the court are often vigorously defended (especially by commercial fishers).

FMOs have the autonomy to issue an infringement warning after detecting some 'minor' offences that have resulted from a lack of understanding of the rules or an error of judgment, while infringement notices are used to apply a modified penalty and are usually used in cases where the offence does not warrant prosecution action that is likely to end up in court. Modified penalties are prescribed in Schedule 12 of the FRMR and can only be applied to particular sections of the FRMA (including contravening a provision of a Management Plan) and the FRMR[102]. A copy of the infringement notice is provided in Schedule 14 of the FRMR. If there is a dispute over an infringement notice, the offender can request the matter be heard in court.

More serious offences against the legislation will require the Department to seek to prosecute. The Department's Prosecution Advisory Panel (PAP) reviews recommendations made by the RSD in respect to alleged offending against the FRMA (or Pearling Act) and considers whether such decisions are in the 'public interest'. This process ensures fairness, consistency and equity in the prosecution decision-making process. The PAP consists of three panel members (representing legal and executive services and the compliance and aquatic management branches) who meet on a monthly basis or as necessary. The PAP operates on a majority basis, with the prosecution process continuing where the majority of the PAP agrees with the recommendation to prosecute. If the majority of the PAP disagrees with the recommendation to prosecute, the matter is referred to the Chief Executive Officer (CEO) of

[102] http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_1458_homepage.html

the Department, who will then make a determination on the matter. Should prosecution action be undertaken, the outcomes are generally released to the public via media releases and recorded on the Department's website[103]. Penalties for illegal activity in WA fisheries are commensurate with the value of the illegal fish involved and the type of illegal activity. This can sometimes result in large monetary penalties for certain types of activities, with large penalties considered necessary in order to create a deterrent effect for high-value species, such as western rock lobster or abalone. Additional penalty provisions that apply should there be a prosecution are provided in the FRMA under sections 222 (mandatory additional penalties based on value of fish), 223 (court ordered cancellations or suspensions of authorisations), 225 (prohibition on offender activities) and 218 (forfeiture of catch, gear, etc.).

A successful prosecution for a serious offence in a commercial fishery may result in a 'black mark' against the fisher or the commercial licence (as per section 224 of the FRMA). If an authorisation holder or a person action on behalf of the holder accumulates three black marks within a 10-year period, the authorisation is suspended for one year. Additionally, under section 143, the CEO has the administrative power to cancel, suspend or not renew an authorisation in certain circumstances, which can be used even if cancellations through the court are unsuccessful. These powers have been regularly used to deal with serious offending in other fisheries.

All fisheries offences in WA are recorded in a dedicated Departmental offences system, which also manages the workflow associated with infringements and prosecutions. In order to link this information with patrol data, FMOs include information about the fishery, DPC area, type of patrol and whether the offence resulted from a targeted inspection in all offence paperwork.

16.3.2.1 Sanctions in the SBPMF

Despite a continuing level of MCS in accordance with the OCP, there have been few offences in the last ten years (Table 16.2). Note the data provided here indicate offences that resulted in an outcome in-line with the enforcement measures described above.

[103] Example of media release: http://www.fish.wa.gov.au/About-Us/Media-releases/Pages/Court-fines-hit-hard-for-out-of-season-lobster-fishing.aspx

Table 16.2. Summary of offences in the SBPMF from 2004/5 – 2013/14

Year	Infringement Warnings	Infringement Notices	Letters of Warning	Prosecution
2004/05	0	0	4	2
2005/06	0	0	4	2
2006/07	0	0	0	2
2007/08	0	0	2	0
2008/09	1	1	0	0
2009/10	0	0	0	0
2010/11	2	0	0	0
2011/12	4	0	1	0
2012/13	0	2	0	0
2013/14	0	0	0	0

16.3.3 Level of Compliance

In recent years, FMO effort has been directed at building stronger relationships with industry through higher levels of contact both at sea and in port. For the 2013/14 financial year, the number of suspected breaches of closed waters detected through the VMS and other monitoring methods in the GCB has increased due to a more focused intelligence base of compliance; however, compliance in the GCB overall is assessed as being at an acceptable level across all the fisheries. Additionally, compliance staff assess that the commercial fishing industry in this area continues to demonstrate a positive approach to complying with regulations and playing their part to ensure the sustainability of their fisheries.

In evaluating compliance in a specific fishery, the Department uses a weight-of-evidence approach, which considers:

- Ongoing evidence of a sustainable fishery, i.e. whether ecological objectives continue to be met;
- Assessment of the risk posed by the fishery to target species and ecosystem components under the current management regime;
- Annual outputs arising from formal MCS systems —
  - Adequacy of commercial compliance coverage (patrol hours) including VMS;
  - Number of offences and successful prosecutions (dependent on whether compliance is undertaken in a random or targeted manner); and
  - Average non-targeted compliance rate;
- Number of reports of illegal activity logged by Fishwatch and from intelligence gathered by FMOs;
- General level of industry support / buy-in around fishing rules; and
- Level of compliance education and communications during key stakeholder engagement (at least annually).

Using this weight-of-evidence approach, there is a high degree of confidence that fishers in the SBPMF comply with the management system in place, including providing information of importance to the effective management of the fishery based on the following:

- There is ongoing evidence that the fishery is operating sustainably, as the performance indicators for each component (i.e. target species, retained non-target species, bycatch, ETP species, habitat and ecosystem processes) of the fishery has been maintained above threshold reference levels.
- In the most recent ecological risk assessment (2010) for the SBPMF, the highest risk for one component was 'high'. This was for the impact on tiger prawns and as a result, the threshold levels to cease fishing were increased. The *Status Report of the Fisheries and Aquatic Resources of Western Australia* report on the evaluation of performance of the fishery annually.
- There have been few offences recorded (based on formal compliance systems) in the SBPMF within the last five years;
- There are 199 intelligence reports for the SBPMF on the Department's intelligence management system, "Seastar", over the last five years (Table 16.3).

Table 16.3. Summary of intelligence reports relating to the SBPMF

Year	ALL	VMS reports	Other reports
2009/10	63	61	2
2010/11	30	28	2
2011/12	38	38	0
2012/13	28	28	0
2013/14	40	39	1

- Additionally, apart from statutory requirements around submitting catch returns, the licensees actively participate in providing extra information for the effective management of the fishery, particularly through the provision of industry boats for Department surveys and the collection of additional data via industry surveys, which are delivered under a SLA with the Department.

The Department also measures compliance outcomes by estimating compliance and non-compliance rates. These terms refer to the proportion of fishers in a defined group (i.e. the SBPMF) that, on the basis of random inspections, were found observing fishing rules or not, respectively. Thus, the estimated average annual compliance rate is obtained by comparing the number of non-targeted contacts with fishers in the SBPMF against the number of detected offences. The average compliance rate for the SBPMF between 2006/07 and 2012/13 is estimated at 98.9 %. Based on the weight-of-evidence approach detailed above and the long-term compliance rate, there is no evidence of systematic non-compliance by the licensees and skippers in the SBPMF, nor is there evidence that the existing (negligible) level of non-compliance in the past five years is a risk to target prawn stocks or ecosystem components.

16.4 Research Plan

As discussed in Section 15.3, the Departments' RMAD Plan forms part of the planning cycle for determining research, monitoring and assessment needs for the SBPMF and specifically outlines the historical, current and proposed activities to support the collection and analysis of data to assist the Department to meet the objectives of the FRMA and the harvest strategy over the next five year period (currently 2011/12 to 2015/16).

The RMAD Plan contains a matrix that sets out the research activities associated with the following components of the SBPMF:

- Target prawn species;
- Habitat and ecosystem;
- Management research; and
- Industry development.

The focus of current monitoring and research for 2014/15 as set out in the RMAD Plan includes:

- Assessment of brown tiger prawn spawning stocks;
- Monitoring of commercial catch and effort;
- Monitoring area of the fishery that is trawled for habitat impacts;
- Monitoring ETP interactions;
- Leeuwin current monitoring; and
- Economic analysis.

The outcomes of monitoring and research undertaken in accordance with the RMAD Plan are reported in *State of the Fisheries.*

Past research that has been undertaken for the SBPMF includes:

- Target species biology and habitat requirements (1970s);
- Stock recruitment dynamics (1980s);
- Fishery-independent recruitment and spawning stock surveys (1991 to present);
- Implementation and assessment of bycatch reduction devices in the Shark Bay and Exmouth Gulf trawl fisheries (2002)[104];
- Biodiversity of bycatch in trawled and untrawled areas within Shark Bay (2007)[105]; and
- Understanding factors relevant to the implementation of formal co-management (2008 and 2009).

[104] http://frdc.com.au/research/Documents/Final_reports/2000-189-DLD.pdf
[105] http://frdc.com.au/research/final-reports/Pages/2002-038-DLD.aspx

16.4.1 Bycatch Action Plan

It is Government policy to minimise bycatch in all commercial fisheries. The Bycatch Action Plan details a program of actions to be undertaken over 2014 – 2019 to address bycatch issues in accordance with the Harvest Strategy for the SBPMF (DoF 2014b). The focus of the Bycatch Action Plan is on developing management responses to ecological risks associated with the fishery and developing appropriate management measures to minimise fishery interactions with species listed under the EPBC Act (i.e. ETP species).

The actions contained in the Bycatch Action Plan are considered appropriate to meet ecological management objectives that are consistent with achieving the outcomes expressed by MSC Principle 2 as they relate to non-target retained, bycatch, ETP species and ecosystem processes.

The Bycatch Action Plan aims to:

- Develop and implement cost-effective strategies to pursue continual improvement in reducing bycatch;
- Review relative changes in bycatch due to bycatch mitigation and extend information on best practice to industry;
- Develop measures to further reduce interactions with, or impacts on, ETP species;
- Respond to adverse impacts on Shark Bay ecology from prawn fishing; and
- Develop measures to better utilise what would otherwise be discarded.

The Bycatch Action Plan includes actions to monitor and manage impacts on high risk bycatch / ETP species, particularly sea snakes. Limited information currently exists on the impact of the fishery on sea snake populations in Shark Bay. The Bycatch Action Plan addresses the need for species-level identification and quantitative estimates of mortality through a bycatch monitoring program, as well as obtaining available information on local population abundances to provide assessments of the sustainability of bycatch and research on mitigation measures for sea snakes.

16.4.2 Other Research

Following the marine heatwave in the summer of 2010/11 two Marine Heatwave Workshops were undertaken and focussed on oceanographic conditions and the longer-term (2 years) effect on fisheries and the marine environment [106]. The Department is currently finalising the report for FRDC Project No. 2010/535 *Management implications of climate change effect on fisheries in Western Australia: Part 1*. As part of this study, prawn species were examined for climate change effects and brown tiger prawns were assessed as being at high risk to impacts resulting from climate change. It is recognized that there is a need to ensure the harvesting approach for the SBPMF is sufficiently robust to be able to take into account long-term changes in abundance and distribution of prawn stocks that may be due to (particularly extreme) climate change effects.

[106] http://www.fish.wa.gov.au/Documents/research_reports/frr250.pdf

An expression of interest to FRDC for funding for a project entitled "*Examining the relationship between fishery recruitment, essential benthic habitats and environmental drivers in Exmouth Gulf and Shark Bay*" has been submitted in conjunction with UWA seagrass experts[107]

The objectives of the project are to:

- Collate and review historical, satellite, habitat and 'environmental productivity' data for the Exmouth Gulf and Shark Bay ecosystems to identify factors that may influence recruitment
- Assess ability of different techniques at various spatial scales to identify and assess critical fish habitat in a range of environmental conditions, comparing Exmouth Gulf and Shark Bay habitat and recruitment patterns in relation to environmental factors.
- Collect in-situ environmental and productivity data to assess the feasibility of collecting broad scale data remotely.
- Develop a cost effective monitoring program for critical fish habitat and environmental drivers which allows the development of mitigation measures to assist in alleviating poor recruitment events.

Industry actively participates in monitoring surveys through the provision of industry boats for Department surveys and the collection of additional data via industry surveys, which are delivered under a SLA with the Department. The SLA outlines specific arrangements between the Department and the SBPTOA regarding collection of research data for the monitoring surveys for three years demonstrating both planning and commitment from both parties on collection of data for monitoring and assessment of prawn stocks.

16.4.3 Research Results

The recent publications relevant to the research projects undertaken for the SBPMF are listed in the RMAD Plan. The results for individual research projects are made publicly available on the Department's website in the form of Fisheries Management Papers, Fisheries Research Reports and Fisheries Occasional Publications in a timely manner[108]. For example, research on minimising gear conflict and resource sharing issues in the Shark Bay trawl fisheries and promotion of scallop recruitment was completed and published in Fisheries Research Report 229 in 2012[109] which is available on the Department's website.

Results are also often available on the WAMSI website and publications can be linked to the WAFIC and Recfishwest websites. If it is an FRDC funded project, the final report will be placed on the FRDC website. Some of the research is peer reviewed and published in international journals.

Research activities in the SBPMF focus on stock assessment and monitoring of the target stocks, particularly brown tiger prawns. The results from the stock assessment that is

[107] http://www.uwa.edu.au/people/gary.kendrick
[108] http://www.fish.wa.gov.au/About-Us/Publications/Pages/default.aspx
[109] http://www.fish.wa.gov.au/Documents/research_reports/frr229.pdf

informed from the recruitment and spawning surveys and commercial catch rate assessments are reported on annually in the State of the Fisheries.

At the SBPMF Annual Management meeting that is held in December and attended by the Industry Association, licence holders, WAFIC and departmental staff, a research presentation is given and a post season report provided. This consists of the results from all of the surveys, catch predictions and catch from the season before (Appendix I). Given that the fishing season finishes in November and the AMM is held in December, the results presented in the season report are disseminated in a timely fashion and will be publically available as it is expected to be placed on the website in the near future.

Communications between the Department's researchers and Industry occur throughout the season to disseminate the survey results and decide, collaboratively, about the opening and closing of areas within the fishery. The survey results are analysed and sent to the Industry Association with a Departmental recommendation within two days of completing the surveys. The Industry Association consults with all licensees and a decision is made as to what if any areas should be opened for fishing.

16.5 Monitoring and Management Performance Evaluation

There is a system for monitoring and evaluating the performance of all parts of the fishery-specific management system against its objectives. There is also effective and timely review of the fishery specific management system.

16.5.1 Evaluation Coverage

The SBPMF has in place mechanisms to evaluate all parts of the management system. Should any data arising from regular monitoring and evaluation indicate that the SBPMF is having an unacceptable impact, review processes are triggered and decision-making processes are implemented.

16.5.1.1 Harvest Strategy Evaluation

Annual evaluation of the performance of the fishery against the reference levels contained in the harvest strategy is the main mechanism used to evaluate the fishery-specific management system. A review of one or more parts of the management system is triggered (see Section 16.5.2) if annual (or in-season) evaluation against the operational (short-term) objectives indicates the potential need (i.e. when the threshold level is breached) for a management response. Thus, a precautionary approach is taken, and potential issues are recognised and addressed in a timely manner prior to the following fishing season or during the current season, to meet both operational and long-term management objectives.

Long-term annual monitoring of performance indicators, together with the evaluation of those indicators against the reference levels in the harvest strategy, indicates that the fishery-specific management system continues to be effective in achieving Principle 1, 2 and economic management objectives. The outcomes of annual monitoring and evaluation are reported annually in the *Status Report of the Fisheries and Aquatic Resources of Western Australia: the State of the Fisheries*.

16.5.1.2 Research

The status and progress of activities required under the SBPMF research plan are closely monitored by Research staff to ensure that actions are being undertaken within the designated timeframes. Any issues around milestones, monitoring, reporting, resourcing etc. are discussed with Management staff as they arise. In addition, the Research Division's Supervising Scientists group has fortnightly meetings to raise any issues, which could include risks around the timing of delivery of research programmes / information. This group develops actions to address slippages, and any significant issues can be included as standing items.

The regular monitoring framework applied to the research plan may identify a need to undertake interim external or internal review of the research plan outside of the normal five year review cycle (see Section 16.5.2).

16.5.1.3 MCS System

Ongoing annual monitoring of compliance service delivery is undertaken at a Regional and local office level that relies on a weight-of-evidence approach considering information available from specialist units, trends and issues identified by local staff and Departmental priorities set by the Aquatic Management Division.

Offence types, numbers and sanctions relevant to the SBPMF are monitored on an annual basis by the Compliance Statistics Unit and, together with annual VMS days, patrol hours and contacts, are reported annually on a bioregional basis in *State of the Fisheries*.

Based on this, data used to annually evaluate compliance effectiveness in the SBPMF include:

- level of fishing effort;
- VMS vessel days;
- patrol hours;
- targeted and non-targeted contacts; and
- detected offences (type and number).

Should the evaluation of the annual non-targeted compliance rate identify a decrease in the level of compliance in the SBPMF, a review is triggered to investigate the reasons, which may result in an immediate review of the Compliance, Surveillance and Monitoring System.

Further details of the data and other information that is used for the purposes of compliance and enforcement can be found in Fisheries Research Report Number 195 (2009) *Compliance Program Evaluation and Optimisation in Commercial and Recreational Western Australian Fisheries.*[110]

[110] http://www.fish.wa.gov.au/Documents/research_reports/frr195.pdf

16.5.1.4 ESD Performance Measures

Monitoring and evaluation against ESD performance measures is undertaken annually and reported in *State of the Fisheries*. In 2012/13[111], all three performance measures relevant to the SBPMF were met (the 2013 evaluation will be provided in the next edition of *State of the Fisheries* 2013/14).

16.5.2 Internal & External Reviews

The fishery specific management system is subject to regular internal and external review.

Operationally, the SBPMF is subject to a management review pursuant to the Department's Fish Plan (which includes an annual update of the RMAD Plan), as part of the risk planning cycle framework. Fish Plan was last reviewed in July 2014. The level of resourcing across management, research and compliance is reviewed periodically and if, as a result, the level of risk has changed it may alter the level of monitoring and assessment in the future.

Annual management meetings and other stakeholder forums (as discussed under Section 16.2 and Section 16.2) are used to review management settings with licensees and provide advice and information. Informal meetings are held with industry throughout the year, as required.

The statutory management framework is reviewed when there is evidence to support statutory changes to the longer term management measures or to implement new longer term measures. The SBPMF management plan has not been amended since 2004, however, there have been several Exemptions granted since this time to better align management arrangements with the operational needs of the fishery. These changes effectively constitute a review, however from an administrative perspective, the grant of an Exemption under section 7 of the FRMA is often more practical. For example, the Exemption that authorises the use of a boat greater than 375 boat units applies to 6 different commercial trawl fisheries that each have their own management plan. Instead of amending six management plans, one Exemption instrument was granted to cover all fisheries.

In 2010, a comprehensive management and research review of the Shark Bay Prawn and Scallop Fisheries was completed, published and placed on the Department's website. [112]

16.5.2.1 Harvest Strategy

The Department's overarching Harvest Strategy Policy illustrates the decision tree for regular review of resource status. The information from this review process is reported on annually in the State of the Fisheries and then summarised to generate the Key Performance Indicator's for the Department's Annual Reports to Parliament.

The SBPMF harvest strategy was recently subject to extensive internal review, followed by external review in consultation with licensees, which resulted in the current harvest strategy (2014 – 2019). While the next review of the harvest strategy will occur in 2019, the appropriateness of the current performance indicators, reference levels and control rules will be further refined and updated during that time in consultation with licensees as further

[111] http://www.fish.wa.gov.au/Documents/sofar/status_reports_of_the_fisheries_and_aquatic_resources_2012-13.pdf
[112] http://www.fish.wa.gov.au/Documents/management_papers/fmp235.pdf

relevant information becomes available (e.g. new research, risk assessments, expert advice etc.).

16.5.2.2 Research

Any results arising from the research plan are generally externally peer reviewed, and always internally peer reviewed prior to publishing. The Supervising Scientists group manages the peer review process of all fisheries, including with external reviewers.

Regular reviews of Fish Plan and the higher level Research Strategic Plan (last reviewed in April 2012) may trigger an immediate review of the SBPMF research plan at any time. The five year cycle review and risk assessment may also trigger a review of the research plan. The RMAD Plan will be reviewed in consultation with external stakeholders in 2016/17.

Requirements for new research can be identified at any time. For example, as part of the FRDC Project No. 2010/535 *Management implications of climate change effect on fisheries in Western Australia: Part 1*, prawn species were examined for climate change effects and brown tiger prawns were assessed as being at high risk to impacts resulting from climate change.

It is recognised that there is a need to ensure the harvesting approach for the SBPMF is sufficiently robust to be able to take into account long-term changes in abundance and distribution of prawn stocks that may be due to (particularly extreme) climate change effects. It is on this basis that the Department (in conjunction with University of Western Australia [UWA] seagrass experts[113]) is currently in the process of applying for funding from the FRDC[114] (currently at the second Expression of Interest (EOI) stage) for a high priority project entitled *Examining the relationship between fishery recruitment, essential benthic habitats and environmental drivers in Exmouth Gulf and Shark Bay.*

The stock assessment and research framework for the SBPMF was externally reviewed by Malcolm Haddon (Marine Research Laboratory Tasmanian Aquaculture and Fisheries Institute, University of Tasmania) during a two day workshop undertaken in November 2012. The workshop was attended by Departmental staff (scientists, statisticians, modellers and managers), a prawn biologist from Mozambique and an external reviewer Dr Malcolm Haddon (CSIRO, Tasmania). The data sources and stock assessment process was reviewed, research gaps and future research identified, as well as a discussion on FRDC funded projects.

An internal review of the survey design was completed at the end of the 2013 season. As a result, the timing of the spawning surveys has changed for at least the next 3 years to enable a more complete stock assessment. Spawning surveys used to only occur in the North CPL in June to check prawn spawning biomass in this area. However, spawning surveys will now also occur in August and September in the North CPL, South CPL and Denham Sound when these areas are closed. Following a review of the survey methodology for assessing brown tiger prawn stock in Shark Bay in 2013, spawning stock surveys are now undertaken both in

[113] http://www.uwa.edu.au/people/gary.kendrick
[114] http://frdc.com.au/research/applying_funding/Pages/annual_call_for_applications.aspx

the North CPL (June, August and September) and the South CPL (August and September). This is because the South CPL has also shown to be key area for spawning brown tiger prawns.

The SBPMF Bycatch Action Plan was recently subject to extensive internal review, followed by external review in consultation with licensees, which resulted in the current Bycatch Action Plan (2014 – 2019).

An internal review of the external 2001 ESD risk assessment for the SBPMF was completed in 2008 and 2010. As a number of key changes had taken place in the fishery since 2001, the aims of the internal risk assessment workshop were to revisit the risk ratings identified in 2001 and determine whether they were still relevant or whether they required amendment. In addition, any possible new risks were identified. The review outcomes were made publically available[115].

16.5.2.3 Cooperative Management Framework

The co-operative management framework employed in the SBPMF is described in a report entitled *Co-management in the Exmouth Gulf Prawn Fishery with comparison to the Shark Bay Prawn Fishery* and formed part of a study conducted by FAO that investigated world-wide examples of fisheries self-governance (Kangas et al. 2008)[116].

The SLA between the Department and SBPTOA regarding research surveys is subject to performance monitoring and review. A performance review is conducted at the end of each annual monitoring and assessment program in order to determine arrangements for the following year. A full performance review is conducted at the end of the agreement (ends 1 December 2016).

16.5.2.4 ESD Accreditation

The SBPMF is subject to external review every five years by the Commonwealth DotE both during the assessment/re-assessment cycle and annually to maintain ESD export accreditation under the EPBC Act. The SBPMF has been assessed as sustainable and provided with export approval under the EPBC Act until 31 January 2018[117].

16.5.2.5 MCS System Review

Regular internal review of the SBPMF's compliance, monitoring and surveillance system is undertaken every 12 – 18 months by means of a compliance risk assessment. The SBPMF OCP is reviewed following the compliance risk assessment.

Gascoyne regional compliance staff and the VMS section primarily contribute to the compliance risk assessment process, however management and research staff can attend, or are given an opportunity to provide advice. Should the level of risk to compliance increase, further advice/resourcing can be sought from other areas of compliance (e.g. Special

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[115] http://www.environment.gov.au/system/files/pages/954b05b1-2c41-45ae-8810-7deddd9a784d/files/appendix-6-application-nov12.pdf
[116] http://www.fao.org/docrep/010/a1497e/a1497e00.htm
[117] http://www.environment.gov.au/topics/marine/fisheries/wa-sbprawn

Operations Unit). Following the compliance risk assessment review, the operational compliance plan is updated as required.

An external Auditor General's Public Sector Performance Report[118] on compliance in Western Australia's commercial and recreational fisheries, including the SBPMF, was submitted to Parliament in June 2009.

Following the Auditor General's Report, in November 2009, the Department's compliance program was evaluated with the aim of recommending optimisation in commercial and recreational fisheries in Western Australia, the result of which were published in Fisheries Research Report Number 195 (2009) *Compliance Program Evaluation and Optimisation in Commercial and Recreational Western Australian Fisheries* [119].

As a result of these reviews, the Department has greatly improved its compliance program by:

- developing regional and state-wide compliance risk assessments as a basis for its compliance program;
- determining the level of compliance activity that is required to achieve effective compliance outcomes for individual fisheries;
- identifying and collecting the key information required for compliance reporting and management purposes.

The Department has recently applied for funding from the FRDC for a project entitled *Measurement of Fisheries Compliance Outcomes: A Preliminary National Study* which began on 1 July 2014. Co-investigators include expert staff from AFMA, South Australian Fisheries and Victorian Fisheries. The project was requested by the National Fisheries Compliance Committee who has recognised that Fisheries Compliance groups face serious challenges demonstrating acceptable compliance outcomes as a result of their activities and the need for outcome indicators. The proposal is also strongly supported by the Australian Fisheries Management Forum.

Appropriate outcome indicators will measure whether compliance outcomes are being achieved in the long term. This will help to validate the effectiveness of the existing weight of evidence approach of combining compliance risks assessments and compliance outputs with sectoral involvement and research advice.

The measurement of compliance outcomes is different from fisheries compliance outputs. Output measures are relatively easy to determine (e.g. number of people fined), but fisheries compliance outcomes are not (i.e. a change in the skills, attitude, behaviour and circumstances of the target group or community in general). The project seeks to outline current best practice for compliance outcome measures, assess their strengths and weaknesses and where possible set a direction for the adoption of a national framework based on best

[118] https://audit.wa.gov.au/wp-content/uploads/2013/05/report2009_07.pdf
[119] http://www.fish.wa.gov.au/Documents/research_reports/frr195.pdf

practice. This is expected to result in a credible, reviewable framework for measuring fisheries compliance outcomes that can readily demonstrate value for money and an assessment of quality.

17. References

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18. Appendices

Appendix A: 2014 Internal PSA Risk Assessment Outcomes

1. Introduction

The Shark Bay Prawn Managed Fishery (SBPMF) has a number of processes in place to assess and mitigate the potential impacts of the fishery on target, non-target retained, bycatch and ETPs such as ecological risk assessments (ERA), spatial closures, bycatch action plans (BAPs), and compulsory reporting. All these processes are described in detail in the MSC Report for the SBPMF.

In addition to these processes, a Productivity Susceptibility Analysis (PSA) was conducted for all target and retained non-targeted species in the SBPMF. All ETPs with recorded interactions and by catch species comprising >3% of the total landings of the fishery (based on surveys conducted by Kangas et al. 2007) were included in the analysis. Where productivity attributes for a particular species were not available, values for a similar species (in the same family) were used. If no productivity scores were available a precautionary approach was used and species were assigned the most conservative score. In some cases, where species identifications were uncertain similar species were grouped together. In these cases, the most conservative score was applied across the group i.e. cephalopods which grouped octopus, cuttlefish and squid. Where possible, productivity scores were obtained from Fishbase (www.fishbase.org) or the Department of Environment's Species Profile database (sprat) (http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl). For productivity scores used in the PSA and explanation see Table 1.

No species / categories were assessed as high risk and only seven species / categories were assessed as medium risk including; one retained non-target species (mulloway), five ETPs (dolphins, dugong, two species of marine turtles, sea snakes general and indirect impacts with air breathing mammals (i.e. boat strikes) (see Table 2 for PSA scores). The species / categories assessed as medium risk were primarily scored at these levels due to their low productivity attributes rather than their susceptibility to the fishery per se as in many cases the PSA methodology does not allow sufficient scope to fully account for any mitigation that may be in place in the fishery to minimise interactions with these species. Some additional explanation for species / categories assessed as medium and high risk is provided below, additional information for ETPs is also available in Section 12 of the MSC Report for the SBPMF.

2. Medium species/categories from PSA

2.1. Mulloway (Argryosomus japonicas)

Mulloway have a wide distribution from Africa, Madagascar and along the southern coastline of Australia from Shark Bay in Western Australia to north of Brisbane in Queensland. Mulloway are currently reported as mixed finfish species in SBPMF which is also comprised of whiting, flathead, and flounder. Mixed finfish are generally caught in very low amounts (< 1 – 15 t), with 13 t retained in 2013 (for further details, see Section 10 of the MSC Report for the SBPMF). A target of ≤ 15 t has been implemented in the SBPMF Harvest Strategy (DoF 2014a).

As Mulloway are widely distributed and only relatively small quantities are caught in the SBPMF. The medium risk allocated by the PSA is primarily due to their low productivity attributes (i.e. average maximum size, age and age at maturity). These factors along with a target range of ≤15 t suggest that the actual risk to the species due to SBPMF is negligible.

2.2 Dolphins

Dolphins were identified as a medium risk in the PSA. However, as trawlers do not operate at speeds greater than four knots it is unlikely that any cetacean would come in direct contact with a trawler or the gear being towed as they are able to remove themselves from the path. In addition, dolphins are common in inshore/coastal waters in Australia and there have been only been two interactions reported in the SBPMF since 2006. Therefore, despite the outcome of the PSA it is considered that the risk to dolphins from the SBPMF is negligible.

2.3 Dugongs

The dugong (*Dugong dugon*) is a large herbivorous marine mammal and the only extant member of the Family Dugongidae. Approximately 10% of the world's dugongs reside in Shark Bay (Marsh et al. 2002, Gales et al. 2004). Surveys of Shark Bay indicate that the dugong population is approximately 10 000 individuals and that the Shark Bay population has remained relatively stable apart from an increase in 1999 following a cyclone that destroyed seagrass beds in Ningaloo / Exmouth.(Hodgson 2007, Hodgson et al. 2008). The movement of dugongs from Ningaloo Reef and Exmouth Gulf to Shark Bay during this period supports the fact that dugong populations in Ningaloo and Exmouth are connected with Shark Bay (Gales et al. 2004). Dugongs are seagrass specialists and as large areas of seagrass beds in Shark Bay are permanently closed to trawling the potential for interactions with dugongs is reduced. While there remains some overlap of dugong distribution and fishing effort throughout the year there have been no reported interactions with dugongs throughout the history of the fishery. Therefore, the medium risk ranking of the PSA is primarily due to the inherently low productivity of dugongs (i.e. long-lived, low reproductive rate and long generation time) and the actual risk posed to dugong populations by SBPMF is considered to be low.

2.4. Marine Turtles

Two species of marine turtles (green turtle *Chelonia mydas* and loggerhead turtle *Caretta caretta*) were assessed as medium risk by the PSA primarily due to the inability of the PSA to fully account for mitigation in the fishery that minimises the interactions with these species. Turtle bycatch mitigation in the SBPMF has been addressed with the introduction of the mandatory use of grids in 2002/03. These grids have shown to be effective in the fishery with a 95 – 100 % reduction in turtle bycatch (Kangas & Thomson 2004). In 2013, 36 interactions with turtles were reported, with 35 turtles returned to the water alive.

In 2010 the Northern Prawn Fishery (NPF), which is currently MSC certified, reported 27 interactions with marine turtles. A quantitative level 2.5 ERA of the NPF assessed 6 turtle species, including the two species with reported interactions with the SBPMF. None of the six species of marine turtles assessed were found to be at high risk due to the NPF largely due to the mitigation in place in the fishery and the fact that almost all turtles survive their interactions with the fishery (MRAG 2012). In comparison the SBMPF reported nine interactions with marine turtles in 2010, all of which were released alive.

Therefore, given the mitigation in place in the SBPMF, the scale of the interaction compared with a similar fishery (NPF) and the high likelihood of survival post release this level of interaction is considered to be a low risk to loggerhead turtles and negligible risk to green turtle populations, particularly as these species have wide distributions both within the Shark Bay and the greater Gascoyne Coast Bioregion (Kangas et al. 2006) (for more information see Section 12 of the MSC Report for the SBPMF).

2.3 Sea Snakes general

Most species of sea snakes are considered abundant or common in Shark Bay and are not known to be vulnerable. In 2013, 363 sea snake interactions were reported in the SBPMF, with 351 sea snakes returned to the water alive. Anecdotal evidence suggests that most sea snakes caught in the fishery are alive and aggressive when brought to the surface, which is thought to be an indication of health and lack of damage from the trawl. A study of sea snake survival following capture in trawlers in the Gulf of Carpentaria (Northern Territory) indicated that greater than 60% of sea snakes survived capture in trawl nets (Wassenberg et al. 1994), it is likely that sea snakes in Shark Bay have a similar level of survival.

Fish escape devices (i.e. a single panel of square mesh located in the top of the net posterior to the grid) have been a statutory requirement in the SBPMF since 2002/03. These devices, in combination with grids, have been successful in reducing the incidental capture of sea snakes by as much as 50% during experimental trials in 1995 (Brewer et al. 1998), although later testing indicated only a five per cent reducion (Brewer et al. 2006). Fisheye bycatch reduction devices (BRDs) have also shown very promising results elsewhere, with a 43% reduction being reported in the NPF (Heales et al. 2008). Grids have also been shown to increase sea snake survival in the NPF by reducing the weight of the total (all species) catch in the net (Wassenberg et al. 2001). The results of a study by Milton et al. (2009) in the NPF suggests that the short shot times (i.e. 60 – 180 minutes) in the SBPMF are also likely to increase the survival of captured sea snakes.

Similarly, sea snakes were highlighted as being of concern in a level 2.5 quantitative risk assessment of the NPF. Milton et al. (2008) found that the catch rates of the ten most common species have remained stable since 1976. The study also found that trawl induced mortality was below the reference points and no species appeared to be at risk based on the current levels of fishing effort in the NPF. Therefore, while sea snakes continue to be monitored in the NPF there are currently no sea snake species on the NPF list of priority species based on the outcomes of risk assessments.

Most sea snake species are considered to be abundant or common in Shark Bay, and given the level of interactions with SBPMF, 327 recorded interactions with sea snakes in 2010 compared to 7 478 recorded interactions in the NPF, is not considered to have any significant detrimental effects on sea snake populations in Shark Bay (Kangas et al. 2006).

However, it was recognised during the MSC pre-assessment that there is limited information on sea snake populations in Shark Bay and that there is a need for species level identification, quantitative estimates of mortality and research on additional mitigation measures for sea snakes. In order to address this issue, the Department has developed the *SBPMF Bycatch Action Plan*, which includes an overview of ETP species issues, including sea snakes, in Shark Bay and a proposed work plan for future / ongoing monitoring and research.

2.4 Indirect interactions with air breathing mammals (i.e. boat strikes)

Trawlers do not operate at speeds greater than four knots it is unlikely that any cetacean or dugong would come in direct contact with a trawler or the gear being towed as they are able to remove themselves from the path. Therefore this interaction is considered to pose a negligible risk to population of air breathing mammals.

Table 1: Productivity and Susceptibility attributes and associated explanations of species/categories included in PSA for SMPMF.

Species/Group	Productivity							Susceptibility				Comments
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS - broadcast spawner DEL - demersal egg layer LB - live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality	
Western king prawns	~0.5 y	1-2 y	>100000	~6 cm CL	~2.5 cm CL	BS	3	~7 % [A]	High	High	Retained	
Brown tiger prawns	~0.5 y	1-2 y	>96000	~5.5 cm CL	~3 cm CL	BS	3	~7 % [A]	High	High	Retained	
Coral prawns	~0.5 y*	1-2 y*	>20000*	~3 cm CL	~1 cm CL	BS	3	~7 % [A]	High	High	Retained	*Based on information for other prawn species.
Endeavour prawns	~0.5 y	1-2 y	296000	4.7 cm CL	~2.6 cm CL	BS	3	~7 % [A]	High	High	Retained	
Blue swimmer crab	0.5-1 y	3-4 y	>68000	25 cm CL	9 cm CL	BS	3	~7 % [A]	High	High	Retained	
Coral crab	~7 months	3 y	~2-9 million	17 cm CL	7 cm CL	BS	3	~7 % [A]	High	High	Retained	
Bugs	3 y	4-8 y	32230	9.5 cm CL	<40 cm CL*	BS	3	~7 % [A]	High	High	Retained	*Based on max size being 9.5 cm CL.
Cephalopods	0.5-1 y	< 2 y	~20-100000s	Typically <100 cm	Typically 15-25 cm ML	DEL	4	~7 % [A]	High	High	Retained	As the fecundity of cephalopods can vary widely, it was assigned a precautionary score based on the lower value of the range.
Whiting	1-2 y	~ 8 y	100000s	~20-30 cm	~15 cm	BS	3.2	~7 % [A]	High	High	Retained	
Flounder	<2-3 y	~6 y	>800000	45 cm	~20 cm	BS	4.2	~7 % [A]	High	High	Retained	
Flathead	1-4 y	13 y	>200000	~60-70 cm	30-50 cm	BS	4	~7 % [A]	High	High	Retained	
Mulloway	5 y	25 y	>900000	130 cm	~90 cm	BS	4.5	~7 % [A]	High	High	Retained	

[A] For all by product species, a precautionary approach has been adopted assuming that the stock of each species in Shark Bay is functionally independent of other stocks. Thus the percentage overlap of the fishery with the stock is calculated as the average percentage of the fishery area trawled over the past five years.

Species/Group	Productivity							Susceptibility				Comments
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS - broadcast spawner DEL - demersal egg layer LB - live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality	
Saucer scallop	1 y	3-4 y	>3.2x10^{5}	11.5	9	BS		Low	High	High	Released alive	Filter-feeding bivalve, trophic level assumed to be relatively low (<2.75). Wide distribution outside fishery.
Fan scallop				10	4.5	BS		Low	High	High	Released alive	Biology poorly known. Based on related species assumed to be fast-maturing and short-lived with low-trophic level. Spawns year-round, so likely high fecundity. Wide distribution outside fishery.
Other portunid crabs						BS		Low	High	High	Released alive	Biology poorly known, biology assumed to be similar to blue-swimmer crab. Wide-distribution outside fishery.
Asymmetrical goatfish				30		BS	3.5	Low	High	High	Majority released dead	Biology poorly known, but assumed to be fast-maturing, short-lived and fecund. Maturity inferred to be <40cm. Wide distribution outside fishery.
Hair-finned leatherjacket				11		BS	3.1	Low	High	High	Majority released dead	Biology poorly known, but assumed to be fast-maturing, short-lived and fecund. Maturity inferred to be <40cm. Wide distribution outside fishery.
Trumpeter				30		DEL	3.5	Low	High	High	Majority released dead	Biology poorly known, but assumed to be fast-maturing, short-lived and fecund. Maturity inferred to be <40cm. Wide distribution outside fishery.
Scorpionfish							3.2	Low	High	High	Majority released dead	Biology poorly known, but assumed to be fast-maturing, short-lived and fecund. Maximum size not >100cm, and maturity inferred to be <40cm. Wide distribution outside fishery.
Threadfin emperor		7		25		BS	3.5	Low	High	High	Majority released dead	Assumed to be relatively fast-maturing and fecund, and maturity inferred to be <40cm. Wide distribution outside fishery.
Orange-spotted toadfish				18		DEL	3.3	Low	High	High	Majority released dead	Assumed to be relatively fast-maturing, short-lived and fecund, maturity inferred to be <40cm. Wide distribution outside fishery.
Goodlad's stinkfish				22		BS	3.4	Low	High	High	Majority released dead	Assumed to be relatively fast-maturing, short-lived and fecund, maturity inferred to be <40cm. Wide distribution outside fishery.
Large-scaled grinner		8		50		BS	4.5	Low	High	High	Majority released dead	Assumed to be relatively fast-maturing and fecund, maturity inferred to be <40cm. Wide distribution outside fishery.

Species/Group	Productivity							Susceptibility				Comments
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS - broadcast spawner DEL - demersal egg layer LB - live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality	
Dolphins, general	10-15 years	40 years	1 off-spring every 3 years	2.3 m	2 m	LB	> 3	Low	Low	Excluded from nets via grids	Majority released alive	Common in inshore/coastal waters along Australia; most common species in SB is *T. aduncus*, with large local population size; only 2 interactions reported in the SBPMF in last 10 years (1 alive, 1 unknown)
Dugong	10 years	70 years	1 off-spring every 3-4 years	3 m	2.5 m	LB	2	Low	Low		Released alive	Common in Shark Bay, usually found outside of trawl grounds in seagrass habitat (permanent closure areas) but do seasonally move throughout bay; no interactions reported in history of SBPMF
Green turtle	25 years	40 years	500 eggs per season, but only breed every 1 – 9 years (i.e. < 100 eggs per year)	1 m CCL	30 – 40 cm CCL	DEL	2	Low	Medium	Excluded from nets via grids	Majority (> 95 %) released alive	WA population estimated to be 20000 individuals; Adults primarily found in seagrass/algae areas where they forage; no major rookeries or foraging areas in SB; 36 'general turtle' interactions reported in SBPMF in 2013, however, unlikely to be green turtles due to spatial separation from trawling activities (adults mainly occur in permanently closed seagrass areas)
Loggerhead turtle	25 years	> 25 years	500 eggs per season, but females do not breed each year (i.e. < 100 eggs per year)	1 m CCL	70 cm CCL	DEL	> 3	Low	Medium	Excluded from nets via grids	Majority (> 95 %) released alive	WA population separate from East Coast population; Adults primarily found in coral and rocky reefs, seagrass beds and muddy bays where they forage; major nesting and interesting area (800 – 1500 females annually) around northern end of Dirk Hartog Island; 36 'general turtle' interactions reported in SBPMF in 2013, likely to be mainly loggerheads due to spatial overlap with trawling activities; some 'loggerhead' interactions reported in previous years

Species/Group	Productivity							Susceptibility				Comments
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS - broadcast spawner DEL - demersal egg layer LB - live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality	
Syngnathids (*Hippocampus* spp.)	< 5 years	< 5 years	Small brood size (< 100 offspring per year)	~ 20 – 30 cm	~ 10 cm	LB	> 3	Low	Medium	High	Majority released alive	Relatively low population densities, with strong habitat association (generally found around edges of seagrass beds and macroalgae-dominated reefs); low natural rates of mortality; very few reported in SBPMF(< 10 every few years), but likely to be under-reported since difficult to see and count within trawl catch
Sea snakes (Hydrophiinae)	2 years	10 years	Small broods with high mortality (< 100 per year)	1 - 2 m	Likely 40 – 200 cm	LB	> 3	Low	Medium	High	Released alive; use of hoppers may increase survival	Most sea snakes considered abundant or common SB and are found throughout N. Aus.; Sea snakes may be damaged if caught in mesh, but generally in good condition inside of net; Trawl duration within breath-holding capabilities for most species (i.e. < 2 hours); majority reported as returned alive (351 of the 363 individuals reported in 2013)
Short-nosed sea snake	? (as above used as proxy)	? (as above used as proxy)	Small broods with high mortality (< 100 per year)	60 cm length	Likely 40 – 200 cm	LB	> 3	Low	Medium	High	Released alive; use of hoppers may increase survival	Endemic to North West WA; occupies reef flats or shallow water along outer reef edge in up to 10 m depths; reported in SB during biodiversity sampling (Kangas et al. 2007)
Boat strikes: Air-breathing megafauna (Cetaceans, dugongs, marine turtles)	Scored as high productivity across all categories as per most precautionary species							Low	Low	Low	Likely to survive due to low trawl speed	Trawl speed very low (3-4 knots), allows for avoidance of large megafauna; no boat strikes reported in recent years

Table 2: Results of PSA for SBPMF

Species/Group	Productivity								Susceptibility					PSA Score	MSC Score
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy	Trophic level	**Total Productivity**	Availability	Encounterability	Selectivity	Post-capture mortality	**Total Susceptibility**		
Western king prawns (*Penaeus latisulcatus*)	1	1	1	1	1	1	2	1.14	1	3	3	3	1.65	2.01	94.8
Brown tiger prawns (*Penaeus esculentus*)	1	1	1	1	1	1	2	1.14	1	3	3	3	1.65	2.01	94.8
Coral prawns (*Metapenaeus* spp., *Metapenaeopsis* spp.)	1	1	1	1	1	1	2	1.14	1	3	3	3	1.65	2.01	94.8
Endeavour prawns (*Metapenaeus endeavouri*)	1	1	1	1	1	1	2	1.14	1	3	3	3	1.65	2.01	94.8
Blue swimmer crab (*Portunus armatus*)	1	1	1	1	1	1	2	1.14	1	3	3	3	1.65	2.01	94.8
Coral crab (*Charybdis feriata*)	1	1	1	1	1	1	2	1.14	1	3	3	3	1.65	2.01	94.8
Bugs (*Thenus orientalis*)	1	1	1	1	1	1	2	1.14	1	3	3	3	1.65	2.01	94.8
Cephalopods (cuttlefish, squid, octopus)	1	1	3	1	1	2	3	1.71	1	2	3	3	1.43	2.23	90.8
Whiting (*Sillago* spp.)	1	1	1	1	1	1	2	1.14	1	3	3	3	1.65	2.01	94.8
Flounder (Bothidae)	1	1	1	1	1	1	3	1.29	1	3	3	3	1.65	2.09	93.4
Flathead (Platycephalidae)	1	2	1	1	2	1	3	1.57	1	3	3	3	1.65	2.28	89.7
Mulloway (*Argyrosomus japonicas*)	2	3	1	3	3	1	3	2.29	1	3	3	3	1.65	2.82	74.2

Species/Group	Productivity								Susceptibility					PSA Score	MSC Score
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy	Trophic level	**Total Productivity**	Availability	Encounterability	Selectivity	Post-capture mortality	**Total Susceptibility**		
Saucer scallop (*Amusium balloti*)	1	1	1	1	1	1	1	1.00	1	3	3	2	1.43	1.74	98.2
Fan scallop (*Annachlamys flabellate*)	1	1	1	1	1	1	1	1.00	1	3	3	2	1.43	1.74	98.2
Other portunid crabs (*Portunus robromarginatus*)	1	1	1	1	1	1	2	1.00	1	3	3	2	1.43	1.74	98.2
Asymmetrical goatfish (*Upeneus asymmetricus*)	1	1	1	1	1	1	3	1.29	1	3	3	3	1.65	2.09	93.4
Hair-finned leatherjacket (*Paramonacanthus choirocephalus*)	1	1	1	1	1	1	2	1.14	1	3	3	3	1.65	2.01	94.8
Trumpeter (*Pelates quadrilineatus*)	1	1	1	1	1	2	3	1.43	1	3	3	3	1.65	2.18	91.7
Scorpionfish (*Paracentropogon vespa*)	1	1	1	1	1	2	2	1.29	1	3	3	3	1.65	2.09	93.4
Threadfin emperor (*Lethrinus genivittatus*)	1	1	1	1	1	2	3	1.43	1	3	3	3	1.65	2.18	91.7
Orange-spotted toadfish (*Torquigener pallimaculatus*)	1	1	1	1	1	2	3	1.43	1	3	3	3	1.65	2.18	91.7
Goodlad's stinkfish (*Callionymus goodladi*)	1	1	1	1	1	1	3	1.29	1	3	3	3	1.65	2.09	93.4
Large-scaled grinner (*Saurida undosquamis*)	1	1	1	1	1	1	3	1.29	1	3	3	3	1.65	2.09	93.4

Species/Group	Productivity								Susceptibility					PSA Score	MSC Score
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy	Trophic level	**Total Productivity**	Availability	Encounterability	Selectivity	Post-capture mortality	**Total Susceptibility**		
Dolphins, general (Dolphinidae)	2	3	3	3	3	3	3	**2.86**	1	1	1	2	**1.03**	**3.04**	**66.0**
Dugong (*D. dugong*)	2	3	3	3	3	3	2	**2.71**	1	1	1	2	**1.03**	**2.90**	**71.2**
Green turtle (*Chelonia mydas*)	3	3	3	3	3	3	2	**2.86**	1	2	1	1	**1.03**	**3.04**	**66.0**
Loggerhead turtle (*Caretta caretta*)	3	3	3	3	3	3	3	**3.00**	1	2	1	1	**1.03**	**3.17**	**60.3**
Sygnathids, general (*Hippocampus* spp.)	1	1	3	1	1	3	3	**1.86**	1	2	3	3	**1.43**	**2.34**	**88.3**
Short-nosed sea snake (*Aipysurus apraefrontalis)*	2	2	3	1	2	3	3	**2.29**	1	2	3	2	**1.28**	**2.62**	**80.8**
Sea snakes, general (Subfamily Hydrophiinae)	2	2	3	2	2	3	3	**2.43**	1	2	3	2	**1.28**	**2.74**	**76.8**
Indirect impacts on air-breathing megafauna (e.g. boat strikes)	3	3	3	3	3	3	3	**3.00**	1	1	1	2	**1.03**	**3.17**	**60.3**

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Appendix B: History of Prawn Fishing and Key Management Changes in Shark Bay

Fishing History

Details of the early history of the fishery are provided in Slack-Smith (1978). The following represents a summary of the management history of the Shark

Bay prawn fishery:

- 1962: the Shark Bay prawn fishery commenced with 4 boats recording catch.
- 1963: the limited entry management system was introduced, however, no formal season opening or closure of the fishery or daily time restrictions for fishing operations. Logbooks were issued to fishers. The number of boats was limited to 25 but only 9 boats were built for the purpose of trawling (Slack-Smith 1963). Fisheries Research logbooks were issued to collect detailed prawn catch and effort and spatial information.

  Prawn boats at this stage varied considerably in size and construction. Some boats were built in Western Australia and were steel construction approximately 50 ft (15 m) in length, several wooden trawlers from Queensland and boats used in both the lobster fishing and prawn trawl industry and they ranged from 42 to 70 ft in length (13 to 21 m).

  Some areas where there were known abundance of small size prawns were closed to all trawling in the southern part of the bay (Slack-Smith 1969) thus the introduction of permanently closed nursery areas. Areas south of the lines from east of Cape Peron and Cape Bellefin were closed to trawling.
- 1964: the number of fishing boats was increased to 30.
- 1966: from this year boats were constructed primarily as twin rigged trawlers.
- 1968 and 1969: Nor West Whaling Company continued to introduce large twin rigged boats to the fishery.
- 1970: boats commenced fitting radar navigational systems.
- 1975: fishing boats numbers increased to 35 boats.
- 1977: most of the boats were replaced by boats larger than 21metres.
- 1978: introduction of an Extended Nursery Area (ENA) commencing at Cape Peron then in a north easterly direction to the mainland. The ENA is closed until 15 April each season (Figure 2).
- There were no management changes between 1979 and 1981.

- 1982: the extent of the temporary closed ENA was increased and was enclosed by a line commencing at Cape Peron then due north to the intersection of 25º 15.2' south latitude and 113º 30.6'east longitude, then due east to Denham's Hummock on the mainland (Figure 3). The larger extended nursery area had the desired effect of reducing the catch of small size prawns and improving the overall value of the catch taken.
    - The month of January was declared a total closure of the fishery.
    - April 15: ENA opened; December 10: fishing season closed. Closure of the season was introduced.
- 1983: A more formal opening and closing of the prawn season was introduced and was judged to be successful by the Industry (Figure 4).
    - March 1: Prawn season opened
    - April 15: ENA opened
    - August 1: Experimental closure date for the ENA introduced
    - November 1: Season closed
- 1984 to 1986: The season and the ENA opening and closing dates remained the same as those implemented in 1983.
- 1986: The ENA was temporarily closed (23 April to 11 May) because of the small size prawns. The decision was based on survey information obtained during a survey undertaken within the ENA. The closure and later opening of the ENA resulted in a reduction of the take of small-sized prawns.
- 1987: Fishing strategy changed as the season opened based on lunar phase (Figure 5).
    - March 7: Season opened
    - April 21: ENA opened
    - August 1: ENA closed
    - November 7: Season closed
    - The introduction of voluntary moon closures (5 to 7 days around the full moon). The permanent nursery area was extended. A 7-mile arc, from Cape Peron North was introduced with the line then extending at the intersection of the line due east to the mainland.
- 1988:
    - March 21: Season opened

- April 15: ENA opened
    - November 15: Season closed
    - A change in the daylight fishing hours to allow 24 hour fishing in the deeper waters north of Koks Islands (Figure 6).
- 1989: Fishing was restricted to the area north of a line from due west of Carnarvon.
    - April 15: season opened
    - April 25: all fishing grounds open (including ENA)
    - August 1: ENA closed
    - November 15: season closed
    - The 7 mile arc was increased to 9 nm. The Carnarvon Line (24° 52.75') was introduced (Figure 7).
- 1990:
    - April 11: season opened
    - Fishing restricted to north of Carnarvon Line between 11 April to 18 April.
    - April 18: all fishing areas open (including ENA)
    - April 27: part of ENA closed (area 3 nm south of the Lombardo line; Figure 8).
    - May 15: closed section of ENA re-opened
    - A Voluntary Fishery Adjustment Scheme was implemented whereby eight boats were removed from the fishery reducing the boat numbers from 35 to 27.
- 1991:
    - March 7: season opened
    - May 6: Carnarvon/Peron line opened
    - The Carnarvon Line was modified so that fishing could be undertaken south of 25° 52.75' and west of a boundary line from Cape Peron to the intersection of 25° 52.75' and 113° 19.4', then in a south east direction to Cape Peron. The prawns west of the Carnarvon/Peron Line (CPL) are generally large size, as some were residual prawns and the more mature prawns from this season's recruitment are available at the commencement of the season. This modification of the CPL allowed fishing boats to access these prawns (Figure 9).

- June 5: ENA opened
- August 1: ENA closed
- October 23: Season closed
- Moon closures were re-introduced but were restricted to three days each.
- Boats commenced fitting GPS.

- 1992: implementation of the Dorre Islands Recreational Closure
  - Closure of Denham Sound between May and August (Figure 10).
  - All boats with GPS
- 1996: Net standardisation for all the pawn boats and rigged with two 8-fathom nets for a total fleet headrope length of 432 fathoms.
  - The Dorre Island Recreational Closure increased in size to include Bernier Island. All the waters east of these islands to the boundary are closed to trawling.
  - Tiger Prawn Spawning Area (TPSA) closure implemented (Figure 11).
- 1998: The Torbay Line was introduced in Denham Sound to control fishing to small size prawns in the early part of the season (March/April; Figure 12).
- 2000: a Research/ Industry closure implemented in Denham Sound to control the extent of area trawled for the entire season to protect small size prawns in the southern part of Denham Sound. The Torbay line closure and the closed fishing period between May to August was still in force (Figure 13).
- 2001: the nursery line east of Peron Peninsular was modified with the arc removed and position co-ordinates were provided because boats had GPS (compared to earlier years with radar). The nursery area northern boundary line was shifted further north by 1.6 nm because of the presence of small size prawns. The TPSA was split in two parts, northern and southern areas. The southern part was increased in size to include more area where spawning tiger prawns were abundant (Figure 14).
  - The TPSA is closed at a catch rate level rather than an arbitrary date. The TPSA was closed 19 June at a mean catch rate level of 10.2 kg / hr. based on the catch rate level.
- 2002:
  - The new southern TPSA area is the current defined area. The TPSA closed at a mean catch rate level of 15.5 kg / hr.

- 2003: the northern part of the TPSA was removed as it did not appear to provide any protection to the take of tiger prawn because of low fishing effort in the latter part of the season in the area (Figure 15). The TPSA was closed May 21 at a mean catch rate of 26.8 kg / hr.
    - A pre-season survey of king prawns commenced in collaboration with industry to assist with developing harvesting strategies.
- 2004: the Snapper trawl closure area was implemented in Denham Sound. The TPSA closed on May 26 at the catch rate level of 20.3 kg / hr. Wooramel seagrass banks closure implemented.
- 2005: four boats trialed quad gear (4x 5.5 fathom nets) and the fleet boat numbers were reduced from 27 to 25.
- 2006: five boats continued trialling quad gear but the fleet boat numbers remained at 25
- 2007: all prawn boats towed quad gear (4x 5.5 fathom nets) and the total number of boats fishing was reduced to 18.

Restructuring and gear amalgamation within the prawn fleet over the years has reduced the number of boats actively fishing from 35 to 27 (1990) and further reduced to 18 (in 2007) which was formalised through a FVAS in 2011.

The maximum net head rope length is 432 fathoms, but only 396 is currently being utilised.

Real-time Management to protect breeding stock and optimise resource use is in place. Since 2003, the season arrangements involve flexible fishing strategy and voluntary industry closures and openings based on an assessment of king and tiger prawn size and catch rates through fishery-independent surveys.

A flexible system for managing the harvest of prawns is required to account for the high inter and intra-annual variability in stock abundance levels and fishing activity. “Real time management” is a process that underpins the regulatory framework for the fishery to enable a highly consultative and reactive process between industry and the DoF to occur, which accounts for the high spatial and temporal variability in prawn abundance from year to year. The objective of the real time management framework is to avoid excessive depletion of the breeding stock (recruitment overfishing) and to optimise yield for the fishery each year (e.g. avoid growth overfishing).

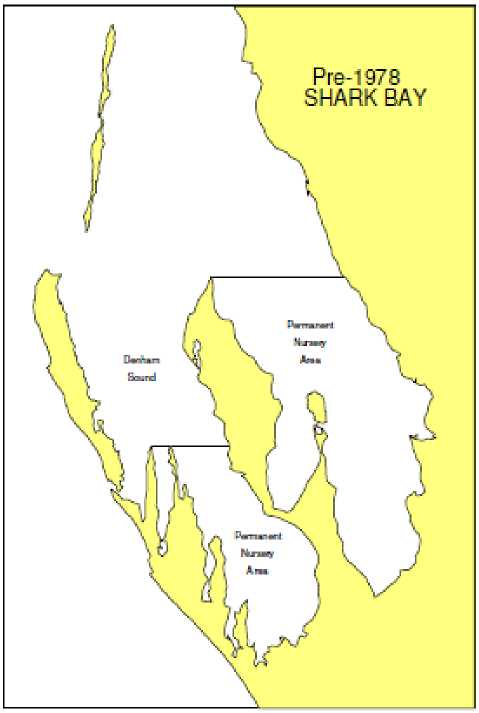

Figure 1. **Pre-1978 closures lines (nursery areas only)**

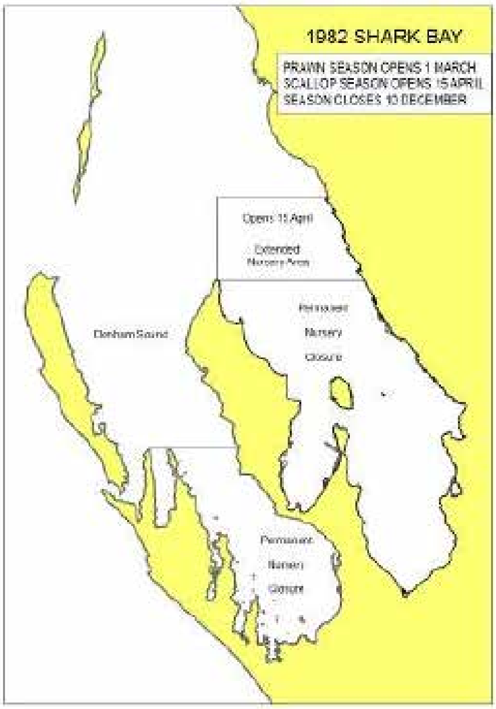

Figure 3. **1982 Further expansion of the ENA**

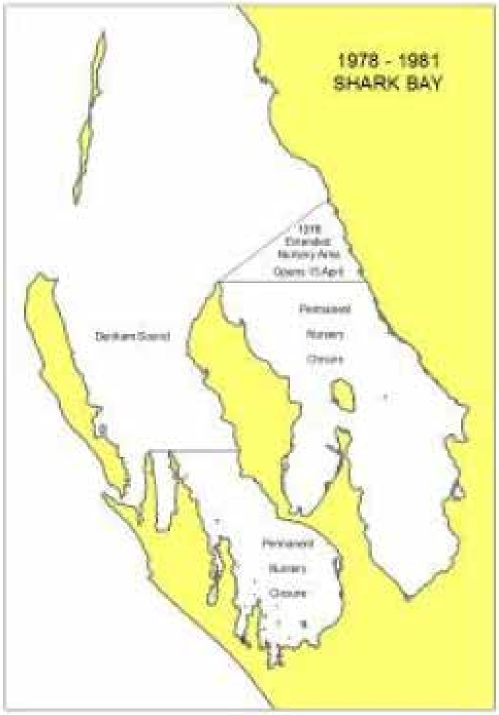

Figure 2. **1978: Introduction of the extended nursery area (ENA)**

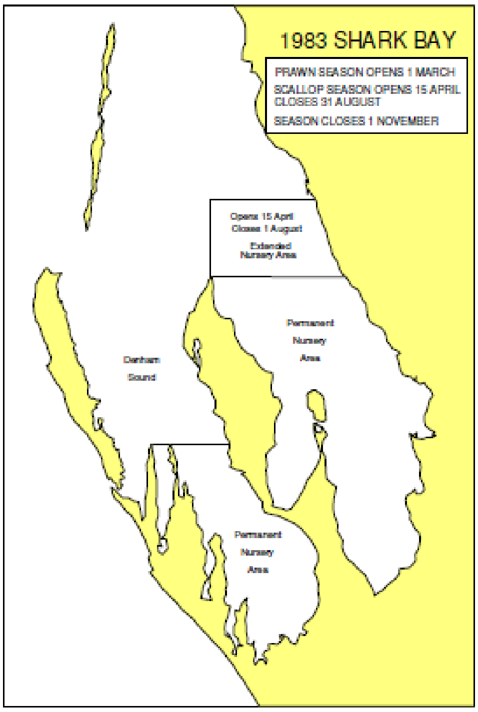

Figure 4. **1983: Introduction of formal season opening and closing dates**

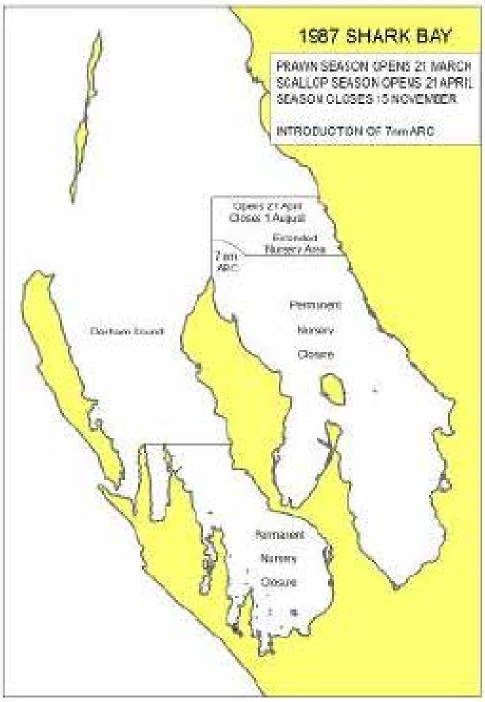

Figure 5. **1987: Introduction of lunar phased openings and closings and increase of the nursery area with the 7 nm arc.**

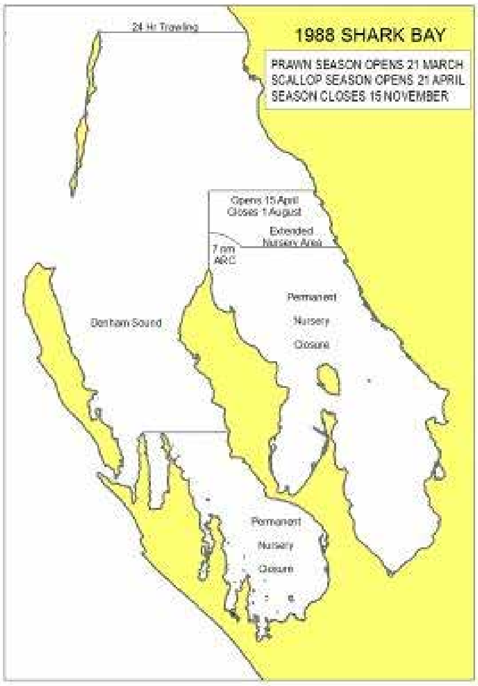

Figure 6. **1988: Introduction of 24 hour trawling north of Koks Island.**

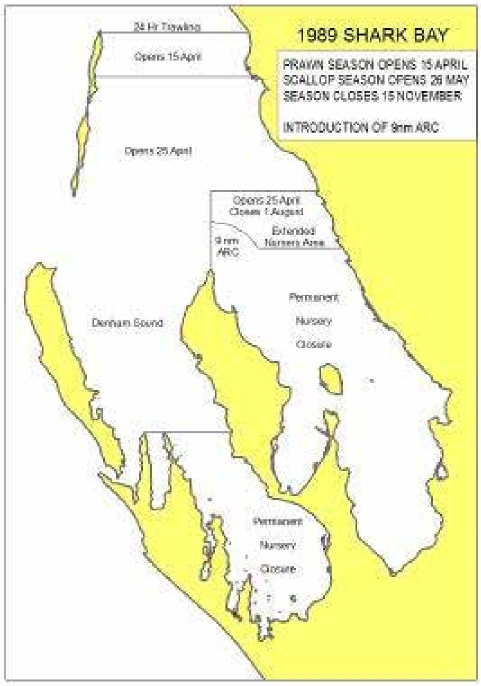

Figure 7. **1989: Introduction of Carnarvon Line and increase in nursery area by 9 nm arc.**

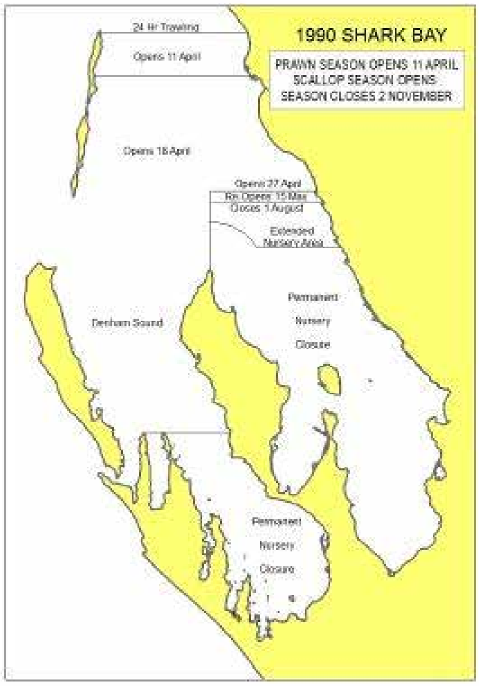

Figure 8. **1990: Partial closures of the Extended Nursery Area (ENA).**

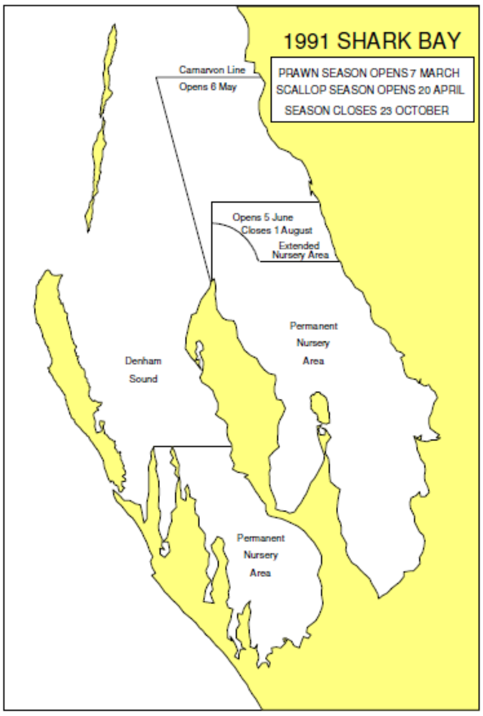

Figure 9. 1991: Re-alignment of the Carnarvon Line to tbe the Carnarvon-Peron Line (CPL).

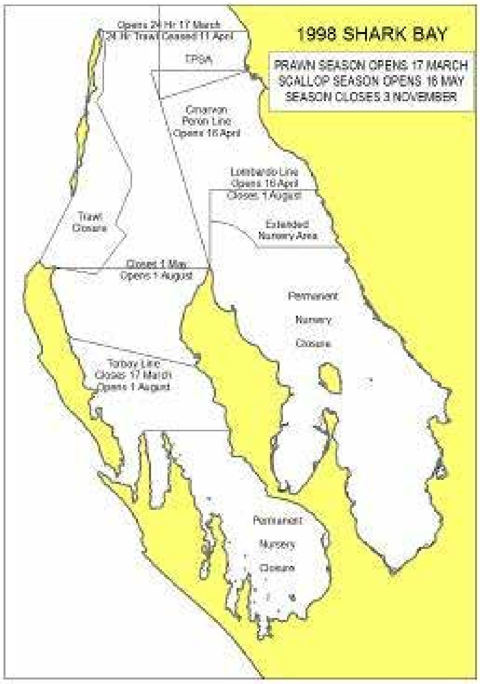

Figure 11. 1996: The Dorre Island recreation closure increased to include Bernier Island and becomes a total trawl closure. TPSA closure implemented.

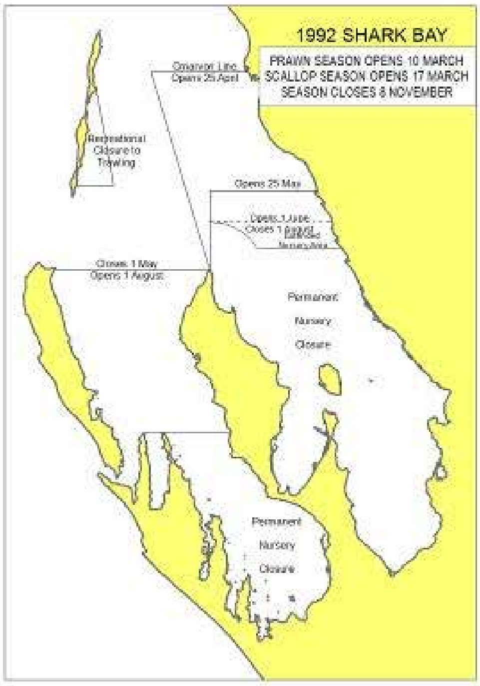

Figure 10. 1992: Introduction of the Dorre Island recreational closure and Denham Sound closure between May and August.

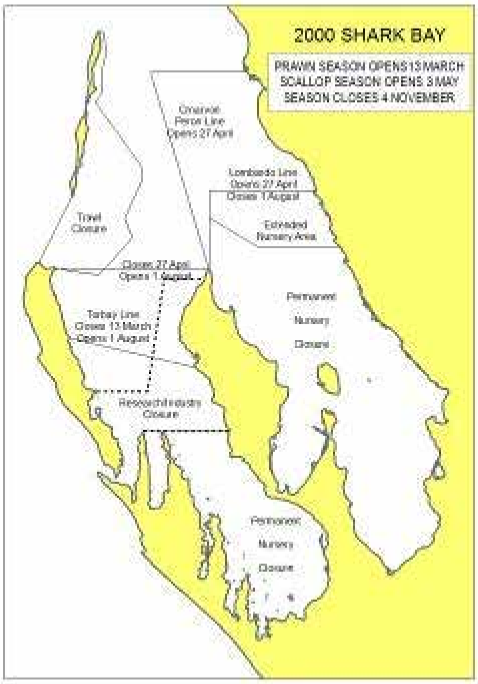

Figure 12. 1998: Introduction of the Torbay Line.

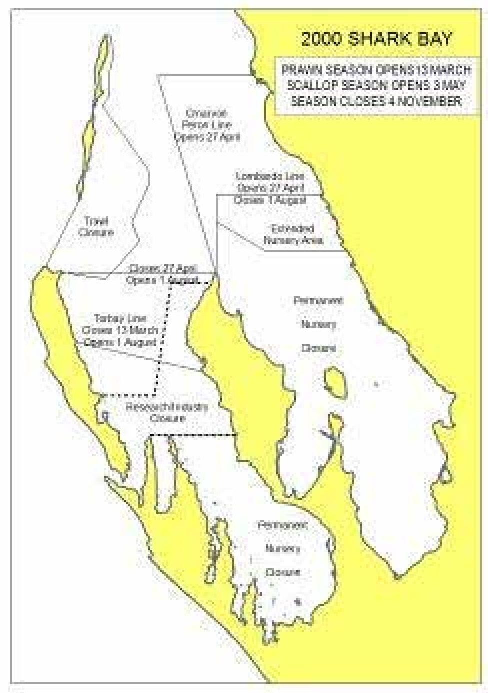

Figure 13. **2000: The Research/Industry closure in Denham Sound to protect small prawns.**

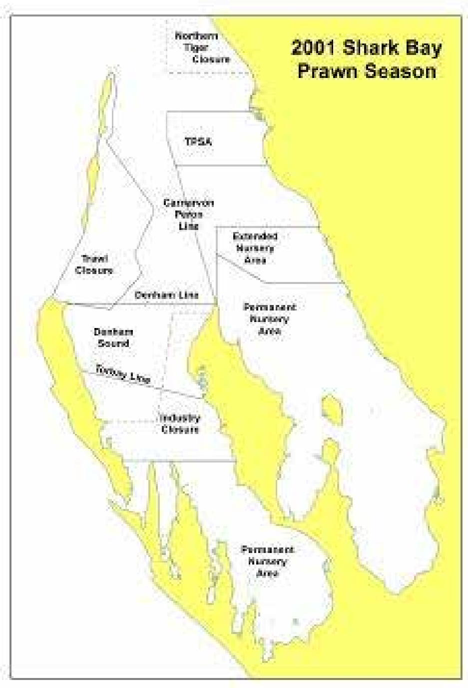

Figure 14. **2001: The 9 nm arc was modified and removed with position coordinates provided because of GPS. The TPSA was split into two parts, the northern closure and TPSA. Modification of CPL.**

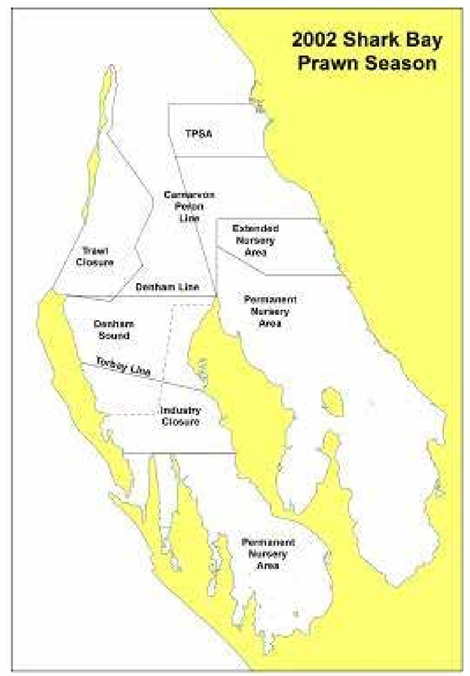

Figure 15. **2002: The northern TPSA was**

Appendix C: Fishing Efficiency Analysis

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Department of Fisheries

21 December 2009

Executive Summary

- Catch efficiency increase for quad gear (four 5.5 fathom nets) for total prawn catches is up to 6-9 % compared to twin gear (2 × 8 fathom nets) based on logbook data in 2006 after taking into account net size. The increase is mostly attributed to king prawns.

- No significant efficiency gain was observed for tiger prawn catch rates based on logbook data so the adjustment of the tiger prawn catch rate threshold only requires the increase in the amount of net being towed. The increase from 16 fathoms (2 × 8 fathom nets) to 22 fathoms (4 × 5.5 fathoms) is 37.5 % .The amended tiger prawn catch rate threshold from 20 kg / hr twin gear is therefore 27 kg / hr quad gear with a range of 25 to 30 kg / hr.

- Direct comparison of a quad and twin gear boats catch rate/fathom/distance trawled during surveys in April and August 2006, for specified survey sites (total of 33 sites) showed a 12.5 % increase in catch efficiency for king prawns and tiger prawns but was not statistically significant.

- The 8 % reduction in overall headrope allocation currently used in the Shark Bay Prawn fishery for converting twin to quad gear is precautionary but appropriate.

Introduction

In 2005, the NW Seafoods Pty. sought to trial quad gear (four 5.5-fathom nets) in the Shark Bay Prawn fishery using four boats in the trial. For each of these vessels, there was a 37.5 % increase in overall net towed using 22 fathoms of net head rope in quad gear configuration compared to standard twin nets (16 fathoms). Consequently, two of the 15 boats were removed from the fishery for that year, so that no additional head rope was being towed in the fishery. In 2006, one additional boat towed four 5.5-fathom nets, with another two boats being removed from the NW Seafoods fleet. The remaining boats in the fishery, in both years, towed two 8-fathom nets. Comparison of the overall performance was made between boats towing quad (4 nets with 5.5 fathoms head-rope) and twin gear (2 nets with 8 fathoms head-rope).

Methods

The catch rate (kg/fathom of net) for king and tiger prawns combined per fishing month was compared in 2005 for twin and quad gear. Secondly, the combined king and tiger prawn catch rates and the separate king and tiger prawns catch rates were compared for specified fishing periods in 2006. Analysis of Variance (ANOVA) was performed on the datasets, and the resulting least mean squares (LMS) presented. Comparisons were made monthly for the whole season for kings prawns and for the first three months of the fishing season only for tiger prawns, as after this period tiger prawn catch rates are very low.

These comparisons will be used to establish a conversion ratio for twin to quad gear to allow for an adjustment of the tiger prawn catch rate threshold (20 kg / hr for twin gear) and a basis for comparing historic catch rates with current catch rates with quad gear for the different species.

The standardised catch rate (kg prawns/hr/fathom of net) were compared for two boats which sampled the same survey sites during recruitment surveys in 2005 and one recruitment survey and one spawning stock survey in 2006. For the 2006 surveys, the catch rate per/fathom of net/nm trawled was also compared due to differences in the towing speed of the two boats during the surveys.

Data Standardisation

The fishing efficiency of the different boats was compared initially. This was achieved by using 2003 and 2004 logbook data; the most recent period in which all boats used the same gear (twin nets) and comparing year, fishing ground, month and interactions between these factors by Analysis of Variance (ANOVA). The ANOVA on the log-transformed catch of kilogram per trawling hour (CPUE) identified differences in the fishing efficiency between boats (Table 1, $P < 0.01$) and therefore the data were standardised for fishing efficiency before analysing for gear type effect.

Commercial Catch Data

For 2005, all the commercial catch data were used comparing monthly mean catch rates of twin gear boats to the monthly mean catch rates of the four quad gear boats taking into account the fishing grounds being fished (ANOVA).

For 2006, the data used was restricted to the following periods: 22 April – 27 April; 24 May – 29 May; 22 June – 26 June; 20 July – 24 July; and 18 August – 28 August. These periods represent times when the fleet generally fished together. Since the fleet were fishing together for these selected time periods, it is assumed that the same area has been fished over that period and hence, month and area are confounded. Therefore, only month is used in the ANOVA on the kg of catch per trawling hour (CPUE).

Based on the previous ANOVA, the ranking of each boat was determined. The catch per unit effort (CPUE) data were then standardised to be a ratio of the most efficient boat in the fleet. In this way, the effect of boat fishing efficiency was removed from the data, and any difference in fishing gear (twin or quad) could be estimated.

2005 and 2006 Surveys

Direct comparisons were made (t-tests) of the catch per unit effort (standardised for fathom of net) of king and tiger prawns caught for each sampling site (20 sites) in the eastern gulf surveys in March and April 2005 and April 2006 and in the tiger prawn spawning area (TPSA; eight sites) in 2006 between twin (two x 8 fathom nets) and quad (four x 5.5 fathom nets) gear.

A comparison of tiger prawn and king prawn landings per hour and nm trawled for two boats was made for April and August 2006 for 33 survey sites (TPSA and Denham Sound).

Results

Data Standardisation

All factors were significantly different between boats and years for 2003 and 2004 (Table 1).

Table 1. ANOVA of log (x+1) transformed CPUE of prawns for years 2003 and 2004.

Factor	Df	SS	MS	F	P
Year	1	732.9	132.9	25.34	< 0.01
Fishing ground	19	7177.1	377.7	13.06	< 0.01
Month	7	27717.6	3959.7	136.89	< 0.01
Vessel	27	16916.0	626.5	21.66	< 0.01
Year*Fground	18	1068.5	59.4	2.05	< 0.01
Year*Month	7	763.5	109.1	3.77	< 0.01
Fground*Month	101	42402.3	419.8	14.51	< 0.01
Year*Fgound*Month	80	17255.3	215.7	7.46	< 0.01
Residuals	32334	935318.8	28.9		

The boats were ranked according to mean CPUE (not shown due to confidentiality), and these rankings were used in subsequent analyses.

2005 Logbook Data

Overall for 2005 there was a significant difference between net gear configuration, fishing ground and month (Table 2) with the twin boats being more efficient than quad boats (Table 3), catching an extra 10.1 % of prawns per hour per fathom of net on average in 2005. However, when fishing months were compared (Table 4), the efficiency of quad boats improved towards the end of the season and became higher than the twin boats.

Table 2. **ANOVA of log (x+1) transformed catch rate of prawns (all prawns combined) for restricted dates. Type 3 sum of squares have been used and the observations have been weighted by their associated duration. Catch rate is defined as the weight of prawns (kg) caught per trawling hour per fathom of net.**

Factor	Df	SS	MS	F	P
Gear type	1	1414.9	1414.9	83.30	< 0.01
Fishing ground	17	3491.0	205.4	12.09	< 0.01
Month	7	4072.8	581.8	34.26	< 0.01
Fground*Month	89	15749.3	177.0	10.42	< 0.01
Residuals	11503	195381.7	17.0		

Table 3. **The LSM of CPUE (kg of prawn per hour trawled per fathom of net)**

		95 % Confidence Interval	
Gear type	**Mean**	**Lower**	**Upper**
2 x 8	2.18	2.08	2.30
4 x 5.5	1.96	1.85	2.07

Table 4. **The LSM of CPUE (kg of prawn per hour trawled per fathom of net) by gear type and fishing month and estimated net efficiency (% quad net efficiency difference) by fishing month**

Month	2 x 8	4 x 5.5	Efficiency
3	2.179	2.026	-7
4	2.664	2.157	-19
5	2.786	2.355	-15.5
6	3.304	2.668	-19.2
7	2.128	2.267	6.5
8	1.642	1.442	-12.2
9	1.34	1.448	8.1
10	1.298	1.356	4.5

2006 Logbook Data

King and tiger prawns combined

Significant differences ($p < 0.01$) in CPUE were observed for both month and gear configuration (Table 5) for king and tiger prawns combined.

Table 5. ANOVA of the log (x+1) transformed catch rate (the weight of prawns [kg] caught per trawling hour per fathom of net) of king and tiger prawns for restricted dates. Type 3 Sum of Squares have been used, and the observation have been weighted by duration.

Factor	Df	SS	MS	F	P
Month	4	15259.3	3814.8	332.1	< 0.01
Gear type	1	185.0	185.0	16.1	< 0.01
Month*Gear type	4	32.9	8.2	0.7	< 0.01
Residuals	4386	50381.6	11.5		

The month-effect on efficiency that was apparent in 2005 was not observed in 2006 (both species combined; Table 6). However, it appears that generally there is an increase in efficiency with the quad gear this year associated with increased abundance (CPUE).

Table 6. Comparison of standarised catch rates for different gears and net efficiency (twin versus quad) for selected time periods in 2006 when all boats were fishing together.

Month	2 x 8	4 x 5.5	Efficiency
4	3.359	3.818	7.9
5	3.933	4.312	9.6
6	4.677	4.751	1.6
7	3.872	4.277	10.5
8	2.018	2.155	6.8

The efficiency estimates for the restricted data set for CPUE during those periods of time when boats were fishing together using least-squares means (LSM) estimates for the two gear types (quad versus twin) indicate that the quad gear caught an extra 7.1 % of catch of prawns per hour per fathom of net (Table 7) for both species combined.

Table 7. The LSM of CPUE of king and tiger prawns combined (kg of prawn per hour trawled per fathom net) as determined by the preceding ANOVA.

		95 % Confidence Interval	
Gear type	**Mean**	**Lower**	**Upper**
2 x 8	3.51	3.44	3.58
4 x 5.5	3.76	3.64	3.89

King Prawns

Monthly king prawn catch efficiency is variable with a range of –3.42 to 40.98 (Table 8) with an overall increase in efficiency of 12.5% by quad gear (Table 9) on average for the whole season.

Table 8. Efficiency gain for king prawns when using quad gear compared to twin gear.

Month	2 x 8 estimate	Lower	Upper	4 x 5.5 estimate	Lower	Upper	Efficiency (%)
4	1.75	1.63	1.88	2.47	2.20	2.76	41.0
5	2.64	2.48	2.81	3.21	2.90	3.56	21.7
6	3.74	3.52	3.98	3.61	3.23	4.02	-3.4
7	3.77	3.53	4.02	4.02	3.57	4.51	6.6
8	1.83	1.73	1.94	1.90	1.72	2.10	4.0

Table 9. The LSM of king prawn CPUE (kg of prawn per hour trawled per fathom net) as determined by preceding ANOVA.

		95 % Confidence Interval	
Gear type	**Mean**	**Lower**	**Upper**
2 x 8	2.64	2.58	2.70
4 x 5.5	2.97	2.85	3.08

Tiger Prawns

Tiger prawn catch efficiency was also variable with a range between -10.42 to 27.60 (Table 10); however, there was no significant difference in catch efficiency on average for the first three months of the fishing season (Table 11).

Table 10. Efficiency gain for tiger prawns when using quad gear compared to 2 x 8 nets.

Month	2 x 8 estimate	Lower	Upper	4 x 5.5 estimate	Lower	Upper	Efficiency (%)
4	1.53	1.42	1.65	1.25	1.08	1.45	-18.0
5	1.09	1.00	1.20	0.98	0.83	1.15	-10.4
6	0.84	0.75	0.93	1.07	0.89	1.26	27.6

Table 11. The LSM of tiger prawn CPUE (kg of prawn per hour trawled per fathom net) as determined by the preceding ANOVA.

		95 % Confidence Interval	
Gear type	Mean	Lower	Upper
2 x 8	1.14	1.09	1.19
4 x 5.5	1.10	1.01	1.19

2005 and 2006 Surveys

The difference in CPUE (kg of prawn per hour trawled per fathom net) of king and tiger prawns from March and April surveys in 2005 and April and July surveys in 2006 were highly variable (Table 12). For all surveys combined king prawn catch efficiency was up 4 % and tiger prawn catch efficiency was up 2 % for quad gear but these were not significant (Table 13).

Table 12. The % difference between CPUE (kg of prawn per hour trawled per fathom net) for king and tiger prawns for one quad boat compared to a twin gear boat during prawn surveys in 2005 and 2006. *P* shows the probability level.

	King Prawns				Tiger Prawns			
Survey	Mar05	Apr05	Apr06	Jul06	Mar05	Apr05	Apr06	Jul06
% Diff. Quad	10.1	-2.8	1.9	21.2	-2.5	13.8	-4.4	-4.1
P	0.22	0.82	0.84	0.13	0.42	0.85	0.13	0.81

Table 13. **The % difference between CPUE (kg of prawn per hour trawled per fathom net) for king and tiger prawns for one quad boat compared to a twin gear boat during prawn for all surveys in 2005 and 2006 combined. *P* shows the probability level.**

	King Prawns	Tiger Prawns
% Diff. Quad	+4.0	+1.7
P	0.42	0.76

For April and August surveys in 2006, the catch rate per fathom of net including the distance trawled (nm) were compared for 33 sites for king prawns, 31 sites for tiger prawns and 30 sites for both king and tiger prawns combined. Although the quad gear boat was 12.5 % more efficient for both king and tiger prawns combined (15 % more efficient for king prawns on average compared to the twin gear boat and was 10 % more efficient for tiger prawns) these differences were not significant (Table 14).

Table 14. **The % difference between CPUE (kg of prawn per hour trawled per fathom net/nm trawled) for king and tiger prawns for one quad boat compared to a twin gear boat during prawn for April and August surveys 2006 combined. *P* shows the probability level.**

Survey	# Sites	2 x 8	4 x 5.5	Efficiency (%)	*P*
Apr ENA	16	0.885	0.989	10.5	0.204
Aug TPSA	6	0.186	0.228	19.5	0.087
Aug DS	8	0.389	0.477	19.4	0.166
All Surveys	30	0.613	0.700	12.5	0.104

Discussion

In 2005 when quad gear was initially trialled, improvement in catch efficiency was observed for skippers as the season progressed. This year was a learning phase for those skippers using quad gear and therefore the data collected provided useful insight into the learning process and did demonstrate that by the end of the season, even though prawn catch abundance was lower than at the start of the season, the quad boats were 4 – 6 % more efficient/fathom of net towed than the twin boats. In 2006, the improvement in overall catch efficiency during the season was not obvious, and it is likely that those skippers who had used quad gear in 2005 were already using quad gear effectively in 2006. In 2006, a higher efficiency is observed for king prawns during April and May, likely due to higher abundances during this time. Some increase in catch efficiency at higher prawn abundances was also evident.

Directly comparing two boats (one quad and one twin) over standardised survey sites did not show any significant difference for king or tiger prawn catch rates (or the two species combined), even though they were higher on average for the quad boat. The tow speed of the twin boat was faster than the quad boat covering 5-10 % more distance on average. Further analysis of catch rates per distance trawled during April and August 2006 indicated a 12.5 % catch efficiency increase for quad gear overall (king and tiger prawns combined) however this was not significant. Although a total of 68 sites were compared for catch rates between a single quad and twin boat during 2005 and 2006 surveys, only 30 sites could be compared for catch rate/nm trawled which is a more robust comparison due to varying trawl speeds of the survey boats.

When considering tiger prawns separately, there was no significant difference in catch efficiency of quad gear compared to twin. However, as tiger prawns are vulnerable to over fishing (regardless of gear type) the catch rate threshold to close the Tiger Prawn Spawning Area (TPSA) of 20 kg / hr for tiger prawns established for twin gear requires the 37.5 % increase related to the increase in net head rope length per boat to be incorporated for quad gear. The cut-off threshold to retain sufficient spawning stock needs to be adjusted to 27.5 kg / hr with a range between 25 and 30 kg / hr. The closure of the TPSA at the catch rate threshold level of 20 kg / hr for twin gear or 27 kg / hr for quad gear will continue to be monitored. This is to ensure protection of the tiger prawn spawning stock.

It must be recognised, however, that the datasets used to determine changes in catch rate and fishing efficiency are limited for both the logbook data and surveys. For the logbook data, this is due to only four boats towing quad gear in 2005 and the availability of comparable data for only those time periods when boats were fishing together in similar areas in 2006. Only 30 survey sites could to be directly compared for king and tiger prawn catch rates during April and August 2006 for two boats.

The percentage increase in moving from twin to quad gear for king and tiger prawns combined using logbook data is 7 % with a range of 6-9 % whereas the direct boat comparisons indicated a slightly higher level of 12.5 %. Therefore the current reduction in overall net allowance in the fishery of approximately 8 % is within this range.

Appendix D: Daily Trawl Logbook Sheet

YOU ARE REQUIRED BY LAW TO FILL IN THIS FORM CORRECTLY.
(REFER TO EXPLANATORY NOTES)

Prawn Trawl Log Sheet

Date (Date of the Day Trawling Commences)	Boat name	Skipper (Name (print) and Signature)	Master CFL	Fishery (eg. Shark Bay, Exmouth Gulf, Onslow, Nickol Bay, Broome)
30.06.12	SUNRISE RAIDER	SHARON BROWN	61012	EXM GULF

Fishing Location (Please record the start latitude and longitude of **each** shot): Start Latitude eg. 25°10.36'	Start Longitude eg. 113°30.31'	Fishing Ground	Shot no.	Start Time in 24 Hour Clock (If 24hr fishing start new pg 0800hrs)	Duration in Minutes	Mean Depth of Trawl	King (☐ if Banana Please tick) U10	King U15	King U20	King	King	King S/B	Tiger U10	Tiger U15	Tiger U20	Tiger	Tiger	Tiger S/B	Endeavour	Total KTE	Ban	Cor	Sc	REMARKS (Eg. weather, jellyfish, weed, scallop meat count (No./lb). Please include avg. CTN weight in first days comments and when changes made.)
22 2.60	114 20.45	C	01	1830	180	30		5	10			2		50	75			20	5	167				
22 1.24	114 19.80	C	02	2200	160	27		10	15			3		75	90			25	10	228				
21 59.00	114 19.75	B	03	0100	180	26		10	15			1		60	70			20	5	181				
			04																					
			05																					
			06																					
			07																					
			08																					
			09																					
			10																					
			11																					
			12																					
			13																					
			14																					
			15																					

INDICATE KGS OR CARTONS — If catch is mainly Banana prawn, please substitute with King prawn grade column.

	King U10	King U15	King U20	King	King	King S/B	Tiger U10	Tiger U15	Tiger U20	Tiger	Tiger	Tiger S/B	Endeavour	Total KTE
Daily Total		25	40			6		185	235			65	20	576
Total Brought Forward	90	225	420	136		54	20	1600	2115	200		600	176	5636
Accumulated Total	90	250	460	136		60	20	1785	2350	200		665	196	6212

Water Temperature	21.3
Moon Phase	NEW MOON
Unload Date	
Unload Port	EXMOUTH
Re-fuel Date	
Litres of Fuel	
Crew No. this month (incl. skipper)	4

PERSONAL NOTES

PROTECTED MARINE SPECIES INTERACTIONS		Returned Alive	Dead
Turtles (species)	—		
Seasnakes (no.)	2	2	
Seahorses and pipefish (total no.)	—		
Interactions with other Protected Species	—		

DAILY BY-PRODUCT		B/F	TOTAL
Crab	20	125	145
Squid	10	90	100
Tuna			
C'fish	5	60	65
Bug	5	70	75
Please indicate Kg or CTN's (If CTN's please include weight)			

Appendix E: Bycatch RRAMP Risk Scores

List of Gascoyne Coast Bioregion teleost and elasmobranch species and their risk scores under varying weighted analyses in order of lowest to highest average risk. The columns show the different possibilities of priorities in the analysis. Parameters listed at the top of each column are considered the most important in that analysis and are double weighted. The 'none' column has no weighting. The 'ave' column is the average of the 12 columns with extra weighting. R: reproduction; F: fishing; C: conservation listing; M: management; D: depth; Di: distribution; Mo: mortality; S: size. Colours represent risk categories. Blue: low risk; Green: low-moderate risk; Yellow: moderate risk; Orange: moderate-high risk; Red: high risk (Source: Evans & Molony 2010)

			Parameters considered most important in analysis																
Family	**Common name**	**Species name**	**R&F**	**R&C**	**R&M**	**R& Di**	**R& Mo**	**D&F**	**D&C**	**D&M**	**D& Di**	**D& Mo**	**S&F**	**S&C**	**S&M**	**S& Di**	**S& Mo**	**None**	**Ave**
Sillaginidae	Whiting, Yellow-Finned (Western Sand)	*Sillago schomburgkii*	2.62	2.62	2.75	3.14	2.62	2.29	2.29	2.40	3.20	2.29	2.57	2.57	3.09	3.09	2.57	2.63	2.67
Monacanthidae	Leatherjacket, Hair-finned	*Paramonacanthus choirocephalus*	3.00	2.43	2.50	2.43	3.00	3.00	2.43	2.50	2.57	3.00	3.00	2.43	2.86	2.43	3.00	2.67	2.70
Syngnathidae	Pipefish, Alligator	*Syngnathoides biaculeatus*	2.57	3.14	2.50	2.57	2.57	2.57	3.14	2.50	2.86	2.57	2.57	3.14	2.86	2.57	2.57	2.67	2.71
Lutjanidae	Brownstripe snapper	*Lutjanus vitta*	2.73	2.30	2.20	2.30	2.68	3.64	3.07	2.94	3.36	3.57	3.28	2.76	3.02	2.76	3.21	2.84	2.92
Monacanthidae	Leatherjacket, Bearded	*Anacanthus barbatus*	2.83	2.50	2.63	2.50	3.17	2.91	2.57	2.70	2.74	3.26	3.40	3.00	3.60	3.00	3.80	2.92	2.97
Monacanthidae	Leatherjacket, Pot-bellied	*Pseudomonacanthus peroni*	2.83	2.50	2.63	2.50	3.17	2.91	2.57	2.70	2.74	3.26	3.40	3.00	3.60	3.00	3.80	2.92	2.97
Syngnathidae	Seahorse, False-eyed	*Hippocampus biocellatus*	2.88	2.88	2.75	3.93	2.88	2.83	2.83	2.70	4.11	2.83	2.51	2.51	2.74	3.43	2.51	2.92	2.96
Syngnathidae	Pipefish, Spotted	*Stigmatopora argus*	2.88	3.40	2.75	3.40	2.88	2.51	2.97	2.40	3.20	2.51	2.83	3.34	3.09	3.34	2.83	2.92	2.96
Syngnathidae	Seahorse, Winged	*Hippocampus alatus*	2.86	3.43	2.75	3.14	2.86	3.14	3.77	3.03	3.77	3.14	2.57	3.09	2.83	2.83	2.57	3.00	3.05
Syngnathidae	Seahorse, Flat-face	*Hippocampus planifrons (trimaculatus)*	3.14	3.43	2.75	2.86	2.86	3.14	3.43	2.75	3.14	2.86	3.14	3.43	3.14	2.86	2.86	3.00	3.05
Syngnathidae	Seahorse, Zebra	*Hippocampus zebra*	2.86	3.43	2.75	3.14	2.86	3.14	3.77	3.03	3.77	3.14	2.57	3.09	2.83	2.83	2.57	3.00	3.05
Lutjanidae	Jobfish, Rosy (Rosy Snapper)	*Pristipomoides filamentosus*	2.57	2.57	2.75	2.57	2.86	3.86	3.86	4.13	4.71	4.29	3.34	3.34	4.09	3.34	3.71	3.33	3.47
Tetraodontidae	Toadfish, Orange-spotted	*Torquigener pallimaculatus*	3.33	2.83	2.92	3.00	3.50	4.00	3.40	3.50	3.80	4.20	3.43	2.91	3.43	3.09	3.60	3.33	3.40

Family	Common name	Species name	R&F	R&C	R&M	R& Di	R& Mo	D&F	D&C	D&M	D& Di	D& Mo	S&F	S&C	S&M	S& Di	S& Mo	None	Ave
Syngnathidae	Pipefish, Ribboned	*Haliichthys taeniophorus*	3.10	3.71	2.98	3.40	3.10	3.43	4.11	3.30	4.11	3.43	3.14	3.77	3.46	3.46	3.14	3.38	3.44
Syngnathidae	Pipefish, Short-tailed	*Trachyrhamphus bicoarctatus*	3.40	3.71	2.98	3.10	3.10	3.77	4.11	3.30	3.77	3.43	3.46	3.77	3.46	3.14	3.14	3.38	3.44
Gobiidae	Goby, Shadow	*Yongeichthys nebulosus*	4.05	3.57	3.75	3.57	4.52	3.40	3.00	3.15	3.20	3.80	3.40	3.00	3.60	3.00	3.80	3.50	3.52
Leiognathidae	Ponyfish, Zig-Zag	*Leiognathus moretoniensis*	3.24	2.86	3.00	2.86	3.62	4.37	3.86	4.05	4.11	4.89	3.40	3.00	3.60	3.00	3.80	3.50	3.58
Pomacentridae	Damsel, Gulf	*Pristotis obtusirostris*	3.24	2.86	3.00	2.86	3.62	4.37	3.86	4.05	4.11	4.89	3.40	3.00	3.60	3.00	3.80	3.50	3.58
Soleidae	Sole, Dark-Spotted	*Aseraggodes melanospilus*	4.05	3.57	3.75	3.57	4.52	3.40	3.00	3.15	3.20	3.80	3.40	3.00	3.60	3.00	3.80	3.50	3.52
Gerreidae	Roach/Banded Silver Biddy	*Gerres subfasciatus*	3.43	3.05	3.17	3.24	3.81	4.63	4.11	4.28	4.63	5.14	3.60	3.20	3.80	3.40	4.00	3.75	3.83
Monacanthidae	Leatherjacket, Fan-bellied	*Monacanthus chinensis*	3.62	3.05	3.17	3.05	3.81	4.34	3.66	3.80	3.89	4.57	4.34	3.66	4.34	3.66	4.57	3.75	3.83
Syngnathidae	Pipefish, Tiger	*Filicampus tigris*	3.40	4.02	3.25	4.02	3.40	3.77	4.46	3.60	4.80	3.77	3.46	4.09	3.77	4.09	3.46	3.75	3.82
Syngnathidae	Seahorse, Western Spiny	*Hippocampus angustus*	3.71	4.02	3.25	3.71	3.40	4.11	4.46	3.60	4.46	3.77	3.77	4.09	3.77	3.77	3.46	3.75	3.82
Tetraodontidae	Toadfish, Whitley's	*Torquigener whitleyi*	3.43	3.05	3.17	3.24	3.81	4.63	4.11	4.28	4.63	5.14	3.60	3.20	3.80	3.40	4.00	3.75	3.83
Siganidae	Spinefoot, White-spotted/ Smudgespot	*Siganus canaliculatus*	3.43	3.00	3.19	3.00	3.64	4.57	4.00	4.25	4.29	4.86	4.11	3.60	4.37	3.60	4.37	3.79	3.89
Lutjanidae	Stripey sea perch	*Lutjanus carponotatus*	4.09	3.47	3.30	3.47	4.15	4.53	3.84	3.66	4.18	4.59	4.15	3.52	3.83	3.52	4.21	3.83	3.90
Centrogenyidae	Rockcod, False Scorpionfish	*Centrogenys vaigiensis*	4.45	3.93	4.13	3.93	4.98	3.89	3.43	3.60	3.66	4.34	4.37	3.86	4.63	3.86	4.89	4.08	4.13
Leiognathidae	Ponyfish, Orangefin	Leiognathus bindus	3.64	3.21	3.38	3.21	4.07	5.34	4.71	4.95	5.03	5.97	3.89	3.43	4.11	3.43	4.34	4.08	4.18
Mullidae	Goatfish, Sunrise	*Upeneus sulphureus*	3.64	3.21	3.38	3.21	4.07	4.86	4.29	4.50	4.57	5.43	4.37	3.86	4.63	3.86	4.89	4.08	4.18
Mullidae	Goatfish, Bar-tailed	*Upeneus tragula*	3.64	3.21	3.38	3.21	4.07	4.86	4.29	4.50	4.57	5.43	4.37	3.86	4.63	3.86	4.89	4.08	4.18
Nemipteridae	Monocle Bream, False Whiptail	*Pentapodus porosus*	3.64	3.21	3.38	3.43	3.86	4.86	4.29	4.50	4.86	5.14	4.37	3.86	4.63	4.11	4.63	4.08	4.18

Family	Common name	Species name	R&F	R&C	R&M	R& Di	R& Mo	D&F	D&C	D&M	D& Di	D& Mo	S&F	S&C	S&M	S& Di	S& Mo	None	Ave
Synodontidae	Lizardfish, Netted	*Synodus sageneus*	3.64	3.21	3.38	3.21	4.07	4.86	4.29	4.50	4.57	5.43	4.37	3.86	4.63	3.86	4.89	4.08	4.18
Synodontidae	Lizardfish, Painted Grinner	*Trachinocephalus myops*	3.64	3.21	3.38	3.21	4.07	4.86	4.29	4.50	4.57	5.43	4.37	3.86	4.63	3.86	4.89	4.08	4.18
Tetraodontidae	Toadfish, Rough Golden	*Lagocephalus lunaris*	3.64	3.21	3.38	3.21	4.07	4.86	4.29	4.50	4.57	5.43	4.37	3.86	4.63	3.86	4.89	4.08	4.18
Serranidae	Cod, Flowery	*Epinephelus fuscoguttatus*	3.57	4.29	3.44	3.57	3.93	4.00	4.80	3.85	4.40	4.40	4.29	5.14	4.71	4.29	4.71	4.13	4.23
Sparidae	Bream, Western Yellowfin	*Acanthopagrus latus*	3.71	3.71	4.33	4.02	4.02	4.11	4.11	4.80	5.14	4.46	3.77	3.77	5.03	4.09	4.09	4.13	4.21
Centropomidae	Sand Bass	*Psammoperca waigiensis*	4.43	3.86	4.13	3.86	4.57	4.43	3.86	4.13	4.14	4.57	4.43	3.86	4.71	3.86	4.57	4.17	4.23
Leiognathidae	Ponyfish, Whipfin	*Leiognathus leuciscus*	4.07	3.43	3.56	3.43	4.29	5.43	4.57	4.75	4.86	5.71	4.89	4.11	4.89	4.11	5.14	4.38	4.48
Lutjanidae	Sharptooth jobfish	*Pristipomoides typus*	3.81	3.81	4.00	4.19	4.19	4.86	4.86	5.10	6.31	5.34	4.29	4.29	5.14	4.71	4.71	4.50	4.64
Pomatomidae	Tailor	*Pomatomus saltatrix*	3.67	3.40	3.90	3.40	3.93	4.80	4.46	5.10	5.14	5.14	5.20	4.83	6.31	4.83	5.57	4.50	4.65
Serranidae	Groper, Queensland	*Epinephelus lanceolatus*	3.81	4.57	3.67	3.81	4.19	4.29	5.14	4.13	4.71	4.71	4.86	5.83	5.34	4.86	5.34	4.50	4.62
Sparidae	Tarwhine	*Rhabdosargus sarba*	3.93	3.45	3.65	3.69	4.05	5.19	4.56	4.81	5.19	5.34	5.19	4.56	5.50	4.87	5.34	4.50	4.62
Lutjanidae	Seaperch, Saddle-tailed	*Lutjanus malabaricus*	4.67	4.00	3.79	4.00	5.00	5.20	4.46	4.23	4.83	5.57	5.20	4.46	4.83	4.46	5.57	4.58	4.68
Lethrinidae	Emperor, Yellow-Tailed	*Lethrinus atkinsoni*	4.45	4.45	5.31	4.45	4.86	4.40	4.40	5.25	5.20	4.80	4.09	4.09	5.57	4.09	4.46	4.58	4.66
Mullidae	Goatfish, Asymmetrical	*Upeneus asymmetricus*	4.50	3.64	3.75	3.64	4.50	6.00	4.86	5.00	5.14	6.00	5.40	4.37	5.14	4.37	5.40	4.67	4.78
Apogonidae	Cardinalfish, Cavite	*Apogon cavitiensis*	4.86	4.29	4.50	4.29	5.43	5.34	4.71	4.95	5.03	5.97	4.37	3.86	4.63	3.86	4.89	4.67	4.73
Apogonidae	Cardinalfish, Two-eyed	*Apogon nigripinnis*	4.86	4.29	4.50	4.29	5.43	5.34	4.71	4.95	5.03	5.97	4.37	3.86	4.63	3.86	4.89	4.67	4.73
Bothidae	Flounder, Intermediate	*Asterorhombus intermedius*	4.86	4.29	4.50	4.29	5.43	5.34	4.71	4.95	5.03	5.97	4.37	3.86	4.63	3.86	4.89	4.67	4.73
Bothidae	Flounder, Blue-spotted	*Crossorhombus azureus*	4.86	4.29	4.50	4.29	5.43	5.34	4.71	4.95	5.03	5.97	4.37	3.86	4.63	3.86	4.89	4.67	4.73

Family	Common name	Species name	R&F	R&C	R&M	R& Di	R& Mo	D&F	D&C	D&M	D& Di	D& Mo	S&F	S&C	S&M	S& Di	S& Mo	None	Ave
Clupeidae	Sardine, Gold-striped	*Sardinella gibbosa*	4.86	4.29	4.50	4.29	5.43	5.34	4.71	4.95	5.03	5.97	4.37	3.86	4.63	3.86	4.89	4.67	4.73
Cynoglossidae	Sole, Patterned Tongue	*Paraplagusia bilineata*	4.86	4.29	4.50	4.29	5.43	4.86	4.29	4.50	4.57	5.43	4.86	4.29	5.14	4.29	5.43	4.67	4.73
Pegasidae	Seamoth, Slender	*Pegasus volitans*	4.86	4.29	4.50	4.29	5.43	5.34	4.71	4.95	5.03	5.97	4.37	3.86	4.63	3.86	4.89	4.67	4.73
Platycephalidae	Flathead, Heart-headed	*Sorsogona tuberculata*	4.86	4.29	4.50	4.29	5.43	5.34	4.71	4.95	5.03	5.97	4.37	3.86	4.63	3.86	4.89	4.67	4.73
Platycephalidae	Flathead, Bar-tailed	*Platycephalus endrachtensis*	4.80	4.18	4.47	4.18	4.95	5.31	4.63	4.95	4.97	5.49	4.87	4.24	5.19	4.24	5.03	4.69	4.77
Terapontidae	Trumpeter, Striped/Six-lined	*Pelates sexlineatus*	5.29	4.43	4.63	4.71	5.14	5.81	4.87	5.09	5.50	5.66	4.76	3.99	4.76	4.24	4.63	4.83	4.90
Carangidae	Golden trevally	*Gnathanodon speciosus*	5.32	4.40	4.66	4.40	5.08	4.91	4.06	4.30	4.34	4.69	6.39	5.27	6.39	5.27	6.09	4.95	5.04
Tetraodontidae	Silverstripe blaasop	*Lagocephalus sceleratus*	4.50	3.72	3.94	3.72	4.30	5.90	4.87	5.16	5.21	5.62	6.39	5.27	6.39	5.27	6.09	4.95	5.09
Carcharhinidae	Shark, Dusky	*Carcharhinus obscurus*	5.14	5.79	5.06	5.14	5.14	4.34	4.89	4.28	4.89	4.34	5.03	5.66	5.66	5.03	5.03	4.96	5.03
Apogonidae	Cardinalfish, Many-banded	*Apogon brevicaudata*	5.14	4.57	4.75	4.86	5.71	5.66	5.03	5.23	5.66	6.29	4.63	4.11	4.89	4.37	5.14	5.00	5.07
Lethrinidae	Emperor, Sweetlip (Red Throat)	*Lethrinus miniatus*	4.67	4.33	4.96	4.67	4.67	5.20	4.83	5.53	5.94	5.20	5.20	4.83	6.31	5.20	5.20	5.00	5.12
Scorpaenidae	Scorpionfish, Long-finned Waspfish	*Apistus carinatus*	5.43	4.57	4.75	4.57	5.71	5.97	5.03	5.23	5.34	6.29	4.89	4.11	4.89	4.11	5.14	5.00	5.07
Scorpaenidae	Scorpionfish, Spot Fin Waspfish/ Bullrout	*Paracentropogon vespa*	5.43	4.57	4.75	4.57	5.71	5.97	5.03	5.23	5.34	6.29	4.89	4.11	4.89	4.11	5.14	5.00	5.07
Nemipteridae	Striped whiptail	*Pentapodus vitta*	4.76	3.90	3.98	4.54	4.37	6.34	5.20	5.30	6.34	5.83	5.71	4.68	5.45	5.45	5.25	5.02	5.14
Lethrinidae	Spangled Emperor	*Lethrinus nebulosus*	4.64	4.29	5.00	4.29	4.64	5.57	5.14	6.00	6.00	5.57	5.20	4.80	6.40	4.80	5.20	5.04	5.17
Bothidae	Flounder, Deep-bodied	*Pseudorhombus elevatus*	5.26	4.64	4.88	4.64	5.88	6.31	5.57	5.85	5.94	7.06	4.86	4.29	5.14	4.29	5.43	5.25	5.34

Family	Common name	Species name	R&F	R&C	R&M	R& Di	R& Mo	D&F	D&C	D&M	D& Di	D& Mo	S&F	S&C	S&M	S& Di	S& Mo	None	Ave
Carangidae	Trevally, Smooth-tailed	*Selaroides leptolepis*	5.26	4.64	4.88	4.64	5.88	5.83	5.14	5.40	5.49	6.51	5.34	4.71	5.66	4.71	5.97	5.25	5.34
Lutjanidae	Goldbanded jobfish	*Pristipomoides multidens*	5.24	4.76	5.00	4.76	5.24	5.97	5.43	5.70	6.51	5.97	5.34	4.86	5.83	4.86	5.34	5.25	5.39
Odontaspididae	Grey Nurse Shark	*Carcharias taurus*	5.33	6.00	5.25	5.33	5.33	4.80	5.40	4.73	5.40	4.80	5.26	5.91	5.91	5.26	5.26	5.25	5.33
Ostraciidae	Boxfish, Small-nosed	*Ostracion nasus*	5.26	4.64	4.88	4.64	5.88	5.83	5.14	5.40	5.49	6.51	5.34	4.71	5.66	4.71	5.97	5.25	5.34
Pinguipedidae	Grubfish, Red-barred	*Parapercis nebulosa*	5.26	4.64	4.88	4.64	5.88	5.83	5.14	5.40	5.49	6.51	5.34	4.71	5.66	4.71	5.97	5.25	5.34
Platycephalidae	Flathead, Northen Sand	*Platycephalus arenarius*	5.26	4.64	4.88	4.95	5.57	5.83	5.14	5.40	5.83	6.17	5.34	4.71	5.66	5.03	5.66	5.25	5.34
Scorpaenidae	Stinger, Spotted	*Inimicus sinensis*	5.26	4.64	4.88	4.64	5.88	5.83	5.14	5.40	5.49	6.51	5.34	4.71	5.66	4.71	5.97	5.25	5.34
Synodontidae	Brushtooth lizardfish	*Saurida undosquamis*	4.71	3.93	4.13	3.93	4.71	7.20	6.00	6.30	6.40	7.20	5.66	4.71	5.66	4.71	5.66	5.25	5.39
Terapontidae	Trumpeter, Banded	*Terapon theraps*	5.26	4.64	4.88	4.64	5.88	5.83	5.14	5.40	5.49	6.51	5.34	4.71	5.66	4.71	5.97	5.25	5.34
Labridae	Wrasse, Soela	*Suezichthys soelae*	4.86	4.86	5.00	6.00	6.00	5.34	5.34	5.50	6.91	6.60	4.37	4.37	5.14	5.40	5.40	5.33	5.41
Bothidae	Flounder, Spiny-headed	*Engyprosopon grandisquama*	5.88	4.95	5.15	4.95	6.19	7.06	5.94	6.18	6.31	7.43	5.43	4.57	5.43	4.57	5.71	5.63	5.72
Callionymidae	Dragonet, High-finned	*Synchiropus rameus*	6.43	5.71	5.94	6.07	7.14	5.66	5.03	5.23	5.66	6.29	5.14	4.57	5.43	4.86	5.71	5.63	5.66
Clupeidae	Sardine, Scaly Mackerel	*Sardinella lemuru*	5.57	4.95	5.15	5.26	6.19	6.17	5.49	5.70	6.17	6.86	5.66	5.03	5.97	5.34	6.29	5.63	5.72
Labridae	Tuskfish, Purple	*Choerodon cephalotes*	5.88	4.95	5.15	5.26	5.88	6.51	5.49	5.70	6.17	6.51	5.97	5.03	5.97	5.34	5.97	5.63	5.72
Lethrinidae	Emperor, Threadfin	*Lethrinus genivittatus*	6.19	4.95	5.15	4.95	5.88	6.86	5.49	5.70	5.83	6.51	6.29	5.03	5.97	5.03	5.97	5.63	5.72
Lutjanidae	Red Emperor	*Lutjanus sebae*	5.50	5.00	5.25	5.00	5.50	6.29	5.71	6.00	6.86	6.29	5.97	5.43	6.51	5.43	5.97	5.63	5.78
Platycephalidae	Flathead, Rusty	*Inegocia japonica*	5.88	4.95	5.15	4.95	6.19	6.51	5.49	5.70	5.83	6.86	5.97	5.03	5.97	5.03	6.29	5.63	5.72
Priacanthidae	Bigeye, Red	*Priacanthus macracanthus*	5.57	4.95	5.15	5.26	6.19	6.17	5.49	5.70	6.17	6.86	5.66	5.03	5.97	5.34	6.29	5.63	5.72
Terapontidae	Trumpeter	*Pelates quadrilineatus*	5.88	4.95	5.15	4.95	6.19	6.51	5.49	5.70	5.83	6.86	5.97	5.03	5.97	5.03	6.29	5.63	5.72

Family	Common name	Species name	R&F	R&C	R&M	R& Di	R& Mo	D&F	D&C	D&M	D& Di	D& Mo	S&F	S&C	S&M	S& Di	S& Mo	None	Ave
Labridae	Tuskfish, Blue Spotted	*Choerodon cauteroma*	5.73	5.11	5.28	6.04	5.88	6.34	5.66	5.85	7.03	6.51	5.81	5.19	6.13	6.13	5.97	5.81	5.91
Bothidae	Flounder, Large-toothed	*Pseudorhombus arsius*	5.67	5.00	5.25	5.00	6.33	6.80	6.00	6.30	6.40	7.60	5.83	5.14	6.17	5.14	6.51	5.83	5.94
Bothidae	Flounder, Small-toothed	*Pseudorhombus jenynsii*	5.67	5.00	5.25	5.33	6.00	6.80	6.00	6.30	6.80	7.20	5.83	5.14	6.17	5.49	6.17	5.83	5.94
Ostraciidae	Turretfish, Small spined	*Tetrosomus reipublicae*	5.67	5.00	5.25	5.00	6.33	6.80	6.00	6.30	6.40	7.60	5.83	5.14	6.17	5.14	6.51	5.83	5.94
Sillaginidae	Whiting, Western School	*Sillago vittata*	5.78	5.16	5.33	6.09	5.98	6.40	5.71	5.90	7.09	6.63	5.87	5.24	6.18	6.18	6.08	5.88	5.97
Carangidae	Trevally, Black-banded Kingfish	*Seriolina nigrofasciata*	5.71	5.00	5.31	5.00	6.07	6.86	6.00	6.38	6.43	7.29	6.40	5.60	6.80	5.60	6.80	5.96	6.08
Callionymidae	Stinkfish, Gross's	*Callionymus grossi*	7.14	6.07	6.25	6.43	7.50	6.29	5.34	5.50	5.97	6.60	5.71	4.86	5.71	5.14	6.00	6.00	6.03
Glaucosomatidae	Deepsea jewfish	*Glaucosoma burgeri*	5.33	4.95	5.67	5.33	5.33	6.80	6.31	7.23	7.77	6.80	6.00	5.57	7.29	6.00	6.00	6.00	6.16
Platycephalidae	Flathead, Long-spined	*Platycephalus longispinis*	5.88	5.26	5.42	5.88	6.50	6.51	5.83	6.00	6.86	7.20	5.97	5.34	6.29	5.97	6.60	6.00	6.10
Sillaginidae	Whiting, Trumpeter	*Sillago burrus*	6.19	5.26	5.42	5.57	6.50	6.86	5.83	6.00	6.51	7.20	6.29	5.34	6.29	5.66	6.60	6.00	6.10
Sillaginidae	Whiting, Robust	*Sillago robusta*	5.88	5.26	5.42	5.88	6.50	6.51	5.83	6.00	6.86	7.20	5.97	5.34	6.29	5.97	6.60	6.00	6.10
Carcharhinidae	Sandbar shark	*Carcharhinus plumbeus*	6.75	6.75	5.91	6.11	6.43	5.70	5.70	4.99	5.70	5.43	6.60	6.60	6.60	5.97	6.29	6.02	6.10
Lethrindae	Emperor, Blue-Lined (Black Snapper)	*Lethrinus laticaudis*	5.83	5.17	5.69	5.50	6.00	6.50	5.76	6.34	6.87	6.69	6.50	5.76	7.24	6.13	6.69	6.04	6.18
Lethrinidae	Emperor, Blue-Spotted	*Lethrinus punctulatus*	6.35	5.42	5.55	6.35	6.19	7.03	6.00	6.15	7.37	6.86	6.44	5.50	6.44	6.44	6.29	6.19	6.29
Bothidae	Flounder, Spiny	*Pseudorhombus spinosus*	6.00	5.33	5.54	5.67	6.67	7.20	6.40	6.65	7.20	8.00	6.17	5.49	6.51	5.83	6.86	6.25	6.37
Mullidae	Goatfish, Yellow-striped	*Parupeneus chrysopleuron*	5.14	4.57	4.75	4.86	5.71	7.71	6.86	7.13	7.71	8.57	6.69	5.94	7.06	6.31	7.43	6.25	6.43
Platycephalidae	Flathead, Fringe-eyed	*Cymbacephalus nematophthalmus*	6.00	5.33	5.54	5.67	6.67	6.69	5.94	6.18	6.69	7.43	6.69	5.94	7.06	6.31	7.43	6.25	6.37
Serranidae	Cod, Breaksea (Black-arse Cod)	*Epinephelides armatus*	5.79	6.21	6.19	7.07	6.00	5.79	6.21	6.19	7.50	6.00	5.79	6.21	7.07	7.07	6.00	6.25	6.34

Family	Common name	Species name	R&F	R&C	R&M	R& Di	R& Mo	D&F	D&C	D&M	D& Di	D& Mo	S&F	S&C	S&M	S& Di	S& Mo	None	Ave
Carcharhinidae	Shark, Grey Reef	*Carcharhinus amblyrhynchos*	6.43	7.07	7.31	6.43	6.43	5.43	5.97	6.18	5.97	5.43	6.29	6.91	8.17	6.29	6.29	6.38	6.44
Carcharhinidae	Shark, Tiger	*Galeocerdo cuvier*	6.43	7.07	7.31	6.43	6.43	5.43	5.97	6.18	5.97	5.43	6.29	6.91	8.17	6.29	6.29	6.38	6.44
Carcharhinidae	Shark, Whitetip	*Triaenodon obesus*	6.43	7.07	7.31	6.43	6.43	5.43	5.97	6.18	5.97	5.43	6.29	6.91	8.17	6.29	6.29	6.38	6.44
Plotosidae	Catfish, Striped	*Plotosus lineatus*	6.88	6.07	6.38	6.07	7.69	6.80	6.00	6.30	6.40	7.60	6.31	5.57	6.69	5.57	7.06	6.42	6.49
Callionymidae	Dragonet, Fingered	*Dactylopus dactylopus*	6.88	6.07	6.38	6.07	7.69	6.80	6.00	6.30	6.40	7.60	6.31	5.57	6.69	5.57	7.06	6.42	6.49
Dactylopteridae	Searobin, Oriental	*Dactyloptena orientalis*	6.88	6.07	6.38	6.07	7.69	6.80	6.00	6.30	6.40	7.60	6.31	5.57	6.69	5.57	7.06	6.42	6.49
Platycephalidae	Flathead, Spiny	*Onigocia spinosa*	6.07	5.36	5.63	5.36	6.79	7.77	6.86	7.20	7.31	8.69	6.31	5.57	6.69	5.57	7.06	6.42	6.55
Aulostomidae	Flutemouth, Smooth	*Fistularia commersonii*	6.07	5.36	5.63	5.36	6.79	6.80	6.00	6.30	6.40	7.60	7.29	6.43	7.71	6.43	8.14	6.42	6.55
Aploactinidae	Velvetfish, Bearded	*Paraploactis intonsa*	6.48	6.48	6.67	8.00	8.00	6.31	6.31	6.50	8.17	7.80	5.34	5.34	6.29	6.60	6.60	6.67	6.73
Callionymidae	Stinkfish, Multifilament	*Callionymus sublaevis*	7.62	6.48	6.67	6.86	8.00	7.43	6.31	6.50	7.06	7.80	6.29	5.34	6.29	5.66	6.60	6.67	6.73
Carcharhinidae	Shark, Black-tip Reef	*Carcharhinus melanopterus*	6.75	7.39	7.59	6.75	7.07	5.70	6.24	6.41	6.24	5.97	6.60	7.23	8.49	6.60	6.91	6.73	6.80
Dasyatididae	Stingray, Brown Reticulated	*Dasyatis leylandi*	8.00	8.00	8.00	7.43	8.57	6.40	6.40	6.40	6.40	6.86	6.40	6.40	7.31	5.94	6.86	7.00	7.02
Lamnidae	Shark, Shortfin Mako	*Isurus oxyrinchus*	7.07	7.71	7.88	7.07	7.71	5.97	6.51	6.65	6.51	6.51	6.91	7.54	8.80	6.91	7.54	7.08	7.16
Sphymidae	Shark, Smooth Hammerhead	Sphyrna zygaena	7.07	7.71	7.88	7.07	7.71	5.97	6.51	6.65	6.51	6.51	6.91	7.54	8.80	6.91	7.54	7.08	7.16
Sparidae	Pink snapper	*Pagrus auratus*	6.96	5.75	5.74	6.15	6.64	8.85	7.30	7.29	8.85	8.43	8.35	6.90	7.87	7.38	7.97	7.15	7.36
Callionymidae	Stinkfish, Goodlad's	*Callionymus goodladi*	8.38	7.24	7.33	8.38	8.76	7.54	6.51	6.60	7.89	7.89	7.54	6.51	7.54	7.54	7.89	7.50	7.57
Plotosidae	Catfish, Small-headed	*Euristhmus microceps*	7.71	6.86	7.13	7.29	8.57	7.71	6.86	7.13	7.71	8.57	7.71	6.86	8.14	7.29	8.57	7.50	7.61
Ariidae	Giant seacatfish	*Netuma thalassina*	7.60	6.60	7.09	6.60	7.70	8.69	7.54	8.10	8.11	8.80	8.25	7.17	8.79	7.17	8.36	7.63	7.77
Dasyatididae	Stingray, Black-blotched	*Taeniura meyeni*	8.36	9.64	9.00	8.36	9.64	7.06	8.14	7.60	7.60	8.14	8.17	9.43	10.06	8.17	9.43	8.50	8.59
Rhynchobatidae	Shovelnose Ray, Whitespot Guitar fish	*Rhynchobatus australiae*	8.36	9.00	9.00	9.00	9.64	7.06	7.60	7.60	8.14	8.14	8.17	8.80	10.06	8.80	9.43	8.50	8.59

Appendix F: Bycatch Species List from BRD Trials (2002/03)

Species lists and catch numbers from Shark Bay mesh panel trials in 2002 and 2003 (Tables 1 and 2)

Table 1. Finfish bycatch species sampled during BRD trials in 2002 – 2003. % Sites indicates the proportion of sites were each species were sampled; % of total catch at each site indicates the species' proportion of the catch per nautical mile at each of the sites where it was sampled

Family	Common Name	Species Name	% Sites	% of total catch at each site
Tetraodontidae	Toadfish, Orange-spotted	*Torquigener pallimaculatus*	100.00	< 1 – 20
Terapontidae	Trumpeter	*Pelates quadrilineatus*	100.00	< 1 – 37
Mullidae	Goatfish, Asymmetrical	*Upeneus asymmetricus*	100.00	1 – 27
Monacanthidae	Leatherjacket, Hair-finned	*Paramonacanthus choirocephalus*	100.00	< 1 – 39
Harpodontidae	Lizardfish, Large-scaled Grinner	*Saurida undosquamis*	100.00	< 1 – 11
Bothidae	Flounder, Spiny-headed	*Engyprosopon grandisquama*	100.00	< 1 – 10
Platycephalidae	Flathead, Rusty	*Inegocia japonica*	100.00	< 1 – 3
Callionymidae	Stinkfish, Goodlad's	*Callionymus goodladi*	100.00	< 1 – 14
Sillaginidae	Whiting, Robust	*Sillago robusta*	100.00	< 1 – 36
Platycephalidae	Flathead, Spiny	*Onigocia spinosa*	100.00	< 1 – 2
Platycephalidae	Flathead, Northen Sand	*Platycephalus arenarius*	100.00	< 1 – 2
Platycephalidae	Flathead, Heart-headed	*Sorsogona tuberculata*	100.00	< 1 – 2
Synodontidae	Lizardfish, Netted	*Synodus sageneus*	96.15	< 1 – 2
Scorpaenidae	Scorpionfish, Long-finned Waspfish	*Apistus carinatus*	96.15	< 1 – 17
Pinguipedidae	Grubfish, Red-barred	*Parapercis nebulosa*	92.31	< 1 – 5
Leiognathidae	Ponyfish, Whipfin	*Leiognathus leuciscus*	92.31	< 1 – 20
Cynoglossidae	Sole, McCulloch's Tongue	*Cynoglossus mccullochi*	92.31	< 1
Apogonidae	Cardinalfish, Two-eyed	*Apogon nigripinnis*	92.31	< 1
Siganidae	Spinefoot, White-spotted/Smudgespot	*Siganus canaliculatus*	88.46	< 1 – 4
Scorpaenidae	Scorpionfish, Spot Fin Waspfish/Bullrout	*Paracentropogon vespa*	88.46	< 1 – 26
Platycephalidae	Flathead, Long-spined	*Platycephalus longispinis*	84.62	< 1 – 2
Monacanthidae	Leatherjacket, Fan-bellied	*Monacanthus chinensis*	84.62	< 1 – 11
Lethrinidae	Emperor, Threadfin	*Lethrinus genivittatus*	84.62	< 1 – 43
Gerreidae	Roach/Banded Silver Biddy	*Gerres subfasciatus*	84.62	< 1 – 13
Carangidae	Trevally, Yellowtail	*Trachurus novaezelandiae*	80.77	< 1 – 5
Callionymidae	Stinkfish, Multifilament	*Repomucenus sublaevis*	80.77	< 1 – 5
Bothidae	Flounder, Spiny	*Pseudorhombus spinosus*	80.77	< 1 – 2

Bothidae	Flounder, Intermediate	*Asterorhombus intermedius*	80.77	< 1 – 2
Triglidae	Gurnard, Long-finned	*Lepidotrigla argus*	80.77	< 1 – 12
Nemipteridae	Monocle Bream, Western Butterfish	*Pentapodus vitta*	80.77	< 1 – 11
Mullidae	Goatfish, Bar-tailed	*Upeneus tragula*	80.77	< 1 – 5
Monacanthidae	Leatherjacket, Paxman's	*Colurodontis paxmani*	80.77	< 1 – 42
Lethrinidae	Emperor, Blue-Spotted	*Lethrinus hutchinsi (MS)*	80.77	< 1 – 8
Cynoglossidae	Sole, Patterned Tongue	*Paraplagusia bilineata*	80.77	< 1 – 4
Clupeidae	Sardine, Gold-striped	*Sardinella gibbosa*	76.92	< 1
Bothidae	Flounder, Small-toothed	*Pseudorhombus jenynsii*	76.92	< 1
Sillaginidae	Whiting, Trumpeter	*Sillago burrus*	76.92	< 1 – 10
Ostraciidae	Turretfish, Small spined	*Tetrosomus reipublicae*	76.92	< 1 – 3
Labridae	Tuskfish, Purple	*Choerodon cephalotes*	76.92	< 1
Clupeidae	Sardine, Scaly Mackerel	*Sardinella lemuru*	76.92	< 1
Carangidae	Trevally, Smooth-tailed	*Selaroides leptolepis*	76.92	< 1
Terapontidae	Trumpeter, Striped/Six-lined	*Pelates sexlineatus*	76.92	< 1 – 7
Soleidae	Sole, Dark-Spotted	*Aseraggodes melanospilus*	73.08	< 1 – 2
Sillaginidae	Whiting, Western School	*Sillago vittata*	73.08	< 1 – 2
Platycephalidae	Flathead, Fringe-eyed	*Cymbacephalus nematophthalmus*	73.08	< 1
Pegasidae	Seamoth, Slender	*Pegasus volitans*	73.08	< 1 – 2
Hypinidae	Numbfish, Banded	*Narcine westraliensis*	73.08	< 1
Callionymidae	Dragonet, Fingered	*Dactylopus dactylopus*	69.23	< 1
Bothidae	Flounder, Large-toothed	*Pseudorhombus arsius*	69.23	< 1 – 2
Pomacentridae	Damsel, Gulf	*Pristotis obtusirostris*	69.23	< 1 – 6
Ostraciidae	Boxfish, Small-nosed	*Ostracion nasus*	69.23	< 1
Harpodontidae	Lizardfish, Painted Grinner	*Trachinocephalus myops*	69.23	< 1 – 2
Carangidae	Trevally, Silver	*Pseudocaranx dentex*	69.23	< 1
Tetraodontidae	Toadfish, Whitley's	*Torquigener whitleyi*	69.23	< 1 – 2
Sphyraenidae	Seapike, Striped	*Sphyraena obtusata*	69.23	< 1
Scorpaenidae	Scorpionfish, Plumb-striped Stingfish	*Minous versicolor*	65.38	< 1 – 2
Mullidae	Goatfish, Yellow-striped	*Parupeneus chrysopleuron*	65.38	< 1 – 2
Dasyatididae	Stingray, Brown Reticulated	*Dasyatis leylandi*	65.38	< 1 – 2
Callionymidae	Stinkfish, Gross's	*Callionymus grossi*	65.38	< 1 – 2
Sparidae	Snapper, Pink	*Pagrus auratus*	61.54	< 1
Scorpaenidae	Stinger, Spotted	*Inimicus sinensis*	61.54	< 1
Monacanthidae	Leatherjacket, Prickly	*Chaetodermis penicilligera*	61.54	< 1
Diodontidae	Porcupinefish, Long-spined	*Tragulichthys jaculiferus*	61.54	< 1
Soleidae	Sole, Harrowed	*Strabozebrias cancellatus*	61.54	< 1
Platycephalidae	Flathead, Bossch's	*Cymbacephalus bosschei*	61.54	< 1
Monacanthidae	Leatherjacket, Bearded	*Anacanthus barbatus*	57.69	< 1

Sparidae	Tarwhine	*Rhabdosargus sarba*	57.69	< 1 – 3
Serranidae	Rockcod, False Scorpionfish	*Centrogenys vaigiensis*	57.69	< 1
Platycephalidae	Flathead, Bar-tailed	*Platycephalus endrachtensis*	57.69	< 1 – 2
Apogonidae	Cardinalfish, Broad-banded	*Apogon quadrifasciatus*	53.85	< 1 – 2
Monacanthidae	Leatherjacket, Brown Blotched	*Stephanolepis sp.*	53.85	< 1
Callionymidae	Dragonet, High-finned	*Synchiropus rameus*	53.85	< 1
Bothidae	Flounder, Peacock	*Pseudorhombus argus*	50.00	< 1
Tetraodontidae	Toadfish, Banded	*Torquigener pleurogramma*	50.00	< 1 – 3
Monacanthidae	Leatherjacket, Pot-bellied	*Pseudomonacanthus peroni*	50.00	< 1
Labridae	Wrasse, Flagfin	*Pteragogus enneacanthus*	50.00	< 1 – 3
Dactylopteridae	Searobin, Oriental	*Dactyloptena orientalis*	46.15	< 1
Clupeidae	Herring, Australian Spotted	*Herklotsichthys lippa*	46.15	< 1
Centropomidae	Sand Bass	*Psammoperca waigiensis*	46.15	< 1
Apogonidae	Cardinalfish, Many-banded	*Apogon brevicaudata*	42.31	< 1
Apogonidae	Cardinalfish, Cavite	*Apogon cavitiensis*	42.31	< 1
Apogonidae	Cardinalfish, Gobbleguts	*Apogon rueppellii*	42.31	< 1 – 3
Aploactinidae	Velvetfish, Cod	*Peristrominous dolosus*	42.31	< 1
Nemipteridae	Monocle Bream, False Whiptail	*Pentapodus porosus*	42.31	< 1 – 3
Plotosidae	Catfish, Small-headed	*Euristhmus microceps*	42.31	< 1 – 2
Callionymidae	Stinkfish, Spotted	*Repomucenus calcaratus*	42.31	< 1
Bothidae	Flounder, Blue-spotted	*Crossorhombus azureus*	42.31	< 1
Antennariidae	Anglerfish, Striped	*Antennarius striatus*	42.31	< 1
Uranoscopidae	Stargazer, Marbled	*Uranoscopus bicinctus*	42.31	< 1
Scorpaenidae	Scorpionfish, Western Red	*Scorpaena sumptuosa*	38.46	< 1
Rhynchobatidae	Shovelnose Ray, Whitespot/White-spotted Guitar fis	*Rhynchobatus djiddensis*	34.62	< 1
Priacanthidae	Bigeye, Red	*Priacanthus macracanthus*	34.62	< 1
Syngnathidae	Seahorse, Western Spiny	*Hippocampus angustus*	34.62	< 1
Sparidae	Snapper, Long-spined	*Argyrops spinifer*	34.62	< 1 – 5
Soleidae	Sole, DarkThick-rayed	*Aesopia cornuta*	30.77	< 1
Monacanthidae	Leatherjacket, Blue-spotted	*Eubalichthys caeruleoguttatus*	30.77	< 1
Leiognathidae	Ponyfish, Orangefin	*Leiognathus bindus*	30.77	< 1 – 8
Centropomidae	Spiky Bass	*Hypopterus macropterus*	30.77	< 1 – 2
Apogonidae	Cardinalfish, Black-tipped	*Apogon semilineatus*	26.92	< 1
Antennariidae	Anglerfish, Butler's	*Tathicarpus butleri*	26.92	< 1

Tetraodontidae	Toadfish, Silver/NW Blowie	*Lagocephalus sceleratus*	26.92	< 1
Syngnathidae	Seahorse, False-eyed	*Hippocampus biocellatus*	26.92	< 1
Scorpaenidae	Stonefish, Demon stinger	*Inimicus didactylus*	26.92	< 1
Nemipteridae	Threadfin Bream, Rosy	*Nemipterus furcosus*	26.92	< 1 – 2
Labridae	Tuskfish, Blue Spotted	*Choerodon cauteroma*	26.92	< 1
Bothidae	Flounder, Deep-bodied	*Pseudorhombus elevatus*	26.92	< 1 – 15
Blenniidae	Blenny, Short-headed Sabretooth	*Petroscirtes breviceps*	23.08	< 1
Aploactinidae	Velvetfish, Bearded	*Paraploactis intonsa*	23.08	< 1
Tetraodontidae	Toadfish, Stars and Stripes	*Arothron hispidus*	23.08	< 1
Tetraodontidae	Toadfish, Rough Golden	*Lagocephalus lunaris*	23.08	< 1
Syngnathidae	Pipefish, Tiger	*Filicampus tigris*	23.08	< 1
Pomatomidae	Tailor	*Pomatomus saltator*	23.08	< 1
Hypinidae	Numbfish	*Hypnos monopterygium*	23.08	< 1
Chaetodontidae	Butterflyfish, Western	*Chaetodon assarius*	23.08	< 1
Triakidae	Shark, Grey Gummy	*Mustelus sp. A*	19.23	< 1
Syngnathidae	Pipefish, Short-tailed	*Trachyrhamphus bicoarctatus*	19.23	< 1
Scorpaenidae	Scorpionfish, Dwarf Lionfish	*Dendrochirus brachypterus*	19.23	< 1
Nemipteridae	Threadfin Bream, 5-lined	*Nemipterus celebicus*	19.23	< 1 – 2
Monacanthidae	Leatherjacket, Rough	*Scobinichthys granulatus*	19.23	< 1
Lutjanidae	Seaperch, Saddle-tailed	*Lutjanus malabaricus*	19.23	< 1 – 2
Leiognathidae	Ponyfish, Pugnose	*Secutor insidiator*	15.38	< 1
Gymnuridae	Ray, Rat-tailed/Butterfly	*Gymnura australis*	15.38	< 1 – 6
Gobiidae	Goby, Shadow	*Yongeichthys nebulosus*	15.38	< 1
Dasyatididae	Whipray, Black-spotted	*Himantura toshi*	15.38	< 1
Carangidae	Trevally, Golden	*Gnathanodon speciosus*	15.38	< 1
Carangidae	Trevally, Black-banded Kingfish	*Seriolina nigrofasciata*	15.38	< 1
Bothidae	Flounder	*Engyprosopon sp.*	15.38	< 1
Apogonidae	Cardinalfish, Yellow-eye	*Apogon monochrous*	15.38	< 1
Aploactinidae	Velvetfish, Dusky	*Aploactis aspera*	15.38	< 1
Veliferidae	Veilfin	*Metavelifer multiradiatus*	15.38	< 1
Terapontidae	Trumpeter, Banded	*Terapon theraps*	15.38	< 1
Syngnathidae	Pipefish, Ribboned	*Haliichthys taeniophorus*	15.38	< 1
Soleidae	Sole, Wickerwork	*Zebrias craticula*	15.38	< 1
Scorpaenidae	Scorpionfish, Estuarine Stonefish	*Synanceia horrida*	15.38	< 1
Plotosidae	Catfish, Striped	*Plotosus lineatus*	15.38	< 1 – 2
Pempherididae	Bullseye, Lamp-light	*Pempheris ypsilychnus*	11.54	< 1
Lethrinidae	Emperor, Grass/Black Snapper	*Lethrinus laticaudis*	11.54	< 1
Dasyatididae	Stingray, Blue-spotted	*Dasyatis kuhlii*	11.54	< 1

Dactylopteridae	Searobin, Sharp-eared	*Dactyloptena papilio*	11.54	< 1
Congridae	Eel, Silver Conger	*Gnathophis habenatus*	11.54	< 1
Aulostomidae	Flutemouth, Smooth	*Fistularia commersonii*	11.54	< 1
Apogonidae	Cardinalfish, Victorian	*Apogon victoriae*	11.54	< 1 – 2
Apogonidae	Cardinalfish, Weed	*Foa brachygramma*	11.54	< 1
Apogonidae	Cardinalfish, Pink-breasted Siphonfish	*Siphamia roseigaster*	11.54	< 1
Uranoscopidae	Stargazer, Double-banded	*Ichthyscopus insperatus*	11.54	< 1
Tetraodontidae	Pufferfish, Starry	*Arothron stellatus*	11.54	< 1
Synodontidae	Lizardfish, Doaks	*Synodus doaki*	11.54	< 1
Soleidae	Sole	*Phyllichthys sp*	11.54	< 1
Scorpaenidae	Scorpionfish, Red Firefish	*Pterois volitans*	11.54	< 1
Scaridae	Parrotfish, Blue-spotted	*Leptoscarus vaigiensis*	11.54	< 1
Scaridae	Parrotfish	*Scarus sp.*	7.69	< 1
Pomacentridae	Anemonefish, Clark's	*Amphiprion clarkii*	7.69	< 1
Pomacentridae	Chromis, Smokey	*Chromis fumea*	7.69	< 1
Plotosidae	Catfish, White-lipped	*Paraplotosus albilabris*	7.69	< 1
Pempherididae	Bullseye, Slender	*Parapriacanthus ransonneti*	7.69	< 1
Ostraciidae	Cowfish, Roundbelly	*Lactoria diaphana*	7.69	< 1
Nemipteridae	Monocle Bream, Coral	*Scaevius milii*	7.69	< 1
Mullidae	Goatfish, Black-spot	*Parupeneus spilurus*	7.69	< 1
Mullidae	Goatfish, Stott's	*Upeneichthys stotti*	7.69	< 1
Microcanthidae	Stripey	*Microcanthus strigatus*	7.69	< 1
Leiognathidae	Ponyfish, Zig-Zag	*Leiognathus moretonensis*	7.69	< 1
Haemulidae	Sweetlip, Painted	*Diagramma labiosum*	7.69	< 1
Dasyatididae	Stingray, Coachwhip	*Himantura sp.*	7.69	< 1
Dasyatididae	Whipray, Reticulate/Coachwhip Ray	*Himantura uarnak*	7.69	< 1
Clupeidae	Sardine	*Sardinella sp.*	7.69	< 1
Clupeidae	Sprat	*Spratelloides?*	7.69	< 1
Carangidae	Trevally, Small Mouth Scad	*Alepes apercna*	7.69	< 1
Carangidae	Trevally, Malabar	*Carangoides malabaricus*	7.69	< 1
Carangidae	Trevally, White-tongued	*Carangoides talamparoides*	7.69	< 1
Bothidae	Flounder, Three-spot	*Grammatobothus polyophthalmus*	7.69	< 1
Apogonidae	Cardinalfish, Pearly-finned	*Apogon poecilopterus*	7.69	< 1
Aploactinidae	Velvetfish, Queensland	*Kanekonica queenslandica*	7.69	< 1
Uranoscopidae	Stargazer, Yellowtail	*Uranoscopus cognatus*	7.69	< 1
Tetraodontidae	Toadfish, Orange-barred Pufferfish	*Polyspina piosae*	7.69	< 1
Terapontidae	Trumpeter, Three-lined	*Terapon puta*	7.69	< 1
Syngnathidae	Seahorse, Flat-face	*Hippocampus planifrons*	7.69	< 1

Syngnathidae	Pipefish, Spotted	*Stigmatopora argus*	7.69	< 1
Syngnathidae	Pipefish, Alligator	*Syngnathoides biaculeatus*	7.69	< 1
Soleidae	Sole, Peacock	*Pardachirus pavoninus*	3.85	< 1
Serranidae	Rockcod, Chinaman	*Epinephelus rivulatus*	3.85	< 1
Scaridae	Parrotfish, Blue-barred	*Scarus cf. ghobban?*	3.85	< 1
Pseudochromidae	Dottyback, Longfin	*Assiculus punctatus*	3.85	< 1
Pseudochromidae	Eel-Blenny, Carpet	*Congrogadus subducens*	3.85	< 1
Priacanthidae	Bigeye, Threadfin	*Priacanthus tayenus*	3.85	< 1
Plotosidae	Catfish, Eel-tailed	*Paraplotosus sp.*	3.85	< 1
Platycephalidae	Flathead, Large-spined	*Suggrundus macracanthus*	3.85	< 1
Platycephalidae	Flathead, Tassel-snouted	*Thysanophrys cirronasus*	3.85	< 1
Nemipteridae	Threadfin Bream, Notched	*Nemipterus peronii*	3.85	< 1
Myliobatidae	Ray, White-spotted Eagle	*Aetobatus narinari*	3.85	< 1
Muraenidae	Eel, Woodward's Reef	*Gymnothorax woodwardi*	3.85	< 1
Muraenesocidae	Eel, Shorttail Pike	*Oxyconger leptognathus*	3.85	< 1
Mullidae	Goatfish, Swarthy-headed	*Parupeneus barberinoides*	3.85	< 1
Mullidae	Goatfish, Sunrise	*Upeneus sulphureus*	3.85	< 1
Lutjanidae	Sweep, Fusilier	*Caesioscorpis theagenes*	3.85	< 1
Lutjanidae	Seaperch, Stripey	*Lutjanus carponotatus*	3.85	< 1
Leiognathidae	Ponyfish, Toothpony	*Gazza minuta*	3.85	< 1
Labridae	Wrasse, Soela	*Suezichthys soelae*	3.85	< 1
Harpodontidae	Lizardfish, Banded	*Synodus dermatogenys*	3.85	< 1
Harpodontidae	Lizardfish, Black-shouldered	*Synodus hoshinonsis*	3.85	< 1
Haemulidae	Javelinfish, Spotted	*Pomadasys kaakan*	3.85	< 1
Gobiidae	Shrimpgoby	*Amblyeleotris sp.*	3.85	< 1
Gobiidae	Shrimpgoby, Yellow-barred	*Cryptocentrus pavoninoides*	3.85	< 1
Gobiidae	Goby, Robust	*Oplopomus caninoides*	3.85	< 1
Gobiidae	Goby, Head-barred	*Priolepis semidoliatus*	3.85	< 1
Engraulididae	Anchovy, Australian	*Engraulis australis*	3.85	< 1
Dasyatididae	Stingray, Black-blotched	*Taeniura meyeni*	3.85	< 1
Congridae	Eel, Longtail Conger	*Uroconger lepturus*	3.85	< 1
Clinidae	Weedfish, Rosy	*Heteroclinus roseus*	3.85	< 1
Chaetodontidae	Coralfish, Ocellate	*Parachaetodon ocellatus*	3.85	< 1
Carangidae	Trevally, Shrimp Scad	*Alepes djedaba*	3.85	< 1
Carangidae	Trevally, Club-nosed	*Carangoides chrysophrys*	3.85	< 1
Carangidae	Trevally, Russell's Mackerel Scad	*Decapterus russelli*	3.85	< 1
Bothidae	Flounder, Pennant	*Grammatobothus pennatus*	3.85	< 1
Balistidae	Triggerfish, Starry	*Abalistes stellatus*	3.85	< 1

Table 2. **Invertebrate bycatch species in the SBPMF sampled during BRD trials in 2002 – 2003. % Sites indicates the proportion of sites were each species were sampled; % of total catch at each site indicates the species' proportion of the catch per nautical mile at each of the sites where it was sampled**

Family	Common Name	Species Name	% Sites	% of total catch at each site
Loliginidae	squid	*Photololigo sp.*	100.00	< 1 – 2
Penaeidae	King Prawn	*Melicertus latisulcatus*	100.00	< 1 – 34
Penaeidae	coral prawn	*Metapenaeopsis sp.*	100.00	< 1 – 79
Portunidae	Crab, blue swimmer	*Portunus pelagicus*	100.00	< 1 – 43
Portunidae	swimmer crab	*Portunus rubromarginatus*	100.00	< 1 – 10
Sepiidae	Smith's Cuttlefish	*Sepia smithi*	100.00	< 1
Cucumariidae	holothurian	*Colochirus crassus*	96.15	< 1 – 7
Portunidae	swimming crab	*Thalamita sima*	92.31	< 1 – 5
Ascidiacea	Ascidian	*Ascidiacea*	88.46	< 1 – 20
Penaeidae	Tiger Prawn	*Penaeus esculentus*	88.46	< 1 – 40
Portunidae	coral crab	*Charybdis feriata*	88.46	< 1 – 10
Sepiidae	Papuan Cuttlefish	*Sepia papuensis*	88.46	< 1 – 4
Pectinidae	fan scallop	*Annachlamys flabellata*	84.62	< 1 – 26
Portunidae	swimmer crab	*Portunus tenuipes*	84.62	< 1 – 12
Penaeidae	Western School Prawn	*Metapenaeus dalli*	76.92	< 1 – 13
Philinidae	sea slug	*Philine sp.*	80.77	< 1 – 25
Scyllaridae	slipper lobster	*Eduarctus martensii*	80.77	< 1 – 8
Penaeidae	coral prawn	*Metapenaeopsis crassissima*	76.92	< 1 – 27
Sepiolidae	Southern Dumpling Squid	*Euprymna tasmanica*	76.92	< 1 – 2
Majidae	Spider Crabs	*Majidae*	73.08	< 1 – 2
Pectinidae	Ballot's saucer scallop	*Amusium balloti*	73.08	< 1 – 75
Cucumariidae	holothurian	*Colochirus quadrangularis*	69.23	< 1 – 28
Luidiidae	seastar	*Luidia hardwicki*	69.23	< 1 – 2
Penaeidae	Endeavour Prawn	*Metapenaeus endeavouri*	65.38	< 1 – 25
Sepiadariidae	Pinstripe Bottle-tailed Squid	*Sepioloidea lineolata*	65.38	< 1
Sepiidae	cuttlefish	*Sepia sp.*	65.38	< 1 – 3
Luidiiidae	seastar	*Luidia maculata*	61.54	< 1 – 3
Portunidae	swimmer crab	*Portunus hastatoides*	61.54	< 1 – 6
Squillidae	mantis shrimp	*Oratosquilla oratoria*	61.54	< 1 – 2
Octopodidae	Southern Sand Octopus	*Octopus kaurna*	57.69	< 1
Penaeidae	Hunchback Prawn	*Metapenaeopsis lamellata*	57.69	< 1 – 2
Squillidae	mantis shrimp	*Alimopsoides sp.*	57.69	< 1 – 2
Cucumariidae	holothurian	*Cercodemas anceps*	53.85	< 1
Diogenidae	Hermit Crabs	*Diogenidae*	53.85	< 1 – 2
Portunidae	crab	*Charybdis jaubertensis*	53.85	< 1
Scyllaridae	Morton Bay Bug	*Thenus orientalis*	53.85	< 1

Sepiidae	Pharaoh's Cuttlefish	*Sepia pharaonis*	53.85	< 1 – 2
Temnopleuridae	sea urchin	*Temnopleurus alexandri*	53.85	< 1
Dromiidae	Sponge Crabs	*Dromiidae*	50.00	< 1
Porifera	Sponge	*Porifera*	50.00	< 1
Scyphozoa	Moon Jelly	*Aurelia sp.*	50.00	< 1 – 6
Sepiidae	Flamboyant Cuttlefish	*Metasepia pfefferi*	50.00	< 1
Echinasteridae	seastar	*Metrodira subulata*	46.15	< 1
Portunidae	Swimmer crab	*Charybdis sp.*	46.15	< 1
Temnopleuridae	sea urchin	*Temnotrema elegans*	46.15	< 1 – 3
Alpheidae	Snapping Shrimps	*Alpheidae*	42.31	< 1
Temnopleuridae	sea urchin	*Temnopleurus michaelseni*	42.31	< 1
Actinaria	Anemone	*Actinaria*	38.46	< 1
Ascidiidae	ascidian	*Phallusia millari*	38.46	< 1
Bryozoa	Bryozoan	*Bryozoa*	38.46	< 1
Comasteridae	crinoid	*Comatula solaris*	38.46	< 1
Cucumariidae	holothurian	*Actinocucumis typica*	38.46	< 1
Fungiidae	Coral, Mushroom	*Cycloseris cyclolites*	38.46	< 1 – 2
Stichopodidae	holothurian	*Stichopus sp.*	38.46	< 1
Zygometridae	crinoid	*Zygometra microdiscus*	38.46	< 1
Dorippidae	crab	*Dorippe frascone*	34.62	< 1
Nephtheidae	Soft coral	*Dendronephthya sp.C*	34.62	< 1
Nudibranchia	nudibranch	*Nudibranchia*	34.62	< 1
Parthenopidae	crab	*Parthenope nodosus*	34.62	< 1
Penaeidae	Northern Velvet Prawn	*Metapenaeopsis novaeguineae*	34.62	< 1 – 2
Penaeidae	Southern Rough Prawn	*Trachypenaeus curvirostris*	34.62	< 1 – 6
Portunidae	swimmer crab	*Portunus haanii*	34.62	< 1
Annelida	Polychaete worm	*Annelida*	30.77	< 1
Goniasteridae	seastar	*Stellaster inspinosus*	30.77	< 1
Pleurobranchidae	Side-gilled Seaslug	*Euselenops luniceps*	30.77	< 1
Asterinidae	seastar	*Nepanthia crassa*	26.92	< 1 – 2
Clavelinidae	ascidian	*Clavelina meridionalis*	26.92	< 1
Comasteridae	crinoid	*Comatula rotalaria*	26.92	< 1
Cucumariidae	holothurian	*Staurothyrone rosacea*	26.92	< 1
Loliginidae	Northern Calamari	*Sepioteuthis lessoniana*	26.92	< 1
Opiotrichidae	brittlestar	*Ophiothrix viridialba*	26.92	< 1 – 4
Sepiidae	Giant Cuttlefish	*Sepia apama*	26.92	< 1
Squillidae	mantis shrimp	*Carinosquilla australiensis*	26.92	< 1 – 2
Callyspongiidae	Sponge	*Callyspongia sp.2*	23.08	< 1
Corystidae	Masked Burrowing Crab	*Gomeza bicornis*	23.08	< 1 – 2
Goniasteridae	seastar	*Stellaster equestris*	23.08	< 1
Irciniidae	Fibre sponge	*Psammocinia sp.2*	23.08	< 1
Nephtheidae	Soft coral	*Nephtheid*	23.08	< 1
Octopodidae	Octopus	*Octopus sp.*	23.08	< 1
Oreasteridae	seastar	*Protoreaster nodulosus*	23.08	< 1 – 2
Pennatulacea	Sea Pen	*Pennatulacea*	23.08	< 1

Pilumnidae	hairy crab	*Pilumnus sp.*	23.08	< 1
Portunidae	swimmer crab	*Charybdis granulata*	23.08	< 1
Portunidae	swimmer crab	*Portunus pubescens*	23.08	< 1 – 3
Portunidae	Three-spotted Crab	*Portunus sanguinolentus*	23.08	< 1
Sepiadariidae	bottletail squid	*Sepiadarium sp.*	23.08	< 1
Synaptidae	holothurian	*Synaptula recta*	23.08	< 1
Antedonidae	crinoid	*Dorometra parvicirra*	19.23	< 1
Aplysiidae	Sea Hare	*Aplysia sp.*	19.23	< 1
Astropectinidae	seastar	*Astropecten preissi*	19.23	< 1
Callyspongiidae	Sponge	*Callyspongia sp.1*	19.23	< 1
Cidaridae	sea urchin	*Prionocidaris bispinosa*	19.23	< 1 – 2
Cucumariidae	holothurian	*Mensamaria intercedens*	19.23	< 1
Galatheidae	squat lobster	*Galatheidae*	19.23	< 1 – 2
Isopoda	Isopods	*Isopoda*	19.23	< 1
Leucosiidae	pebble crab	*Myra mammillaris*	19.23	< 1
Octopodidae	blue-ringed octopus	*Hapalochlaena sp.*	19.23	< 1
Pectinidae	scallop	*Mimachlamys australis*	19.23	< 1
Penaeidae	Southern Velvet Prawn	*Metapenaeopsis palmensis*	19.23	< 1
Pilumnidae	Ragged Crab	*Pilumnus semilanatus*	19.23	< 1
Ranellidae	triton shell	*Cymatium vespaceum*	19.23	< 1
Sepiadariidae	Bottletail squid	*Sepiadarium kochii*	19.23	< 1
Spongiidae	Fibre sponge	*Hippospongia sp.1*	19.23	< 1
Turbinidae	turban shell	*Turbo haynesi*	19.23	< 1 – 2
Cardiidae	heart cockle	*Fragum retusum*	15.38	< 1
Corallinaceae	Algae, Coralline	*Corallinaceae*	15.38	< 1 – 3
Cucumariidae	holothurian	*Loisettea amphictena*	15.38	< 1
Holothuriidae	holothurian	*Holothuria pervicax*	15.38	< 1
Holozoidae	ascidian	*Sigillina australis*	15.38	< 1
Mycalidae	Sponge	*Mycale mirabilis*	15.38	< 1
Penaeidae	Redspot King Prawn	*Melicertus longistylus*	15.38	< 1
Penaeidae	Coral Prawn	*Metapenaeus sp.*	15.38	< 1 – 2
Phyllophoridae	holothurian	*Stolus buccalis*	15.38	< 1
Phyllophoridae	holothurian	*Thyone sp.*	15.38	< 1
Portunidae	Hairyback Crab	*Charybdis natator*	15.38	< 1
Portunidae	Rough Rock Crab	*Nectocarcinus integrifrons*	15.38	< 1
Tedaniidae	Fibre sponge	*Tedania sp.3*	15.38	< 1
Xanthidae	crab	*Neoxanthops rotundus*	15.38	< 1
Alcyonacea	Octocoral	*Alcyonacea*	11.54	< 1
Amphinomidae	Fireworm	*Chloeia flava*	11.54	< 1
Astropectinidae	Seastar	*Astropecten sp.*	11.54	< 1
Calappidae	moon crab	*Matuta granulosa*	11.54	< 1 – 2
Chitonidae	chiton	*Chiton sp.*	11.54	< 1
Chondropsidae	Sponge	*Chondropsis sp.2*	11.54	< 1
Crinoidea	Crinoid	*Crinoidea*	11.54	< 1
Loliginidae	Squid	*Photololigo sp.2*	11.54	< 1

Loveniidae	heart urchin	*Echinocardium cordatum*	11.54	< 1 – 9
Majidae	spider crab	*Paranaxia serpulifera*	11.54	< 1
Majidae	decorator crab	*Schizophrys dama*	11.54	< 1
Molgulidae	ascidian	*Molgula ficus*	11.54	< 1
Nephtheidae	Soft coral	*Dendronephthya sp.F*	11.54	< 1
Ostreidae	oyster	*Ostrea sp.*	11.54	< 1
Pectinidae	scallop	*Mimachlamys scabricostata*	11.54	< 1
Phyllophoridae	holothurian	*Havelockia versicolor*	11.54	< 1
Pilumnidae	Hairy Crabs	*Pilumnidae*	11.54	< 1
Portunidae	Swimmer crab	*Thalamita sp.*	7.69	< 1
Raspailiidae	Sponge	*Echinodictyum clathrioides*	11.54	< 1
Raspailiidae	Sponge	*Echinodictyum mesenterinum*	11.54	< 1
Sicyoniidae	Ridgeback Rock Shrimp	*Sicyonia lancifera*	11.54	< 1
Stichopodidae	green fish [beche-de-mer]	*Stichopus chloronotus*	11.54	< 1
Stichopodidae	holothurian	*Stichopus hermanni*	11.54	< 1
Strombidae	stromb	*Strombus campbelli*	11.54	< 1
Thaididae	oyster drill	*Cronia avellana*	11.54	< 1
Toxopneustidae	sea urchin	*Tripneustes gratilla*	11.54	< 1
Veneridae	venus cockle	*Callista planatella*	11.54	< 1
Volutidae	Southern Bailer Shell	*Melo miltonis*	11.54	< 1
Arminidae	nudibranch	*Armina sp.*	7.69	< 1
Astropectinidae	Sea star	*Astropecten monacanthus*	7.69	< 1
Astropectinidae	seastar	*Astropecten zebra*	7.69	< 1
Axinellidae	Sponge	*Stylotella sp.*	7.69	< 1
Calappidae	Crab, Red-spotted Box	*Calappa philargius*	7.69	< 1
Callyspongiidae	Sponge	*Callyspongia sp.3*	7.69	< 1
Cardiidae	heart cockle	*Fragum hemicardium*	7.69	< 1
Comasteridae	crinoid	*Comatula purpurea*	7.69	< 1
Cucumariidae	holothurian	*Plesiocolochirus challengeri*	7.69	< 1
Dictyodendrillidae	Fibre sponge	*Dictyodendrilla sp.1*	7.69	< 1
Dorippidae	Crab	*Dorippe quadridens*	7.69	< 1
Echiuroidea	Echiuroid worm	*Echiuroidea*	7.69	< 1
Fissurellidae	shield limpet	*Scutus antipodes*	7.69	< 1
Halichondriidae	Sponge	*Amorphinopsis sp.1*	7.69	< 1
Holothuriidae	holothurian	*Holothuria impatiens*	7.69	< 1
Holothuriidae	holothurian	*Holothuria michaelseni*	7.69	< 1
Irciniidae	Fibre sponge	*Ircinia sp.1*	7.69	< 1
Irciniidae	Fibre sponge	*Psammocinia sp.4*	7.69	< 1
Laganidae	sand dollar	*Peronella lesueuri*	7.69	< 1
Leucosiidae	pebble crab	*Leucosia haswelli*	7.69	< 1
Loveniidae	heart urchin	*Breynia desorii*	7.69	< 1 – 10
Majidae	spider crab	*Hyastenus spinosus*	7.69	< 1
Matutidae	Armed Crab	*Ashtoret granulosa*	7.69	< 1
Microcionidae	Sponge	*Microcionidae*	7.69	< 1
Mytilidae	mussel	*Modiolus proclivis*	7.69	< 1

Octopodidae	Poison Ocellate Octopus	*Octopus mototi*	7.69	< 1
Odontodactylidae	mantis shrimp	*Odontodactylus latirostris*	7.69	< 1
Olividae	ancillid shell	*Ancillista cingulata*	7.69	< 1
Ophiotrichidae	brittlestar	*Macrophiothrix megapoma*	7.69	< 1
Ophiotrichidae	brittlestar	*Ophiothrix ciliaris*	7.69	< 1
Penaeidae	coral prawn	*Metapenaeopsis wellsi*	7.69	< 1
Pharidae	razor clam	*Ensiculus cultellus*	7.69	< 1
Pleurobranchidae	Side-gilled Seaslug	*Pleurobranchus sp.*	7.69	< 1
Plexauridae	Gorgonian	*Euplexaura sp.A*	7.69	< 1
Portunidae	Swimmer crab	*Portunus sp.*	7.69	< 1
Portunidae	Crab, Swimmer	*Portunus sp.2*	7.69	< 1
Pteriidae	Pearl Oyster	*Pinctada radiata*	7.69	< 1
Pteroeididae	Seapen	*Pteroeides sp.A*	7.69	< 1
Ranellidae	triton shell	*Cymatium sp.*	7.69	< 1
Spirastrellidae	Sponge	*Spirastrella sp.1*	7.69	< 1
Styelidae	ascidian	*Polycarpa aurata*	7.69	< 1
Tedaniidae	Sponge	*Hemitedania sp.1*	7.69	< 1
Turbinidae	pheasant shell	*Phasianella solida*	7.69	< 1
Veretillidae	Seapen	*Veretillum sp.A*	7.69	< 1
Volutidae	Melon Shell	*Melo amphora*	7.69	< 1
Ancorinidae	Sponge	*Stelletta sp.1*	3.85	< 1
Archasteridae	seastar	*Archaster angulatus*	3.85	< 1
Arcidae	ark shell	*Anadara crebricostata*	3.85	< 1
Arcidae	Ark Shell	*Trisidos semitorta*	3.85	< 1
Axinellidae	Sponge	*Axinellidae*	3.85	< 1
Axinellidae	Sponge	*Reniochalina sp.*	3.85	< 1
Axinellidae	Sponge	*Reniochalina stalagmites*	3.85	< 1
Buccinidae	Whelk Shell	*Cantharus erythrostomus*	3.85	< 1
Bullidae	bubble shell	*Bulla ampulla*	3.85	< 1
Bullidae	Bubble Shell	*Bulla quoyii*	3.85	< 1
Callyspongidae	Staircase sponge	*Callyspongia sp.*	3.85	< 1
Callyspongiidae	Sponge	*Callyspongia sp.5*	3.85	< 1
Callyspongiidae	Sponge	*Callyspongia sp.6*	3.85	< 1
Callyspongiidae	Sponge	*Callyspongia sp.7*	3.85	< 1
Callyspongiidae	Sponge	*Callyspongia sp.8*	3.85	< 1
Callyspongiidae	Sponge	*Callyspongia sp.9*	3.85	< 1
Cassidae	Helmet Shell	*Semicassis paucirugis*	3.85	< 1
Caudinidae	holothurian	*Paracaudina chilensis*	3.85	< 1
Chalinidae	Sponge	*Haliclona sp.1*	3.85	< 1
Chondropsidae	Sponge	*Chondropsis sp.1*	3.85	< 1
Chondropsidae	Sponge	*Strongylacidon sp.1*	3.85	< 1
Columbellidae	dove shell	*Pyrene bidentata*	3.85	< 1
Dictyodendrillidae	Fibre sponge	*Igernella sp.1*	3.85	< 1
Didemnidae	ascidian	*Didemnum membranaceum*	3.85	< 1
Didemnidae	ascidian	*Leptoclinides kingi*	3.85	< 1

Dorippidae	Crab	*Paradorippe australiensis*	3.85	< 1
Dysideidae	Sponge	*Dysidea sp.1*	3.85	< 1
Ellisellidae	Gorgonian	*Dichotella sp.A*	3.85	< 1
Eurysquillidae	mantis shrimp	*Manningia notialis*	3.85	< 1
Fasciculariidae	Soft coral	*Studeriotes sp.B*	3.85	< 1
Ficidae	Fig Shell	*Ficus eospila*	3.85	< 1
Fissurellidae	shield limpet	*Scutus sp.*	3.85	< 1
Fissurellidae	shield limpet	*Scutus unguis*	3.85	< 1
Halichondriidae	Sponge	*Epipolosis sp.1*	3.85	< 1
Hiatellidae	bivalve	*Hiatella australis*	3.85	< 1
Hippolytidae	Prawn, Peacock	*Tozeuma pavoninum*	3.85	< 1
Holothuridae	Holothurian	*Holothuria albiventer*	3.85	< 1
Ircinidae	Sponge	*Ircinia sp.2*	3.85	< 1
Ircinidae	Fibre sponge	*Psammocinia sp.5*	3.85	< 1
Ircinidae	Fibre sponge	*Psammocinia sp.6*	3.85	< 1
Ircinidae	Fibre sponge	*Psammocinia sp.7*	3.85	< 1
Irciniidae	Fibre sponge	*Psammocinia sp.1*	3.85	< 1
Irciniidae	Fibre sponge	*Psammocinia sp.3*	3.85	< 1
Mactridae	Trough Clam	*Lutraria rhynchaena*	3.85	< 1
Majidae	spider crab	*Hyastenus diacanthus*	3.85	< 1
Majidae	spider crab	*Micippa sp.*	3.85	< 1
Malleidae	hammer oyster	*Vulsella vulsella*	3.85	< 1
Matutidae	Crab, Reticulated Surf	*Matuta planipes*	3.85	< 1
Microcionidae	Sponge	*Acainus sp.*	3.85	< 1
Muricidae	whelk	*Morula sp.*	3.85	< 1
Mycalidae	Sponge	*Mycale sp.1*	3.85	< 1
Mycalidae	Sponge	*Mycale sp.2*	3.85	< 1
Nassaridae	dog whelk	*Nassarius glans*	3.85	< 1
Naticidae	sand snail	*Natica stellata*	3.85	< 1
Naticidae	Moon Snail	*Natica vitellus*	3.85	< 1
Nephtheidae	Soft coral	*Dendronephthya sp.G*	3.85	< 1
Nephtheidae	Soft coral	*Umbellulifera sp.A*	3.85	< 1
Ocypodidae	ghost/fiddler crab	*Macrophthalmus sp.*	3.85	< 1
Ophiactidae	Brittle star	*Ophiactis savignyi*	3.85	< 1
Ophiactidae	brittlestar	*Ophiactis sp.*	3.85	< 1
Ophidiasteridae	Seastar	*Leiaster coriaceus*	3.85	< 1
Ophiotrichidae	Brittle star	*Macrophiothrix paucispina*	3.85	< 1
Ophiotrichidae	Brittle Star	*Ophiothrix sp.*	3.85	< 1
Oreasteridae	seastar	*Anthenea conjungens*	3.85	< 1
Oreasteridae	seastar	*Pentaceraster gracilis*	3.85	< 1
Ostreidae	oyster	*Dendostrea folium*	3.85	< 1
Palaemonidae	Shrimp, Rock-pool	*Palaemon serenus*	3.85	< 1
Panuliridae	Western Rock Lobster	*Panulirus cygnus*	3.85	< 1
Parthenopidae	crab	*Parthenope sp.*	3.85	< 1
Parthenopidae	Crab	*Pseudolambrus harpax*	3.85	< 1

Pectinidae	doughboy scallop	*Mimachlamys asperrima*	3.85	< 1
Pectinidae	Scallop Shell	*Mimachlamys crassicostata*	3.85	< 1
Pectinidae	King Scallop	*Pecten fumatus*	3.85	< 1
Phyllophoridae	holothurian	*Phyllophorus brocki*	3.85	< 1
Phyllophoridae	holothurian	*Phyllophorus sp.*	3.85	< 1
Phyllophoridae	holothurian	*Phyrella trapeza*	3.85	< 1
Pilumnidae	Crab, Hairy	*Bathypilumnus pugilator*	3.85	< 1
Pinnidae	Razor Clam	*Pinna bicolor*	3.85	< 1
Plexauridae	Gorgonian	*Menella sp.C*	3.85	< 1
Plurellidae	ascidian	*Microgastra granosa*	3.85	< 1
Polyclinidae	ascidian	*Polyclinum vasculosum*	3.85	< 1
Porcellanidae	porcelain crab	*Porcellanella sp.*	3.85	< 1
Portunidae	swimmer crab	*Lupocyclus rotundatus*	3.85	< 1
Portunidae	Crab, Swimmer	*Lupocyclus sp.*	3.85	< 1
Pterasteridae	seastar	*Eurataster insignis*	3.85	< 1
Pteriidae	Shark Bay pearl oyster	*Pinctada albina*	3.85	< 1
Pteroeididae	Seapen	*Pteroeides sp.*	3.85	1
Pteroeididae	Seapen	*Pteroeides sp.D*	3.85	< 1
Pyuridae	ascidian	*Herdmania mentula*	3.85	1
Pyuridae	ascidian	*Herdmania pallida*	3.85	21
Pyuridae	ascidian	*Herdmania sp.*	3.85	< 1
Pyuridae	ascidian	*Microcosmus exasperatus*	3.85	< 1
Ranellidae	triton shell	*Cymatium caudatum*	3.85	< 1
Ranellidae	Triton Shell	*Cymatium oblitum*	3.85	< 1
Raspailiidae	Sponge	*Echinodictyum nidilus*	3.85	< 1
Raspailiidae	Sponge	*Ectyoplasia tabula*	3.85	< 1
Sepiadariidae	southern bottletail squid	*Sepiadarium austrinum*	3.85	< 1
Solenoceridae	Prawn	*Solenocera pectinulata*	3.85	< 1
Spongiidae	Sponge	*Cacospongia sp.1*	3.85	< 1
Spongiidae	Sponge	*Cacospongia sp.2*	3.85	< 1
Spongiidae	Fibre sponge	*Hippospongia sp.2*	3.85	< 1
Spongiidae	Fibre sponge	*Hippospongia sp.3*	3.85	< 1
Spongiidae	Sponge	*Lendenfeldia sp.1*	3.85	< 1
Spongiidae	Sponge	*Spongia sp.1*	3.85	< 1
Spongiidae	Sponge	*Spongia sp.2*	3.85	< 1
Strombidae	stromb	*Strombus vomer*	3.85	< 1
Styelidae	ascidian	*Botrylloides perspicuus*	3.85	< 1
Suberitidae	Sponge	*Caulospongia perfoliata*	3.85	< 1
Synaptidae	Holothurian	*Synaptula reticulata*	3.85	< 1
Tedaniidae	Fibre sponge	*Tedania sp.1*	3.85	< 1
Tedaniidae	Fibre sponge	*Tedania sp.2*	3.85	< 1
Thorectidae	Sponge	*Fenestraspongia sp.1*	3.85	< 1
Toxopneustidae	Sea urchin	*Nudechinus darnleyensis*	3.85	< 1
Trochidae	top shell	*Calthalotia mundula*	3.85	< 1
Trochidae	top shell	*Tallorbis roseolus*	3.85	< 1

Trochidae	top shell	*Thalotia sp.*	3.85	< 1
Turbinidae	pheasant shell	*Phasianella variegata*	3.85	< 1
Velutinidae	gastropod	*Lamellaria sp.*	3.85	< 1
Veneridae	Venus Cockle	*Antigona lamellaris*	3.85	< 1
Veneridae	Venus Cockle	*Circe rivularis*	3.85	< 1
Veneridae	venus cockle	*Circe sulcata*	3.85	< 1
Veneridae	Venus Cockle	*Paphia crassisulca*	3.85	< 1
Veneridae	venus cockle	*Paphia semirugata*	3.85	< 1
Veneridae	Venus Cockle	*Pitar nancyae*	3.85	< 1
Veretillidae	Seapen	*Lituaria sp.A*	3.85	< 1
Veretillidae	Seapen	*Veretillum australis*	3.85	< 1
Veretillidae	Seapen	*Veretillum sp.C*	3.85	< 1
Volutidae	Bailer Shell	*Melo sp.*	3.85	< 1
Xanthidae	black fingered crab	*Actaea savignyi*	3.85	< 1
Zygometridae	crinoid	*Zygometra comata*	3.85	< 1

Appendix G: ETP[1] Species in the Shark Bay Region

*** indicates sea / shore birds listed under CAMBA, JAMBA or ROKAMBA; IUCN Status: CE: Critically endangered; E: Endangered; V: Vulnerable; NT: Near threatened; LC: Least concern; DD: Data deficient; NA: Not yet assessed by the IUCN.**

Common Name	Scientific Name	WC Act[2]	EPBC Act[3]	CITES[4]	IUCN[5]
Marine Mammals					
Sirenia					
Dugong	*Dugong dugon*	Schedule 4	Migratory, Marine	Appendix I	VU
Cetaceans					
Minke whale	*Balaenoptera acutorostrata*		Cetacean	Appendix I	LC
Bryde's whale	*Balaenoptera edeni*		Migratory, Cetacean	Appendix I	DD
Pygmy blue whale	*Balaenoptera musculus brevicauda*		Cetacean	Appendix I	DD
Fin whale	*Balaenoptera physalus*	Schedule 1	Vulnerable, Migratory, Cetacean	Appendix I	EN
Common dolphin	*Delphinus delphis*		Cetacean	Appendix II	LC
Southern right whale	*Eubalaena australis*	Schedule 1	Endangered, Migratory, Cetacean	Appendix I	LC
Pygmy killer whale	*Feresa attenuata*		Cetacean	Appendix II	DD
Risso's dolphin	*Grampus griseus*		Cetacean	Appendix II	LC
Pygmy sperm whale	*Kogia breviceps*		Cetacean	Appendix II	DD
Humpback whales	*Megaptera novaeangliae*	Schedule 1	Vulnerable, Migratory, Cetacean	Appendix I	LC
Blainville's beaked whale	*Mesoplodon densirostris*		Cetacean	Appendix II	DD
Killer whales	*Orcinus orca*		Migratory, Cetacean	Appendix II	DD
Sperm whale	*Physeter macrocephalus*		Migratory, Cetacean	Appendix I	VU
Indo-Pacific humpback dolphin	*Sousa chinensis*		Migratory, Cetacean	Appendix I	NT

[1] For more information on all species found in Shark Bay visit: http://ozcam.org.au/
[2] Current list of threatened fauna (Specially protected fauna notice- 17 Feb 2012) <http://www.dec.wa.gov.au/management-and-protection/threatened-species/listing-of-species-and-ecological-communities.html>
[3] EPBC protection status <http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>
[4] CITES Appendices Listing <http://www.cites.org/eng/app/appendices.php>
[5] IUCN Redlist 2012 <iucnredlist.org>

Spotted dolphin	*Stenella attenuata*		Cetacean	Appendix II	LC
Long-snouted spinner dolphin	*Stenella longirostris*		Cetacean	Appendix II	DD
Rough-toothed dolphin	*Steno bredanensis*		Cetacean	Appendix II	LC
Bottlenose dolphin	*Tursiops aduncus*		Cetacean	Appendix II	DD
Pinnipeds					
New Zealand fur seal	*Arctocephalus forsteri*	Schedule 4	Marine	Appendix II	LC
Australian sea lion	*Neophoca cinerea*	Schedule 4	Vulnerable, Marine		EN
Marine Reptiles					
Marine turtles					
Loggerhead turtles	*Caretta caretta*	Schedule 1	Endangered, Migratory, Marine	Appendix I	EN
Green turtles	*Chelonia mydas*	Schedule 1	Vulnerable, Migratory, Marine	Appendix I	EN
Leatherback turtles	*Dermochelus coriacea*	Schedule 1	Endangered, Migratory, Marine	Appendix I	CE
Hawksbill Turtles	*Eretmochelys imbricata*	Schedule 1	Vulnerable, Migratory, Marine	Appendix I	CE
Sea snakes					
Golden sea snake	*Aipysurus laevis*		Marine		LC
Shark Bay sea snake	*Aipysurus pooleorum*		Marine		NA
North-western mangrove sea snake	*Ephalophis greyae*		Marine		LC
Bar-bellied sea snake	*Hydrophis elegans*		Marine		LC
Olive-headed sea snake	*Hydrophis major*		Marine		LC
Spotted sea snake	*Hydrophis ocellatus*		Marine		LC
Yellow-bellied sea snake	*Pelamis platurus*		Marine		LC
Protected Fish Species					
Sharks and rays					
Grey nurse shark	*Carcharias taurus*	Schedule 1	Vulnerable		VU
White Shark	*Carcharodon carcharias*	Schedule 1	Vulnerable, Migratory	Appendix II	VU
Whale shark	*Rhincodon typus*	Schedule 4	Vulnerable, Migratory	Appendix II	VU

Great hammerhead	*Sphyrna mokarran*			EN
Scalloped hammerhead	*Sphyrna zygaena*			VU
Manta ray	*Manta birostris*	Migratory		VU
Syngnathids and Solenostomids				
Gales pipefish	*Campichthys galei*	Marine		NA
Pacific short-bodied pipefish	*Choeroichthys brachysoma*	Marine		NA
Muiron Island pipefish	*Choeroichthys latispinosus*	Marine		NA
Pig-snouted pipefish	*Choeroichthys suillus*	Marine		NA
Banded pipefish	*Doryrhamphus dactyliophorus*	Marine		DD
Cleaner pipefish	*Doryrhamphus janssi*	Marine		LC
Flagtail pipefish	*Doryrhamphus negrosensis*	Marine		NA
Ladder pipefish	*Festucalex scalaris*	Marine		NA
Tiger pipefish	*Filicampus tigris*	Marine		NA
Brock's pipefish	*Halicampus brocki*	Marine		NA
Gray's pipefish	*Halicampus grayi*	Marine		NA
Glittering pipefish	*Halicampus nitidus*	Marine		NA
Spiny-snout pipefish	*Halicampus spinirostris*	Marine		NA
Ribboned pipefish	*Haliichthys taeniophorus*	Marine		NA
Beady pipefish	*Hippichthys penicillus*	Marine		LC
Winged seahorse	*Hippocampus alatus*	Marine	Appendix II	DD
False-eyed seahorse	*Hippocampus biocellatus*	Marine	Appendix II	NA
Spiny seahorse	*Hippocampus histrix*	Marine	Appendix II	VU
Flat-faced seahorse	*Hippocampus planifrons*	Marine		NA
Zebra seahorse	*Hippocampus zebra*	Marine	Appendix II	DD
Tidepool pipefish	*Micrognathus micronotopterus*	Marine		NA
Common weedy sea dragon	*Phyllopteryx taeniolatus*	Marine		NT
Gunther's pipefish	*Solegnathus lettiensis*	Marine		DD
Robust ghost pipefish	*Solenostomus cyanopterus*	Marine		NA

Spotted pipefish	*Stigmatopora argus*		Marine	NA
Alligator pipefish	*Syngnathoides biaculeatus*		Marine	DD
Short-tailed pipefish	*Trachyrhamphus bicoarctatus*		Marine	NA
Long-nosed pipefish	*Trachyrhamphus longirostris*		Marine	NA
Sea and Shorebirds				
Collared sparrowhawk	*Accipiter cirrocephalus*			LC
Brown goshawk	*Accipiter fasciatus*		Marine	LC
Grey teal	*Anas gracilis*			LC
Australasian shoveler	*Anas rhynchotis*			LC
Australian black duck	*Anas superciliosa*			LC
Fork-tailed swift *	*Apus pacificus*	Schedule 3	Migratory, Marine	LC
White necked heron	*Ardea pacifica*			LC
Ruddy turnstone*	*Arenaria interpres*	Schedule 3	Migratory, Marine	LC
Wedge-tailed eagle	*Aquila audax*			LC
Hardhead	*Aythya australis*			LC
Striated heron	*Butorides striata*			LC
Sharp-tailed sandpiper *	*Calidris acuminata*	Schedule 3	Migratory, Marine	LC
Sanderling *	*Calidris alba*	Schedule 3	Migratory, Marine	LC
Red knot *	*Calidris canutus*	Schedule 3	Migratory, Marine	LC
Curlew sandpiper *	*Calidris ferruginea*	Schedule 3	Migratory, Marine	LC
Red-necked stint *	*Calidris ruficollis*	Schedule 3	Migratory, Marine	LC
Great knot *	*Calidris tenuirostris*	Schedule 3	Migratory, Marine	VU
Streaked shearwater *	*Calonectris leucomelas*	Schedule 3	Migratory, Marine	LC
Greater sand plover *	*Charadrius leschenaultii*	Schedule 3	Migratory, Marine	LC
Lesser sand plover *	*Charadrius mongolus*	Schedule 3	Migratory, Marine	LC
Red-capped plover *	*Charadrius ruficapillus*	Schedule 3	Migratory, Marine	LC
Oriental plover *	*Charadrius veredus*	Schedule 3	Migratory, Marine	LC
Australian wood duck	*Chenonetta jubata*			LC
White-winged black tern *	*Chlidonias leucopterus*	Schedule 3	Migratory, Marine	LC

Silver gull	*Chroicocephalus novaehollandiae*		Marine	LC
Spotted harrier	*Circus assimilis*			LC
Swamp harrier	*Circus approximans*		Marine	LC
Banded stilt	*Cladorhynchus leucocephalus*			LC
Black swan	*Cygnus atratus*			LC
Cape petrel	*Daption capense*		Marine	LC
White faced heron	*Egretta novaehollandiae*			LC
Eastern reef egret *	*Egretta sacra*	Schedule 3	Migratory, Marine	LC
Little egret	*Egretta garzetta*		Marine	LC
Black-shouldered kite	*Elanus axillaris*			LC
Letter-winged kite	*Elanus scripts*			NT
Black-fronted Dotterel	*Elseyornis melanops*			LC
Beach stone curlew	*Esacus neglectus*		Marine	NA
Brown falcon	*Falco berigora*			LC
Nankeen kestrel	*Falco cenchroides*		Marine	LC
Australian hobby	*Falco longipennis*			LC
Lesser frigatebird *	*Fregata ariel*	Schedule 3	Migratory, Marine	LC
Gull-billed tern	*Gelochelidon nilotica*		Marine	NA
Oriental pranticole *	*Glareola maldivarum*	Schedule 3	Migratory, Marine	LC
Sooty oystercatcher	*Haematopus fuliginosus*			LC
Pied oystercatcher	*Haematopus longirostris*			LC
White-breasted sea eagle *	*Haliaeetus leucogaster*	Schedule 3	Migratory, Marine	LC
Whistling kite	*Haliastur sphenurus*		Marine	LC
Grey-tailed tattler *	*Heteroscelus brevipes*	Schedule 3	Migratory, Marine	LC
Little eagle	*Hieraaetus morphnoides*			LC
Black-winged stilt	*Himantopus himantopus*		Marine	LC
Barn swallow *	*Hirundo rustica*	Schedule 3	Migratory, Marine	LC
Pacific gull	*Larus pacificus*		Marine	LC
Broad-billed sandpiper *	*Limicola falcinellus*	Schedule 3	Migratory, Marine	LC
Bar-tailed godwit *	*Limosa lapponica*	Schedule 3	Migratory, Marine	LC

Black-tailed godwit *	*Limosa limosa*	Schedule 3	Migratory, Marine	NT
Southern giant petrel *	*Macronectes giganteus*	Schedule 1	Endangered, Migratory, Marine	LC
Pink-eared duck	*Malacorhynus membranaceus*			LA
Australasian gannet	*Morus serrator*		Marine	LC
Eastern curlew *	*Numenius madagascariensis*	Schedule 3	Migratory, Marine	VU
Little whimbrel *	*Numenius minutus*	Schedule 3	Migratory, Marine	LC
Whimbrel *	*Numenius phaeopus*	Schedule 3	Migratory, Marine	LC
Nankeen night heron	*Nycticorax caledonicus*		Marine	LC
Wilson's storm petrel *	*Oceanites oceanicus*	Schedule 3	Migratory, Marine	LC
Brindled tern *	*Onychoprion anaethetus*	Schedule 3	Migratory, Marine	NA
Osprey *	*Pandion haliaetus*		Migratory, Marine	LC
White-faced storm petrel	*Pelagodroma marina*		Marine	LC
Australian pelican	*Pelecanus conspicillatus*		Marine	LC
Great cormorant	*Phalacrocorax carbo*			LC
Little pied cormorant	*Phalacrocorax melanoleucos*			LC
Pied cormorant	*Phalancrocorax varius*			LC
Ruff *	*Philomachus pugnax*	Schedule 3	Migratory, Marine	LC
Glossy ibis *	*Plegadis falcinellus*	Schedule 3	Migratory, Marine	LC
Grey plover *	*Pluvialis dominica*	Schedule 3	Migratory, Marine	LC
Pacific golden plover *	*Pluvialis fulva*	Schedule 3	Migratory, Marine	LC
Great-winged petrel	*Pterodroma macroptera*		Marine	LC
Soft-plumaged petrel	*Pterodroma mollis*		Vulnerable, Marine	LC
Little shearwater	*Puffinus assimilis*		Marine	LC
Flesh-footed shearwater *	*Puffinus carneipes*	Schedule 3	Migratory, Marine	LC
Hutton's shearwater	*Puffinus huttoni*		Marine	EN
Wedge-tailed shearwater *	*Puffinus pacificus*	Schedule 3	Migratory, Marine	LC
Red-necked Avocet	*Ecurvirostra novaehollandiae*		Marine	LC
Lesser crested tern *	*Sterna bengalensis*	Schedule 3	Migratory, Marine	LC
Crested tern *	*Sterna bergii*		Marine	LC
Caspian tern *	*Sterna caspia*	Schedule 3	Migratory, Marine	LC

Roseate tern *	*Sterna dougallii*	Schedule 3	Migratory, Marine	LC
Sooty tern	*Sterna fuscata*		Marine	LC
Common tern *	*Sterna hirundo*	Schedule 3	Migratory, Marine	LC
Fairy tern	*Sterna neresis neresis*	Schedule 1	Vulnerable, Marine	VU
Brown booby *	*Sula leucogaster*	Schedule 3	Migratory, Marine	LC
Australian shelduck	*Tadorna tadornoides*			LC
Yellow-nosed albatross	*Thalassarche chlororhynchos*	Schedule 1	Migratory, Marine	EN
Wood sandpiper *	*Tringa glareola*	Schedule 3	Migratory, Marine	LC
Common sandpiper *	*Tringa hypoleucos*	Schedule 3	Migratory, Marine	LC
Greenshank *	*Tringa nebularia*	Schedule 3	Migratory, Marine	LC
Common redshank / Marsh sandpiper *	*Tringa totanus*	Schedule 3	Migratory, Marine	LC
Terek sandpiper *	*Xenus terek*	Schedule 3	Migratory, Marine	LC

Appendix H: Summary of Stakeholder Consultation for the SBPMF 2013/14

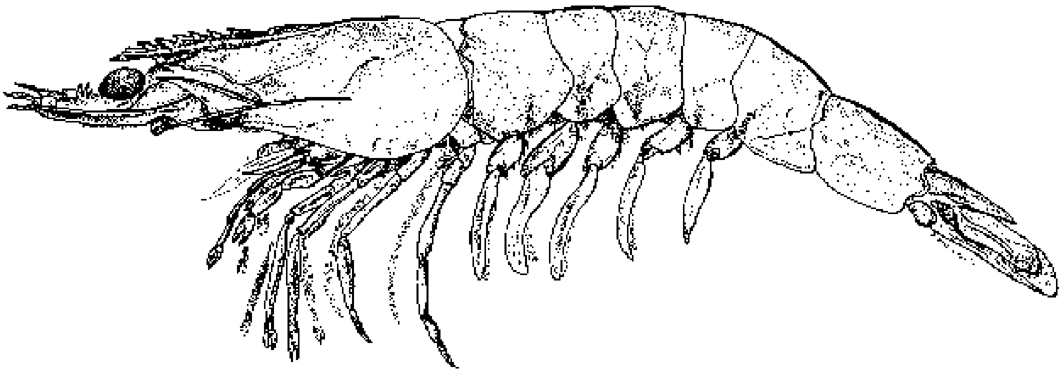
Type of meeting held in 2013-14	Issues discussed	Stakeholders Invited	Date Held
Season Arrangements Meetings	• Management of closures within the Fishery • Fishery opening and closing dates • Moon closure time periods	• Department officers (Management and Research) • Skippers • Industry Association	November 2013 & Jan 2014
Annual Management Meeting	• Research Report • Management Update • Compliance Update	• Department officers (Management, Research and Compliance) • Industry Association • Licence holders • WAFIC	Dec 2013
MSC Meetings (ongoing)	• Pre-assessment outcomes • Options for full assessment • Choice of Conformity Assessment Bodies	• Department officers (Management and Research) • Industry Association • Licence holders • WAFIC • MSC representatives	February - present
Pre-season Skippers Briefing	• Spatial and temporal closures • Compliance requirements	• Department officers (Management, Research and Compliance) • Skippers • Industry Association	March 2014

Appendix I: 2013 Season Report for the SBPMF

SHARK BAY PRAWN MANAGED FISHERY

2013 Season Report

Preliminary



Compiled By Prawn and Scallop Research

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In consultation with the Shark Bay Prawn Fishing Industry

FISHERIES
WESTERN AUSTRALIA

FISHERY DESCRIPTION

The Shark Bay Prawn Managed Fishery targets western king prawns *Melicertus (Penaeus latisulcatus)*, brown tiger prawns *(Penaeus esculentus)* and a variety of smaller prawn species including coral prawns (various species) and endeavour prawns (*Metapenaeus* spp.). King prawns are the dominant species, comprising about 70% of the catch. Tiger prawns make up most of the remaining 30%.

Fishing is undertaken using otter trawls with 'bison' otterboards (under exemption).

Governing legislation/fishing authority

Shark Bay Prawn Management Plan 1993

Shark Bay Prawn Managed Fishery Licence

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

Boundaries

The boundaries of this managed fishery are the waters of the Indian Ocean between latitudes 23°34′ S and 26°30′ S and adjacent to Western Australia on the landward side of the 200 m isobath.

Management arrangements

The SBPMF Plan is the current management plan for the Fishery and is a formal statutory document that sets out the management measures for the fishery. The Fishery is separated into three distinct fishing areas, Koks Island north (north of North of 24°45.18'), northern Shark Bay, which includes the tiger prawn spawning area (TPSA) and the extended nursery area (ENA), Denham Sound, and permanently closed nursery areas (Figure 1).

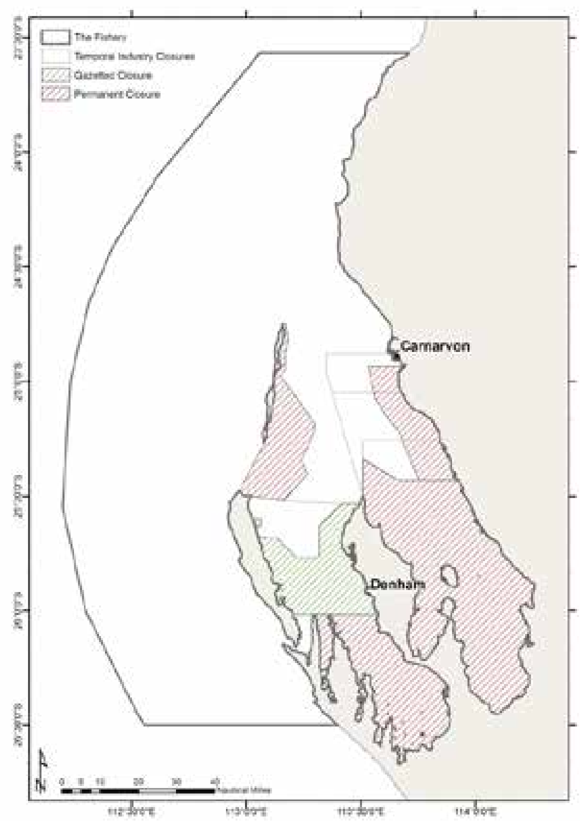

Figure 1. SBP fishery indicating areas closed to fishing, the gazetted closure is commonly referred as the snapper trawl line.

Management Objectives

The Fish Resource Management 1994 (FRMA) is the overarching legislation for the Shark Bay Prawn Managed Fishery (SBPMF).

The key object of the FRMA is to conserve develop and share the fish resources of the State for the benefit of present and future generations.

In particular for the Shark Bay Prawn fishery the Act has the following key objects: conserve fish and protect their environment and ensure that the exploitation of fish resources is carried out in a sustainable manner with aim to achieve the optimum economic, social and other benefits from the use of the fish resources.

The reduction of boat numbers and overall net allocation is continuing with the aim of maximizing economic efficiency, whilst maintaining overall catches in this fishery as well as stock sustainability.

Management of the fishery is through input controls that began as limited entry, with controls on maximum boat and twin trawl net sizes. This system has specific effort controls based on maximum headrope length and the maximum fishing days (season duration). These controls have allowed fleet rationalisation to occur in response to improvements in vessel and gear efficiency. This basic management framework has been supported by a sophisticated system of seasonal, spatial and temporal closures (nursery and spawning area). These management controls, in particular, the spatial and temporal closures are designed to ensure the maintenance of breeding stocks for all prawn species, maximise the size of the prawns at capture and minimize environment impacts of the fishery.

Total allowable effort: The primary control on the fishery effort is through the maximum headrope units in the fishery and the duration of the season. The maximum headrope allocation for the fleet was set at 790 m (or 432 fathoms of headrope). This headrope allocation was originally for use in the twin trawl configuration using nets of maximum size equal to 2 x 14.63 m (8 ftm), but has been reduced by 8.3 % to 724 m (396 ftm), when the change to the more efficient quad gear configuration was approved. This has resulted in a reduction in the number of boats with the headrope allocation being redistributed among the remaining boats. The reduction of boat numbers and overall net allocation is continuing with the aim of maximizing economic efficiency, whilst maintaining overall catches in this fishery as well as stock sustainability.

The key closure controls are:

Annual closed season: The Fishery is generally closed between November and March to protect recruiting juvenile prawns.

Area closures: Spatial management measures include permanent and temporal trawl fishing closures or restrictions. These result in approximately 38% of the fishery being actually fished in any one year. The shallow parts of Shark Bay are permanently closed to trawling to preserve seagrass/algae and other sensitive habitats that are essential nursery areas for prawns and other species. There is also a series of Fishery area openings and closures designed to allow fishing of the prawns as they reach marketable size. The Research Division's monitoring of the fleet for catch and effort and providing real-time advice when to open and close areas is part of the fishery's management strategy for the control of spatial and temporal closures.

Time closures: King and tiger prawns are predominantly nocturnal and therefore trawling is generally only permitted between 1800 hrs and 0800 hrs. Trawling for prawns during the day (except in the deeper waters in the northern part of the fishery where trawling to 1000 hrs each day is permitted) is often unproductive as prawns burrow in the sediment. There are also several complete 24-hour closures throughout the season over each period of the full moon to increase economic efficiency by protecting moulting (soft-shelled) prawns. These lunar closures increase fishing efficiency and provide time off each month for crew.

Additional Gear controls: Gear controls include restrictions on the number of nets and the size of the trawl otter boards and ground chains.

A requirement for bycatch reduction devices (grids and secondary devices) has been implemented in this fishery. All vessels are required by way of a condition on the managed fishery license to fish with a grid and secondary BRD (square mesh panel) in each net.

In 2002 a Vessel Monitoring System (VMS) was introduced allowing the Department to monitor a boat's location and speed with particular attention paid to the surveillance of nursery areas.

The yearly cycle of operation for the fishery is dynamic and multi-faceted. Opening and closing dates vary each year depending on environmental conditions, moon phase and the results of surveys, which predict recruitment dynamics and monitors the size distribution of prawns. The timing of the opening of the season allows the harvesting of the current season's recruits and the large residual prawns not caught the previous season.

2013 Season

The 2013 season fishing arrangements had a season opening date on 11 March and closing 15 October providing a total of 175 nights fishing. Of the 175 fishing nights only 160 were used by the entire fleet. Four boats did not fish the last fishing period commencing 24 September. The entire fleet comprising eighteen boats, fished with quad gear configuration (four, 10.1 m nets).

The fishing strategy during the 2013 season involved flexible fishing arrangements and voluntary industry closures based on assessment of both king and tiger prawn size through fishery-independent surveys. Generally at the commencement of the season the prawns are a small size while the industry aim is to target large size prawns suitable for their market requirements. Therefore a survey early March before the season actually commenced was undertaken west of the Carnarvon/Peron Line (CPL) to provide prawn size information. The survey showed that a high proportion of prawns were a small size resulting in the actual season's commencement of fishing being delayed until 2 April. When fishing actually commenced a closure was put in place in the northern part of the fishery to prevent the take of small tiger prawns and in the southern part of the CPL to prevent the take of small size king prawns (Attachment 1).

Openings within the CPl were based on survey information prior to each opening by using the size of prawns to determine the extent of the area to open in consultation with industry. The co-operation from industry and masters of fishing boats is essential in providing information via the logbook program and adhering to informal closures to prevent the take of small prawns and reducing effort (fishing days) in this fishery.

A survey in Denham Sound was undertaken in July. In addition to the normal survey regime, a site in the eastern part was re-introduced to assist with determination of fishing in part of the closed area below the snapper trawl line (STL).

A comprehensive ESD assessment of this fishery has determined that performance should be reported annually against measures relating to the breeding stocks of target prawn species, bycatch species impacts, protected species interactions, habitat effects and provisioning effects.

Research activities continue to focus on stock assessment and annual monitoring of the prawn stocks, particularly tiger prawns. All boats complete detailed logbooks, which together with pre-season recruitment and during-season spawning stock surveys provide the information sources for monitoring the status of the stocks.

RETAINED SPECIES

Commercial prawn production (season 2013): 1815 t whole weight

Landings

The total landings (whole weight) of major prawn species for this fishery was 1815 tonnes, comprising 1139 tonnes of king prawns, 660 tonnes of tiger prawns and 15 tonnes of endeavour prawns (Table 1). In addition, 122 t of coral prawns (various species, but mainly *Metapenaeopsis crassissima*) were landed. These total landings of major prawn species were within the interim target catch range set in 2009 (1350 – 2150 t) and within the historical target catch range (1501 to 2330 t). The interim catch range reflects the change in the king prawn landings (950 to 1350 t). The target total catch levels are still being reviewed to reflect current fishing/targeting strategies and effort levels under normal environmental conditions.

King prawn landings (1139 t) were within the historical target catch range (1100 to 1600 t) and within the interim catch range. Tiger prawn landings (660 t) were also within the historical target catch range (400-700 t).

No scallop fishing was undertaken this season.

Other retained species recorded landings comprised of 16 t of blue swimmer crabs. Coral prawns, because of their small size only return very low prices and retention is low and blue swimmer crab retention was restricted through a voluntary no-take for most of the season by the prawn fleet due to low stock levels. Other non-targeted invertebrate species landings were 21 t of cuttlefish, 6 t of squid and 3 t bugs. Small amounts of finfish including (whiting, flathead and flounder) were also recorded as landed product.

Fishing effort/access level: Since 1990 the number of boats has been reduced from 27 (between 1990 and 2004) to 25 boats in 2005 and 2006, and further by industry agreement to 18 boats in 2007. Removal of boats (licenses) has been a phased-in approach and has significantly reduced nominal fishing effort. However, to maintain catch efficiency and reduce the cost of fishing, the net headrope to each remaining boat was increased through gear amalgamation (from 29.3 m twin rig to 40.2 m quad rigged configuration). An adjustment is made to nominal effort for the increased headrope (37.5%) towed by the boats resulting in adjusted effort (Table 1).

The preliminary total nominal effort (logbook data) recorded by the prawn fleet in 2013 was 26,107 hours, a slight increase compared to the 2012-fishing season (24,106 hours) but still one of the lowest in over 40 years. The adjusted effort is 35,897 hrs, much lower than that historically recorded by 27 boats between 1990 and 2004 (mean 44,864 hours) (Table 1).

Table 1: **Shark Bay annual prawn landings (t) and effort (nominal and adjusted) for prawn boats 1962 to 2012. Effort has been adjusted to account for boats fishing with 22 fathom head rope quad gear increasing by 37.5%. Adjusted effort has been used from 2005 onwards.**

PRAWN LANDINGS SHARK BAY 1962-2013

Catches are measured to the nearest tonne, heads on. Effort in hours trawled.
The number of boats refers to the maximum number of vessels that fished during any one month

	KING		TIGER		ENDEAVOUR	TOTAL	SCALLOP	NOMINAL	ADJUSTED		
	CATCH	CATCH	CATCH	CATCH	CATCH	PRAWN	CATCH	EFFORT	EFFORT		BOAT
YEAR	(t)	(kg/hr)	(t)	(kg/hr)	(t)	(t)	(t)	(hrs)	(hrs)	BOATS	DAYS
1962	105	43.3	47	19.3	-	152	-	2 420	2 420	4	
1963	359	36.3	244	24.5	-	603	-	9 898	9 898	22	
1964	506	36.2	407	29.1	-	913	-	13 960	13 960	28	
1965	443	24.8	397	22.2	-	840	-	17 861	17 861	28	
1966	261	13.6	406	21.2	-	667	-	19 211	19 211	29	
1967	228	7.2	673	21.3	-	901	-	31 644	31 644	30	
1968	414	11.4	499	13.7	-	913	-	36 379	36 379	29	
1969	789	21.4	460	12.4	-	1 259	-	37 210	37 210	27	
1970	1043	21.4	732	15	-	1 775	-	48 667	48 667	32	
1971	937	20.2	609	13.1	-	1 546	-	46 483	46 483	32	
1972	1383	26.8	369	7.2	-	1 752	-	51 522	51 522	31	
1973	1186	23	636	12.4	-	1 822	-	51 474	51 474	32	
1974	1433	27.6	668	12.9	-	2 101	-	51 814	51 814	32	
1975	1383	25.1	770	14	-	2 153	-	55 134	55 134	35	
1976	1511	24.6	771	12.6	-	2 282	-	61 340	61 340	35	
1977	1071	18.2	550	9.4	36	1 657	-	58 757	58 757	34	
1978	1371	23.9	729	12.7	13	2 112	-	57 244	57 244	35	
1979	1439	23	660	10.5	38	2 137	-	62 655	62 655	35	
1980	1398	24.2	253	4.4	17	1 668	-	57 786	57 786	35	
1981	2014	28.4	324	4.6	32	2 370	-	70 904	70 904	35	
1982	1328	21.8	236	3.9	25	1 589	139	60 788	60 788	35	
1983	1499	25.3	477	8.1	28	2 004	65	59 137	59 137	35	
1984	1693	26.6	351	5.5	18	2 062	52	63 750	63 750	35	
1985	1532	23.1	236	3.6	24	1 792	58	66 410	66 410	35	
1986	1494	23.3	325	5.1	13	1 832	48	64 009	64 009	35	
1987	1477	23	274	4.3	9	1 760	114	64 300	64 300	35	
1988	1627	26.2	259	4.2	17	1 903	186	62 168	62 168	35	
1989	1069	18.4	300	5.2	4	1 373	49	57 923	57 923	35	
1990	730	16.5	270	6.1	2	1 002	169	44 233	44 233	27	
1991	1155	25.9	406	9.1	< 2	1 561	616	44 592	44 592	27	
1992	964	23.1	362	8.7	< 1	1 326	1268	41 681	41 681	27	
1993	790	15.5	365	7.2	< 1	1 155	465	50 888	50 888	27	206
1994	1059	18.2	548	9.4	4	1 611	272	58 092	58 092	27	226
1995	1110	19.1	784	13.5	3	1 897	173	58 242	58 242	27	215
1996	1136	19.2	731	12.3	13	1 880	125	59 232	59 232	27	221
1997	1433	24.5	626	10.7	4	2 063	101	58 393	58 393	27	212
1998	1614	28.7	538	9.6	32	2 185	75	56 175	56 175	27	201
1999	1656	30.4	579	10.6	25	2 261	90	54 523	54 523	27	197
2000	1555	29.9	689	13.2	6	2 250	25	52 049	52 049	27	193
2001	1323	26.2	371	7.4	3	1697	78	50 422	50 422	27	189
2002	1554	31.4	510	10.3	11	2075	74	49 494	49 494	27	182
2003	1145	25.7	485	10.9	3	1632	70	44616	44616	27	169
2004	1164	25.8	576	12.8	8	1748	96	45112	45112	27	169
2005	1049	25.1	579	14.7	<1	1628	167	39327	41716	25	168
2006	1091	27.4	467	11.7	<1	1559	86	37066	39827	25	162
2007	772	21.8	480	13.6	<1	1252	142	25715	35358	18	163
2008	848	26.2	384	11.9	<1	1232	168	26783	36826	18	166
2009	927	23.7	300	7.7	<1	1228	215	28571	39285	18	173
2010	1122	27.5	423	10.3	<1	1545	95	29693	40828	18	174
2011	1310	36.3	690	19.1	15	2014.9	18	26226	36061	18	162
2012	1075	32.4	494	14.9	23	1592	0	24106	33146	18	164
2013	**1139**	**31.7**	**660**	**18.4**	**15**	**1815**	**0**	**26107**	**35897**	**18**	**160**

Table 2: Annual landings (t) of other retained product for prawn boats 2000 to 2013.

YEAR	Corals (t)	Crab (t)	Cuttlefish (t)	Squid (t)	Fish Total (t)	Bugs (t)	Octopus (t)
2000	152.0	42.5	12.9	19.3	22.3	0.0	0.0
2001	164.7	88.9	17.8	26.5	18.7	0.2	0.0
2002	102.2	154.8	18.6	29.3	28.9	0.0	0.2
2003	84.0	110.5	12.0	77.5	26.2	0.0	0.3
2004	64.9	193.9	11.1	76.6	9.9	0.0	0.4
2005	91.0	152.0	7.8	46.6	3.1	0.1	0.4
2006	115.0	114.3	5.7	48.0	23.6	1.5	0.7
2007	27.4	255.6	8.6	23.1	15.8	0.7	0.5
2008	68.9	135.2	9.5	9.5	11.2	1.5	0.2
2009	197.5	251.2	21.5	21.1	16.5	2.2	0.5
2010	105.8	338.2	29.3	45.3	11.3	13.2	1.0
2011	116.8	293.0	19.9	13.9	14.4	0.9	0.5
2012	199.8	12.5	22.6	5.1	2.8	2.5	0.2
2013	121.8	15.8	20.7	5.8	13.1	3.2	0.6

Table 3: Mean prawn landings (t) per boat 2004 to 2013 (18 boats operated 2007-2013 compared to 25 boats operating in 2005-2006 and 27 in 2002-2004).

Boat Average

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
King	43	42	44	43	49	52	62	72	60	63
Tiger	21	23	19	27	22	17	23	38	27	37
Prawn	**64**	**65**	**63**	**69**	**71**	**68**	**86**	**111**	**87**	**100**
Scallops	**3.6**	**6.7**	**7.1**	**7.8**	**9.3**	**12.0**	**5.3**	**1.0**	**0.0**	**0.0**

Table 4: Total scallop landings (t) meat weight in 2013

No Scallops were retained in 2013

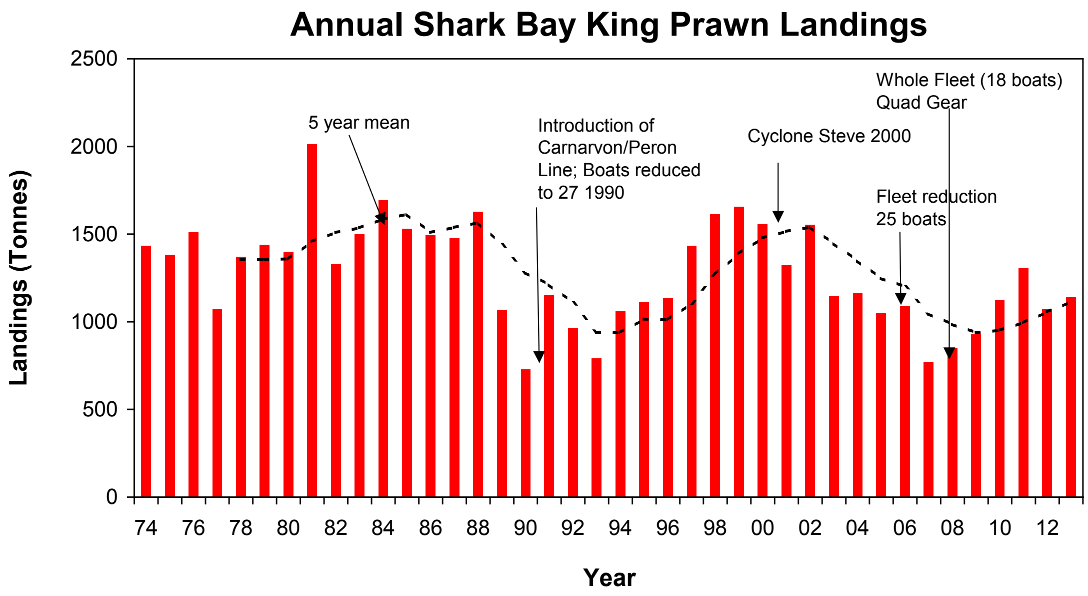

Figure 1. **Historical king prawn landings (t), significant events in the fishery and five year landings moving average (dashed line).**

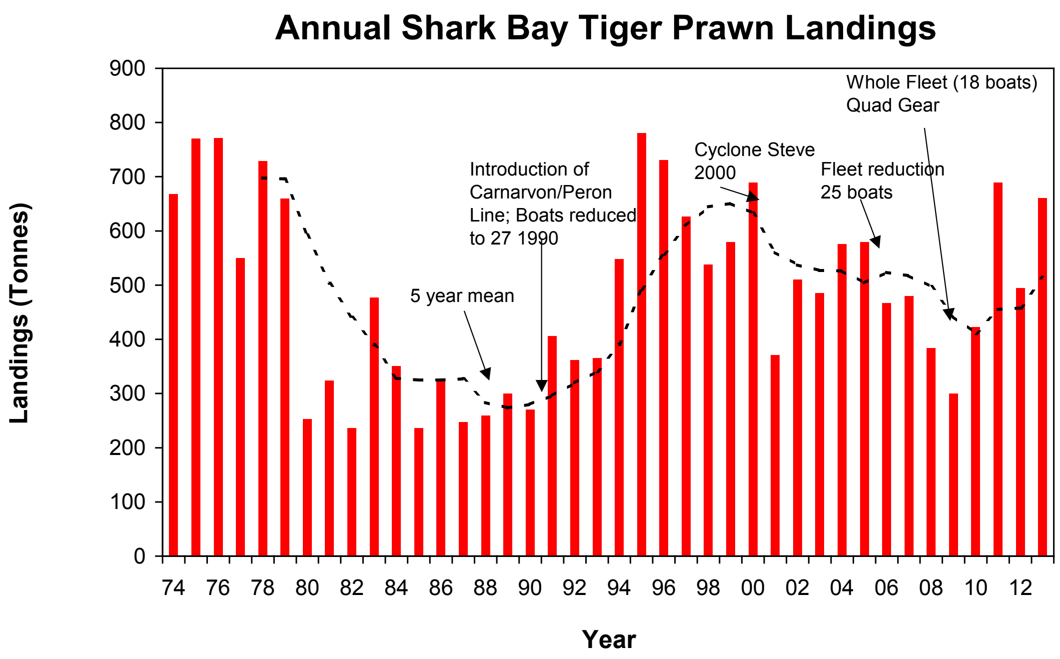

Figure 2. **Historical tiger prawn landings (t), significant events in the fishery and five year landings moving average (dashed line).**

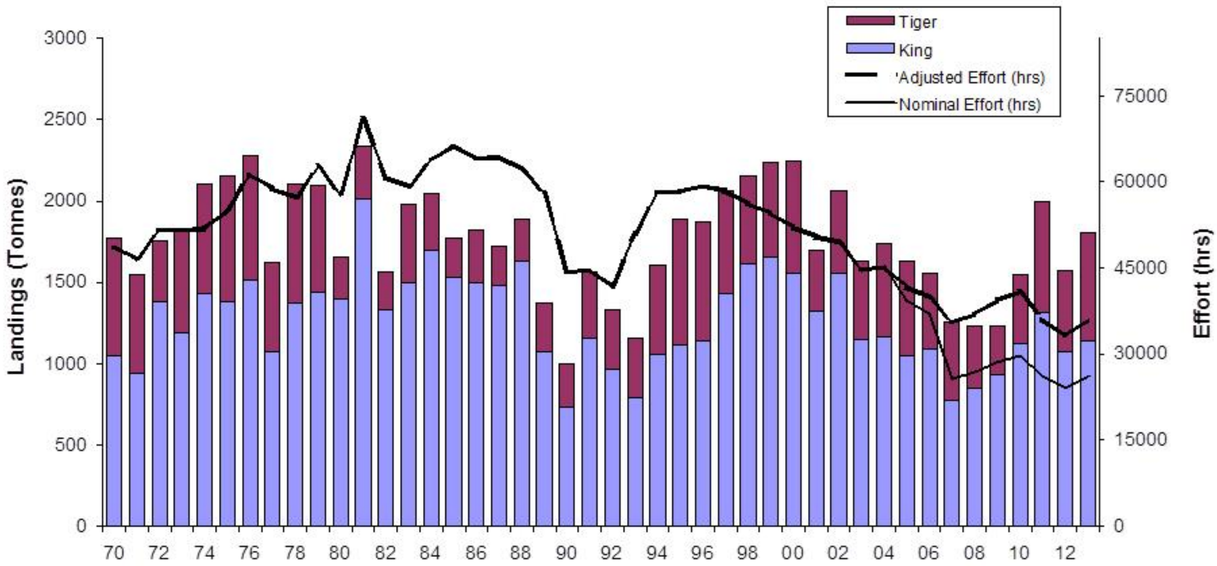

Figure 3. Annual prawn landings (t) and adjusted effort 1970-2013.

STOCK ASSESSMENT

Assessment complete: Yes

Recruitment and spawning surveys are essential for stock assessment within this fishery.

Recruitment assessment:

Fishery-independent recruitment surveys are undertaken for king and tiger prawn stock levels in March and April. Each survey is undertaken over two nights of sampling for 18 standardised sites east of the Carnarvon/ Peron line where prawns have migrated from nursery areas onto the trawl grounds at this time.

Recruitment surveys are undertaken mainly to provide information regarding abundance and size structure of king and tiger prawns. This is used to provide the prawn licensees information to determine the time and extent of area to open east of the Carnarvon/Peron Line for market requirements.

These data are also used to forecast the catch for both king and tiger prawns.

Catch prediction:

The king prawn catch prediction for the 2013 season was 880 t with a catch range between 700 and 1050 t.

The tiger prawn catch prediction for the 2013 season was 500 t with a catch range between 400 and 600 t.

The relationship between survey indices and landings continues to be reviewed

Additional surveys were also carried out during May and June to obtain size (grade) information of king and tiger prawns to determine if a part of the area remains closed within the Carnarvon/Peron line to assist with harvesting strategies and optimise returns to fishers.

Spawning stock assessment:

Two standard spawning stock surveys are generally undertaken around the third moon phase in July and August, in the Tiger Prawn Spawning Area (TPSA). For 2013 the surveys were planned for end of June and July (third moon phase) but the surveys were actually undertaken in July and September due to commercial boat availability. In 2013 the survey system was also changed to include the Extended Nursery Area (ENA). The ENA survey system was implemented to undertake an additional assessment of the spawning stock (spawning condition and abundance) primarily for tiger and king prawns around the same lunar phase each month during the key spawning period. In future it is planned that the surveys be undertaken during August and September when the ENA and the TPSA are both closed. The TPSA was closed to fishing on 21 June to maintain a level spawning stock of tiger prawns between 20 and 25 kg / hr (the target level is 25 kg / hr based on 22 fathoms net headrope length in quad gear configuration).

Tiger prawns: The tiger prawn stock abundance (catch rate kg / hr based on 22 fathoms headrope in quad gear configuration) in the TPSA could not be assessed on the appropriate moon phase directly after closure in 2013.

The catch rates for tiger prawns in the TPSA were 20.2 kg / hr and 7.9 kg / hr in July and September respectively. The tiger prawn spawning stock level was below the target level of 25 kg / hr which is based on July-August catch rates. The lower catch rate in September was expected as the catch rate level generally declines because the prawns migrate through this area. The TPSA is an important area for tiger prawn spawning stock from June onwards, the early stages of the key spawning period, to maintain adequate stock abundance because it is significant for egg production at this time. By September/October the tiger prawn abundance has declined to a low level and may not provide an adequate level of spawning stock in this area in the latter part of the season.

Conversely, the ENA becomes the important area after August as this area maintains the adequate prawn abundance and spawning stock levels throughout the latter part of the key spawning period of tiger prawns. The catch rates of tiger prawns in the ENA were 21.0 and 39.7 kg / hr in July and September respectively.

An additional survey was undertaken this year in the TPSA and ENA in November as part of the annual ‘scallop’ survey. The catch rate of tiger prawns in the TPSA for the November survey was 2.8 kg / hr whereas the catch rate in the ENA increased markedly to 54.6 kg / hr.

King prawns: The king prawn catch rates was extremely high in July at 75.8 kg / hr but declined to 23.1 kg / hr in September.

The survey results showed that catch rates for both tiger and king prawns decreased from July to September indicating very little migration into the area during the latter part of the season but migration out of the area is clearly evident.

Denham Sound:

Two standard surveys have been undertaken in Denham Sound (DS) in July and August since 2004, which included sites in the closed area (south of the Snapper Trawl Line (STL) closure). These surveys were undertaken to; assess the timing of movement of prawns to the area, providing a catch prediction in the future, and obtain prawn size and catch rate data on king prawns prior to fleet fishing in Denham Sound. For 2013, the mean catch rate of king prawns in the permitted fishing area (northern and central sites) was 34.2 kg / hr in July a slight increase compared to 2012. No survey in August was undertaken this year.

The combined catch rate of tiger and king prawns in sites in the proposed area to fish in the STL was 52 kg / hr. Commercial fishing was undertaken in this area during October for a maximum of 10 nights.

Breeding stock levels: **Adequate**

The multi-species nature of this fishery requires the levels of harvest for both king and tiger prawn stocks to be carefully monitored to achieve the overall maximum sustainable catch. Current stock and recruitment studies indicate that at current exploitation levels the king prawn stock remains above the level where recruitment is affected by spawning stock levels. Thus, at the current level of exploitation, most fluctuations in the annual king prawn harvest are likely to have resulted from varying effort levels and environmental effects on recruitment, not from the abundance of the spawning stock.

In contrast, the recruitment levels of tiger prawns during the 1980s were demonstrably affected by reduced spawning stock biomass. Management practices have subsequently been tailored with the aim to initially increase and then maintain the level of tiger prawn spawning stocks. The implementation of a temporal closure of the Carnarvon/Peron line was aimed at reducing effort on tiger prawns early in the season. In addition, since 1982, the ENA was closed to fishing from August each year and provided protection of tiger prawns from August onwards as this area does not re-open to fishing after the closure. Also the introduction of the tiger prawn spawning area (TPSA) closure (with an associated catch rate threshold to trigger closure) appears to have had a favourable impact on the tiger prawn stock since its inception in 1996.

During 2013 the tiger prawn catches were within the acceptable catch range (400-700 t) however, tiger prawns are susceptible to over fishing hence the tiger prawn stocks still need to be monitored. The tiger prawn catch rate declined from 20.2 kg / hr in July to 7.9 in September in the TPSA so the catch rate in the TPSA was below the target (25 kg / hr). However, the tiger prawn catch rate in the ENA for the same periods were 21 kg / hr and 39.7 kg / hr respectively indicating that the ENA is also a key area for the spawning stock. This year is the first year that it has been sampled but it is planned to include this area in the spawning stock survey regime and a spawning stock index for this area will also be developed in the future to supplement the annual spawning stock index.

In 2013 the environmental conditions were within normal ranges for these prawn species and the average annual landings were within ranges expected under these normal environmental conditions.

Variable quantities of minor penaeids (predominantly coral prawns) are also retained, depending on the catch of the target species. Owing to the small size of these species, it is likely that the majority of the stock is able to pass through the mesh, suggesting that the overall exploitation is low.

The main performance measures for the fishery relate to maintenance of breeding stocks for each of the major target prawn species. . The king prawn catch was within the acceptable range. In 2013, the breeding stock indicator for tiger prawns in the TPSA was the below the target catch rate level. However, the mean catch rate of tiger prawns in the ENA was above the target level that is used in the TPSA. The ENA provides an additional level of protection of the tiger and king prawn stocks during the key spawning period. Sampling this area will be incorporated into future surveys. The timing of closure for these two areas (TPSA and ENA) is different for each area aimed at protecting the spawning stock at a level to maintain adequate spawning biomass during the peak spawning period for tiger prawns

2014 Season Fishing Arrangements

The proposed season arrangements provides a maximum of 176 nights fishing, allowing area openings to be based on pre-season surveys providing industry flexibility to target prawns at a size aimed at maximizing product value and marketing requirements. The moon closure periods have been set at between 5 and 7 days, however the periods may be extended if the catch rate of prawns declines to uneconomical levels.

The principles for prawn season arrangements have been discussed and fully endorsed by licensees in the Shark Bay Prawn Managed Fishery.

The formal season opening is on 24 March 2014. Standard recruitment research surveys will be undertaken in March and April to assess both king and tiger prawn size. Other in-season may be undertaken prior to area openings to assess the size of prawns. The formal season closure is 0800 hrs 31 October 2014.

During the season, tiger prawn spawning stock monitoring and a closure will occur of the TPSA on target in June. The TPSA should be sampled directly after its closure at the commencement of the tiger prawn-spawning period. In addition, breeding stock surveys will be undertaken to further monitor the tiger prawn stock during the peak-spawning period (August and September) when the TPSA and the ENA areas are closed.

Stock monitoring of king prawns will also be undertaken in Denham Sound in August.

NON-RETAINED SPECIES

Bycatch species impact: Moderate

Bycatch composition is dominated by dead wire weed, which breaks off from the extensive shallow Wooramel seagrass bank annually over summer. The bycatch also contains a number of small size fish species mostly not taken by other sectors. Small blue swimmer crabs and other crustacean species are also taken in significant quantities but are generally released alive. Overall bycatch taken in trawl nets are moderate relative to other subtropical trawl fisheries at about 4–8 times the prawn catch. Field sampling for a study on the bycatch of trawled and untrawled areas of Shark Bay is now available (Kangas et al. 2008). Grid and secondary bycatch reduction devices (square mesh panels in cod-ends) are fully implemented and should further reduce the quantity of small fish retained in trawls.

The two performance measures for the fishery relate to

(i) its impact on biodiversity through the take of non-target (bycatch) species,

and (ii) its impact on associated species, e.g. dolphins, through the discarding of bycatch (provisioning). In the case of biodiversity, a major project surveying bycatch species on and off the trawl grounds has been completed. Data analysis indicates that trawled areas have similar diversity to the larger adjacent untrawled areas, indicating that the performance indicator will be met. For provisioning, the indicator has been met due to the lower and more targeted trawl effort and implementation of BRDs in the fleet. Both actions have reduced the rate of discards relative to the pre-BRD period.

Protected species interaction: Low

Although protected species including whales, dolphins, dugongs, turtles and sea snakes are particularly abundant in Shark Bay generally, only sea snakes are seen the trawl catches in certain areas, and these are mostly returned to the sea alive. The full implementation of bycatch reduction devices (grids) in the fishery since 2002 has generally reduced the occasional capture of turtles in trawl nets. Table 5 lists the protected species reported in the daily logbooks and their status on return to the water.

Table 5. Protected species as reported in 2013 daily logbooks

Species	Total	Status		
		Alive	Dead	Unknown
Turtles	4	0		4
Sea snakes	120	120		
Syngnathids	0			

ECOSYSTEM EFFECTS

Food chain effects: Low

Although the harvest rates of the retained target species are high, such species have very high natural mortality rates and make up a relatively small proportion of the 'fish' biomass on the trawl grounds. Thus, most prawn predators are opportunistic due to these natural variations in prawn populations. Consequently, it is not likely that the commercial take of prawns impacts significantly on the upper trophic levels within the Shark Bay ecosystem. The reduced levels of effort now used by the fishery, combined with the gear modifications to reduce unwanted catch

Habitat effects: Moderate

As a result of the extensive permanent and temporary closures first introduced via the management plan in the 1960s and 1970s respectively (Shark Bay Prawn Figure 1), the fleet operates in approximately 5-7% of the overall licensed area of the fishery. Inside Shark Bay, trawl fishing is focused in the deeper areas (predominantly sand/shell habitats) of the central bay, north of Cape Peron and in the northern area of Denham Sound. The majority of sponge/coral habitats are contained within specific trawl closures to protect these areas.

External factors:

Four boats did not fish the last fishing period (post moon closure).

Appendix J: 2014 Skipper's Briefing Package

GUIDE ONLY: Please refer to the current Shark Bay Prawn Determination 2014 and the *Shark Bay Prawn Managed Fishery Management Plan 1993* for the precise description of the areas.

2014 SHARK BAY PRAWN MANAGED FISHERY

GUIDE TO MANAGEMENT AREAS

PLEASE NOTE: the information covered in this package is a guide only and should be read in conjunction with the current 2014 Determination and the *Shark Bay Prawn Managed Fishery Management Plan 1993.*

A copy of the current *Shark Bay Prawn Managed Fishery Management Plan 1993* can be located under Legislation on the Department of Fisheries Western Australia website at www.fish.wa.gov.au.

This package contains a written description and maps of the management areas within the Shark Bay Prawn Managed Fishery for the 2014 fishing season. The purpose of this package is to aid fishers' understanding of the 2014 fishing arrangements and management areas. The package has been broken into three main sections as follows:

PART 1

2014 SHARK BAY PRAWN MANAGEMENT PLAN SCHEDULE

The information provided in this section covers the management areas outlined in the *Shark Bay Prawn Managed Fishery Management Plan 1993* (the Plan). These areas are opened and/or closed by Determination from the Chief Executive Officer (CEO), which is provided for under the provisions of clause 10 of the Plan.

This section also includes the management areas in Shark Bay, which are closed to fishing under a section 43 Order, which gives effect to the Department of Environment and Conservation's *Shark Bay Marine Reserves Management Plan.*

PART 2

2014 SHARK BAY PRAWN MANAGEMENT AREAS AS PER DETERMINATION

The information provided in this section covers the management areas, which are not outlined in the Plan, but are included in the current 2014 Determination. These areas are opened and/or closed by Determination from the CEO, which is provided for under the provisions of clause 10 of the Plan.

PART 3

2014 SHARK BAY PRAWN INDUSTRY MANAGED AREAS

The information provided in this section covers the management areas, which are industry agreed closures and are therefore not outlined in either the Plan or the current 2014 Determination. These areas are opened and/or closed based on consultation between industry and the Department of Fisheries Research Division.

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GUIDE ONLY: Please refer to the current Shark Bay Prawn Determination 2014 and the *Shark Bay Prawn Managed Fishery Management Plan 1993* for the precise description of the areas.

PART 1

2014 SHARK BAY PRAWN MANAGEMENT PLAN SCHEDULE

ITEM 1 (The Fishery)

All waters of the Indian Ocean and Shark Bay between 23°34.00′ south latitude and 26°30.00′ south latitude and adjacent to Western Australia on the landward side of a line commencing at the intersection of 23°34.00′ south latitude and 113°03.37′ east longitude; thence continuing south westerly along the geodesic to the intersection of 23°36.00′ south latitude and 113°02.00′ east longitude; thence south westerly along the geodesic to the intersection of 24°06.00′ south latitude and 112°37.00′ east longitude; thence south westerly along the geodesic to the intersection of 24°25.00′ south latitude and 112°25.00′ east longitude; thence south westerly along the geodesic to the intersection of 24°39.00′ south latitude and 112°19.00′ east longitude; thence southerly along the geodesic to the intersection of 25°00.00′ south latitude and 112°14.00′ east longitude; thence southerly along the geodesic to the intersection of 25°33.00′ south latitude and 112°12.00′ east longitude; thence southerly along the geodesic to the intersection of 26°00.00′ south latitude and 112°18.00′ east longitude; thence south easterly along the geodesic to the intersection of 26°24.00′ south latitude and 112°30.00′ east longitude; thence south easterly along the geodesic to the intersection of 26°30.00′ south latitude and 112°33.25′ east longitude, being the end point of the line, together with those waters of Shark Bay south of 26°30.00′ south latitude.

ITEM 2 (Nursery Areas)

That area of the Fishery –

(a) south of a line drawn due east along the parallel from the intersection of 26°00.94' south latitude and 113°17.97' east longitude (being the northern extremity of Cape Bellefin) to Peron Peninsula, at the intersection of 26°00.94' south latitude and 113°34.50' east longitude;

(b) south and east of a line commencing at the intersection of 25°30.20′ south latitude and 113°30.60′ east longitude (Cape Peron); thence extending north along the meridian to 25°20.40' south latitude; thence south easterly along the geodesic to the intersection of 25°26.00′ south latitude and 113°40.00′ east longitude; thence east along the parallel to the intersection of 25°26.00′ south latitude and 113°55.50′ east longitude (high water mark on the coastline of Western Australia) (commonly known as the East Peron Nursery); and

(c) bounded by a line commencing at Cape Ronsard on Bernier Island at the intersection of the high water mark (24° 45.257' south latitude) and 113°09.60' east longitude; thence northerly along the geodesic to the intersection of 24° 44.90' south latitude and 113° 09.70' (Koks Island); thence south easterly along the geodesic to the intersection of 24° 45.30' south latitude and 113° 10.50' east longitude; thence southerly along the geodesic to the intersection of 24° 49' south latitude and 113° 11' east longitude; thence southerly along the geodesic to the intersection of 24°52.75' south latitude and 113° 10.25' east longitude; thence south along the meridian to the intersection of 24°56.80' south latitude and 113°10.25 east longitude; thence south westerly along the geodesic to the intersection of 24°58.50' south latitude and 113°09' east longitude; thence south easterly along the geodesic to the intersection 25°11' south latitude and 113° 18' east longitude; thence south along the meridian to the intersection of 25°13' south latitude and 113°18' east longitude; thence

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south westerly along the geodesic to the intersection of 25°20.50' south latitude and 113°14.50' east longitude; thence south easterly along the geodesic to the intersection of 25°24.25' south latitude and 113°16' east longitude; thence south westerly along the geodesic to the intersection of 25° 31.25' south latitude and 113° 09.75' east longitude; thence westerly along the geodesic to the intersection of 25°30' south latitude and high water at Cape Levillian on Dirk Hartog Island (113° 01.371' east longitude); thence generally in a north westerly direction along the high water mark of Dirk Hartog Island to the intersection of the high water mark at Cape Inscription (25° 28.791' south latitude) and 112°58.30' east longitude; thence north easterly along the geodesic to the intersection of the high water at Cape St Cricq on Dorre Island (25° 16.357' south latitude) and 113°04.60' east longitude; thence generally northerly along the high water mark on the eastern side of Dorre Island to the intersection of the high water mark at Cape Boullanger (24° 59.52' south latitude) and 113° 07.10' east longitude; thence northerly along the geodesic to the intersection of the high water mark at Cape Couture on Bernier Island (24° 59.196' south latitude) and 113° 07.20' east longitude; thence generally northerly along the high water mark on the eastern side of Bernier Island to the commencement point.

ITEM 5 (Port Areas)

Item 1 (Carnarvon)
The intersection of 24°53.934′ south latitude and 113°39.071′ east longitude (T jetty, Fishing Boat Harbour)

Item 2 (Denham)
The intersection of 25°55.71′ south latitude and 113°31.99′ east longitude (Service jetty, Denham)

Department of Environment and Conservation

SANCTUARY ZONES (ALL FISHING PROHIBITED AT ALL TIMES)

WOORAMEL BANKS CLOSURE AREA

In that part of the Fishery bounded by the coast on the eastern border a line commencing at the intersection of 24°56.06′ south latitude and 113°40.80′ east longitude (high water mark on the coastline of Western Australia); thence extending west along the parallel to the intersection of 24°56.06′ south latitude 113°31.89′ east longitude; thence southerly along the geodesic to the intersection of 25°04.80′ south latitude and 113°33.94′ east longitude; thence south south easterly along the geodesic to the intersection of 25°10.01′ south latitude and 113°37.24′ east longitude; thence south easterly along the geodesic to the intersection of 25°12.73′ south latitude and 113°39.67′ east longitude; thence south south easterly along the geodesic to the intersection of 25°27.58′ south latitude and 113°45.90′ east longitude; thence south south easterly along the geodesic to the intersection of 25°37.92′ south latitude and 113°53.15′ east longitude; thence east along the parallel to the intersection of 25°37.92′ south latitude and 114°01.43′ east longitude (high water mark on the coastline of Western Australia).

GUIDE ONLY: Please refer to the current Shark Bay Prawn Determination 2014 and the *Shark Bay Prawn Managed Fishery Management Plan 1993* for the precise description of the areas.

PART 2

2014 SHARK BAY PRAWN MANAGEMENT AREAS AS PER DETERMINATION

SNAPPER/TRAWL CLOSURE

In that part of the Fishery south of a line commencing at the intersection of 25°40.59′ south latitude and 113°02.87′ east longitude (high water mark on Dirk Hartog Island); thence extending east along the parallel to the intersection of 25°40.59′ south latitude and 113°04.80′ east longitude; thence south easterly along the geodesic to the intersection of 25°41.00′ south latitude and 113°05.63′ east longitude; thence extending east along the parallel to the intersection of 25°41.00′ south latitude and 113°08.00′ east longitude; thence south easterly along the geodesic to the intersection of 25°46.00′ south latitude and 113°13.00′ east longitude; thence east along the parallel to the intersection of 25°46.00' south latitude and 113°19.00' east longitude; thence north along the meridian to the intersection of 25°38.00' south latitude and 113°19.00′ east longitude; thence north easterly along the geodesic to the intersection of 25°32.00′ south latitude and 113°25.00′ east longitude; thence east along the parallel to the intersection of 25°32.00' south latitude and 113°29.74′ east longitude (high water mark on Peron Peninsula).

WITHNELL POINT CLOSURE

In that part of the Fishery bounded by a line commencing at the intersection of 25°36.00′ south latitude and 113°01.63′ east longitude (high water mark on Dirk Hartog Island); thence extending east along the parallel to the intersection of 25°36.00′ south latitude and 113°03.75′ east longitude; thence due south along the meridian to the intersection of 25°38.00′ south latitude and 113°03.75′ east longitude; thence west along the parallel to the intersection of 25°38.00′ south latitude and 113°02.30′ east longitude (high water mark on Dirk Hartog Island).

EXTENDED NURSERY AREA (ENA)

In that part of the Fishery bounded by a line commencing at the intersection of 25°26.00′ south latitude and 113°55.50′ east longitude (high water mark on the coastline of Western Australia); thence extending west along the parallel to the intersection of 25°26.00′ south latitude and 113°40.00′ east longitude; thence north westerly along the geodesic to the intersection of 25°20.40′ south latitude and 113°30.60′ east longitude; thence north along the meridian to the intersection of 25°15.20′ south latitude and 113°30.60′ east longitude; thence east along the parallel to the intersection of 25°15.20′ south latitude and 113°50.83′ east longitude (high water mark on the coastline of Western Australia); thence generally southerly along the high water mark of the coastline to the commencement point.

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GUIDE ONLY: Please refer to the current Shark Bay Prawn Determination 2014 and the *Shark Bay Prawn Managed Fishery Management Plan 1993* for the precise description of the areas.

TIGER PRAWN SPAWNING AREA (TPSA)

In that part of the Fishery bounded by a line commencing at the intersection of 24°52.75′ south latitude and 113°37.60′ east longitude (high water mark on the coastline of Babbage Island); thence west along the parallel to the intersection of 24°52.75′ south latitude and 113°21.00′ east longitude; thence south along the meridian to the intersection of 24°58.10′ south latitude and 113°21.00′ east longitude; thence south by east along the geodesic to the intersection of 25°03.00′ south latitude and 113°22.46′ east longitude; thence east along the parallel to the intersection of 25°03.00′ south latitude and 113°40.70′ east longitude (high water mark on the coastline of Western Australia); thence generally northerly along the high water mark of the coastline to commencement point (Babbage Island)

NORTH OF KOKS ISLAND

In that part of the fishery north of 24°45.30' south latitude.

SOUTH OF KOKS ISLAND

In that part of the fishery south of 24°45.30' south latitude.

GEAR TRIAL AREA FOR 2014

The gear trial area is available for use two weeks prior to the start of the season between 0800 hrs and 1600 hrs each day and during the legislated season fishing dates in the area described below (gear trial area). Cod ends must remain open until the Determination detailing the season dates is published in the *Government Gazette* after which time cod ends may be closed. Prior to any fishing activity taking place the Manager Compliance at the Department of Fisheries Carnarvon Office must be notified in writing/email (fax 08 9941 1185 or email)

That area of the Fishery bounded by a line commencing at the intersection of 24°50.00′ south latitude and 113°21.50′ east longitude and extending south along the meridian to the intersection of 24°52.75′ south latitude and 113°21.50′ east longitude; thence east along the parallel to the intersection of 24°52.75′ south latitude and 113°23.50′ east longitude; thence north along the meridian to the intersection of 24°50.00′ south latitude and 113°23.50′ east longitude; thence west along the parallel to the commencement point.

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GUIDE ONLY: Please refer to the current Shark Bay Prawn Determination 2014 and the *Shark Bay Prawn Managed Fishery Management Plan 1993* for the precise description of the areas.

PART 3

2014 SHARK BAY PRAWN INDUSTRY MANAGEMENT AREAS

CARNARVON/ PERON LINE

In that part of the Fishery bounded by a line commencing at the intersection of 25°30.20′ south latitude and 113°30.60′ east longitude (Cape Peron); thence extending north north westerly along the geodesic to the intersection of 24°58.10′ south latitude and 113°21.00′ east longitude; thence north along the meridian to the intersection of 24°52.75′ south latitude and 113°21.00′ east longitude; thence east along the parallel to the intersection of 24°52.75′ south latitude and 113°37.60′ east longitude (high water mark of the coastline of Western Australia); thence generally southerly along the high water mark on the coastline to the intersection of 25°15.20′ south latitude and 113°50.83′ east longitude; thence west along the parallel to the intersection of 25°15.20′ south latitude and 113°30.60′ east longitude; thence south along the meridian to the commencing point (Cape Peron).

DENHAM SOUND CLOSURE (NORTHERN LINE)

In that part of the Fishery south of a line commencing at the intersection of 25°32.00′ south latitude and 113°29.74′ east longitude (high water mark on Peron Peninsula); thence west along the parallel to the intersection of 25°32.00′ south latitude and 113°25.00′ east longitude; thence extending westerly along the geodesic to the intersection of 25°31.25′ south latitude and 113°09.75′ east longitude (southern most point of Red Cliff Nursery Area); thence westerly along the geodesic to the intersection of 25°30.00’ south latitude and high water at Cape Levillian on Dirk Hartog Island (113° 01.371’ east longitude).

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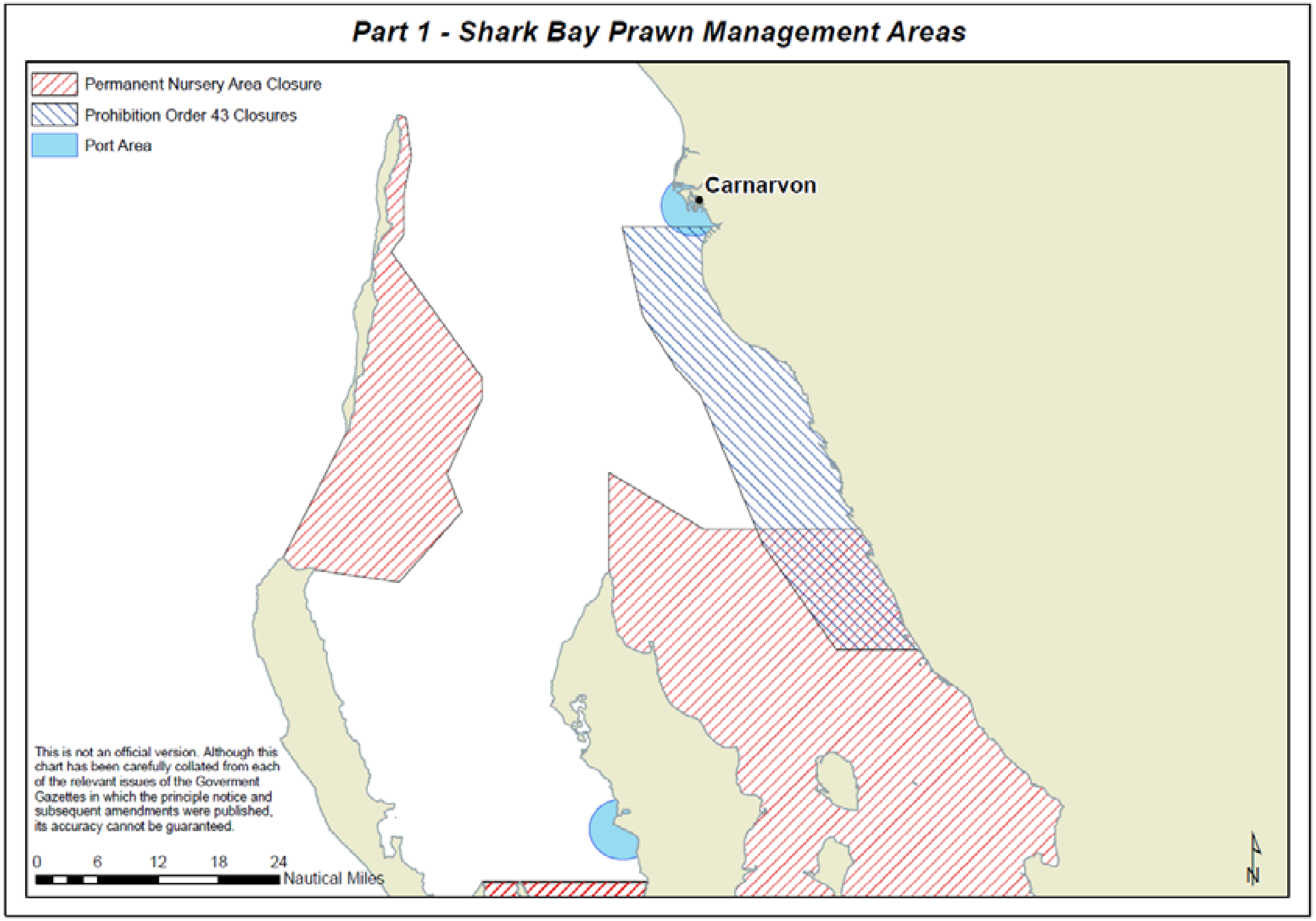
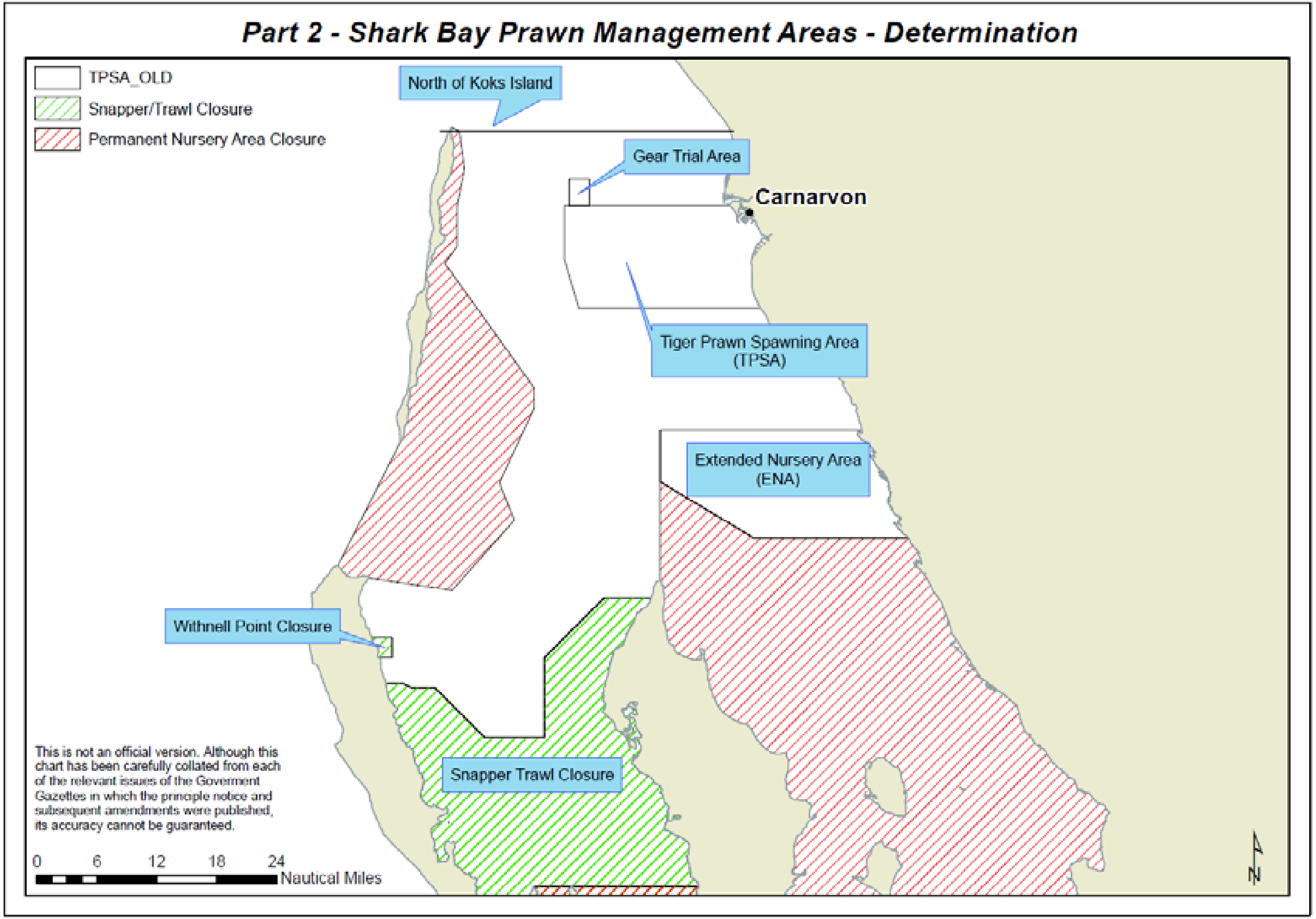

Part 1 - Shark Bay Prawn Management Areas
Permanent Nursery Area Closure
Prohibition Order 43 Closures
Port Area
Carnarvon
This is not an official version. Although this chart has been carefully collated from each of the relevant issues of the Goverment Gazettes in which the principle notice and subsequent amendments were published, its accuracy cannot be guaranteed.
0 6 12 18 24
Nautical Miles
N


Part 2 - Shark Bay Prawn Management Areas - Determination
TPSA_OLD
Snapper/Trawl Closure
Permanent Nursery Area Closure
North of Koks Island
Gear Trial Area
Carnarvon
Tiger Prawn Spawning Area
(TPSA)
Extended Nursery Area
(ENA)
Withnell Point Closure
Snapper Trawl Closure
This is not an official version. Although this chart has been carefully collated from each of the relevant issues of the Goverment Gazettes in which the principle notice and subsequent amendments were published, its accuracy cannot be guaranteed.
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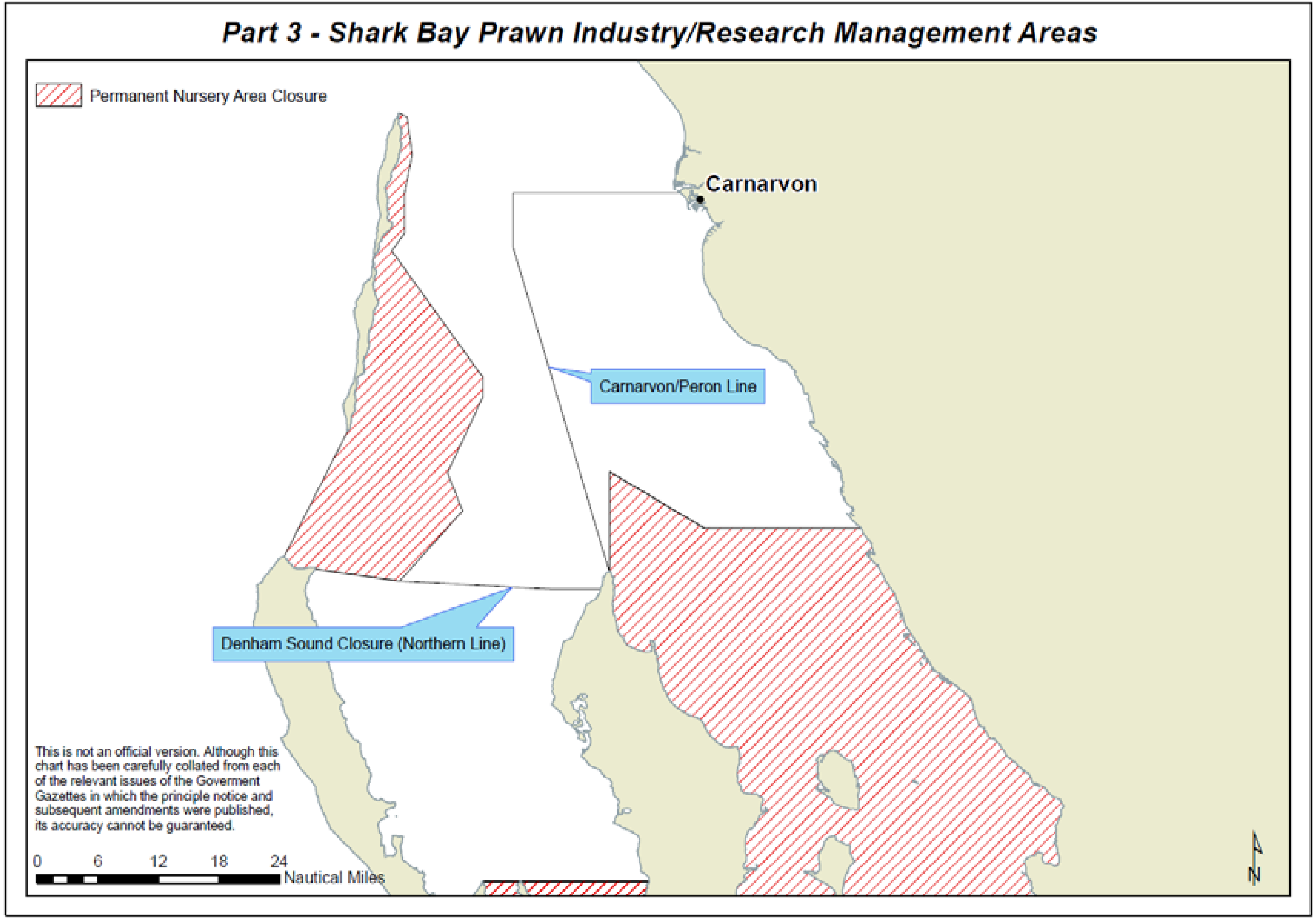
Part 3 - Shark Bay Prawn Industry/Research Management Areas
Permanent Nursery Area Closure
Carnarvon
Carnarvon/Peron Line
Denham Sound Closure (Northern Line)
This is not an official version. Although this chart has been carefully collated from each of the relevant issues of the Goverment Gazettes in which the principle notice and subsequent amendments were published, its accuracy cannot be guaranteed.
0 6 12 18 24
Nautical Miles
N