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# Resource Assessment Report Western Australian Octopus Resource

Hart, A.M., Murphy, D.M., Harry, A.V, Fisher, E.A.

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Department of Primary Industries and Regional Development
Gordon Stephenson House
140 William Street
PERTH WA 6000
Telephone: (08) 6551 4444
Website: dpird.wa.gov.au
ABN: 18 951 343 745

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# Executive Summary

- The WA Octopus Resource comprises several species of octopus, however, >99% of catches comprises the Western Australian Common Octopus (*Octopus* aff. *tetricus*), which this assessment report is focused on.
- The distribution of *O.* aff. *tetricus* extends continuously from Shark Bay in the north to at least Esperance on the south coast. It has been conclusively identified through genetic and morphometric studies as a separate species to *O. tetricus* found on the east coast of Australia, but a species name has not yet been ascertained. The stock is targeted in the West and South Coast Bioregions, with the majority of catches taken in the former.
- The biological characteristics of *O.* aff. *tetricus*, including rapid growth, short lifespan and early maturity, suggest that this highly productive species has a relatively low vulnerability to fishing. Year-round spawning, sperm storage and a strong bias of the trigger traps to catching males is likely to add further protection to the spawning stock.
- The *O.* aff. *tetricus* resource is primarily commercially harvested by the Octopus Interim Managed Fishery (OIMF), the Cockburn Sound Line and Pot Managed Fishery (CSLPF), and as byproduct in the West Coast Rock Lobster Managed Fishery (WCRLF), with less than 1% of total catches retained by the recreational fishing sector. It was not until the introduction of trigger traps in the OIMF in 2010 that targeted catches of OIMF increased substantially, currently comprising more than 70% of the total commercial catch of 200-250 t annually. The OIMF currently has a strategy in place to increase the harvest of octopus over the next three years.
- Data on the life history of *O.* aff. *tetricus* in combination with fine-scale catch and effort logbook data and a number of fishery-independent surveys have been used to inform the current assessment of this stock. The primary performance indicator for monitoring stock status is a standardised commercial catch rate index from Zones 1 and 2 along the West Coast of the OIMF, where the majority of catches are taken. The catch rate index is compared annually to catch rate based reference levels specified in the harvest strategy for this resource.
- A weight-of-evidence assessment of the stocks in 2018 concluded that the risk of unacceptable depletion of the *O.* aff. *tetricus* stock is currently low. The lines of evidence included: catch and effort data, spatial effort distribution, standardised catch rate index, age and size compositions (age was determined by counting daily growth increments deposited on stylets), PSA (Productivity Susceptibility Analysis), and estimates of population size. The assessment did, however, indicate that further work to investigate the efficiency of the fishing gear and spatial extent of the resource, will be needed to provide a more accurate estimation of stock biomass.

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# List of Abbreviations

| | |
|---|---|
| CSLPF | Cockburn Sound Line and Pot Managed Fishery |
| DBCA | Department of Biodiversity, Conservation and Attractions (Western Australia, former Department of Parks and Wildlife) |
| DPIRD | Department of Primary Industries and Regional Development (Western Australia, former Department of Fisheries) |
| DOF | Developmental Octopus Fishery |
| EBFM | Ecosystem-Based Fisheries Management |
| ENSO | El Niño-Southern Oscillation |
| ESD | Ecologically Sustainable Development |
| EPBC | Environment Protection and Biodiversity Conservation (Act) |
| FRMA | Fish Resources Management Act |
| MSC | Marine Stewardship Council |
| OIMF | Octopus Interim Managed Fishery |
| SAFS | Status of Australian Fish Stocks |
| SCB | South Coast Bioregion |
| SCPUE | Standardised Catch Per Unit Effort |
| SWB | South West Bioregion |
| WA | Western Australia |
| WCB | West Coast Bioregion |
| WCRFL | West Coast Rock Lobster Managed Fishery |

# 1 Scope

This document provides a cumulative description and assessment of the Octopus Resource and all of the fishing activities (i.e. fisheries / fishing sectors) affecting this resource in Western Australia (WA). The overall resource essentially comprises a single species of octopus, *Octopus* aff. *tetricus*, which occurs in inshore waters to 70 m depth from Shark Bay to Esperance. Octopus is predominantly captured by the Octopus Interim Managed Fishery (OIMF) using trigger traps in the West Coast Bioregion, with smaller quantities caught in the South Coast Bioregion using shelter pots. Two additional commercial fisheries also catch octopus in WA using pots/traps; the Cockburn Sound Line and Pot Managed Fishery (CSLPF) and the West Coast Rock Lobster Managed Fishery (WCRLF).

The report contains information relevant to assist the assessment of the resource against the Marine Stewardship Council (MSC) Principles and Criteria for Sustainable Fishing, the Environment Protection and Biodiversity Conservation (EPBC) Act export approval requirements and other reporting requirements, e.g. Status of Australian Fish Stocks (SAFS) and Status Report of Fisheries and Aquatic Resources (SRFAR).

# 2 How the Department Operates

Fisheries management in WA has evolved over the last 40-50 years from a focus on managing catch of target species by commercial fishers to a fully integrated Ecosystem-Based Fisheries Management (EBFM) approach, which ensures that fishing impacts on the overall ecosystems are appropriately assessed and managed (Fletcher et al. 2010). In line with the principles of Ecologically Sustainable Development (ESD; Fletcher 2002), the EBFM approach also recognises that the economic and social benefits of fishing to all users must be considered.

Implementation of EBFM involves a risk-based approach to monitoring and assessing the cumulative impacts on WA’s aquatic resources from all fishing activities (commercial, recreational, customary), operating at a bioregional or ecosystem level. The level of risk to each resource is used as a key input to the Department of Primary Industries and Regional Development (DPIRD) Risk Register, which is an integral component of the annual planning cycle for assigning activity priorities (research, management, 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 2.1.

To ensure that management is effective in achieving the relevant ecological, economic and social objectives, formal harvest strategies are being developed for each resource. These harvest strategies outline the performance indicators used to measure how well objectives are being met and set out control rules that specify the management actions to be taken in situations when objectives are not being met. The WA harvest strategy policy (Department of Fisheries 2015) has been designed to ensure that the harvest strategies cover the broader scope EBFM and thus considers not only fishing impacts of target species but also other retained species, bycatch, endangered, threatened and protected (ETP) species, habitats and other ecological components (Fletcher et al. 2016). Note that the effect of octopus fishing on these ecological components was examined in April 2018 as part of an EBFM risk assessment for the OIMF and CSLPF (see Appendix 4).

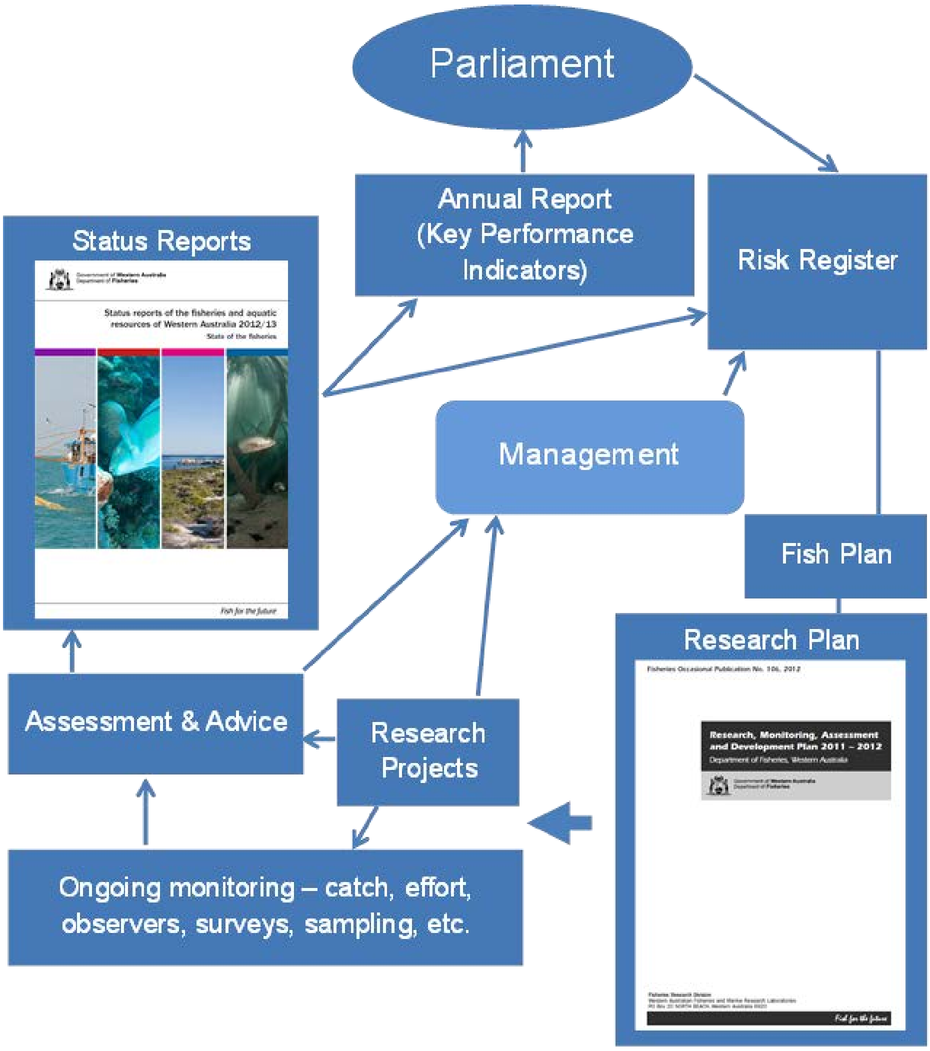

**Figure 2.1. An outline of the risk-based planning cycle used for determining Departmental priorities and activities**

# 3 Aquatic Environment

While numerous species of octopus occur throughout WA waters, the vast majority of commercial and recreational octopus fishing is focused on *O.* aff. *tetricus* and occurs within the West Coast Bioregion and the South Coast Bioregion, collectively referred to as the South West Bioregions (SWB) (Figure 3.1).

Southwest WA has a Mediterranean climate, with most rainfall occurring during the winter months. Coastal water temperatures range from 18°C to about 24°C in the WCB and from approx. 15°C to 21°C in the SCB. The temperatures are generally higher than would be expected at these latitudes, especially in the SCB, due to the influence of the warm Leeuwin Current. From a global perspective, the SWB are generally characterised by low levels of nutrients and high species diversity, including a large number of endemic species. Biological communities are mainly comprised of temperate species, which mix with tropical species in the northern regions of the WCB. These characteristics are considered to be caused by the influence of the Leeuwin Current, the low level of terrestrial run-off and the relatively stable geological history of the south-west region (Commonwealth of Australia 2008).

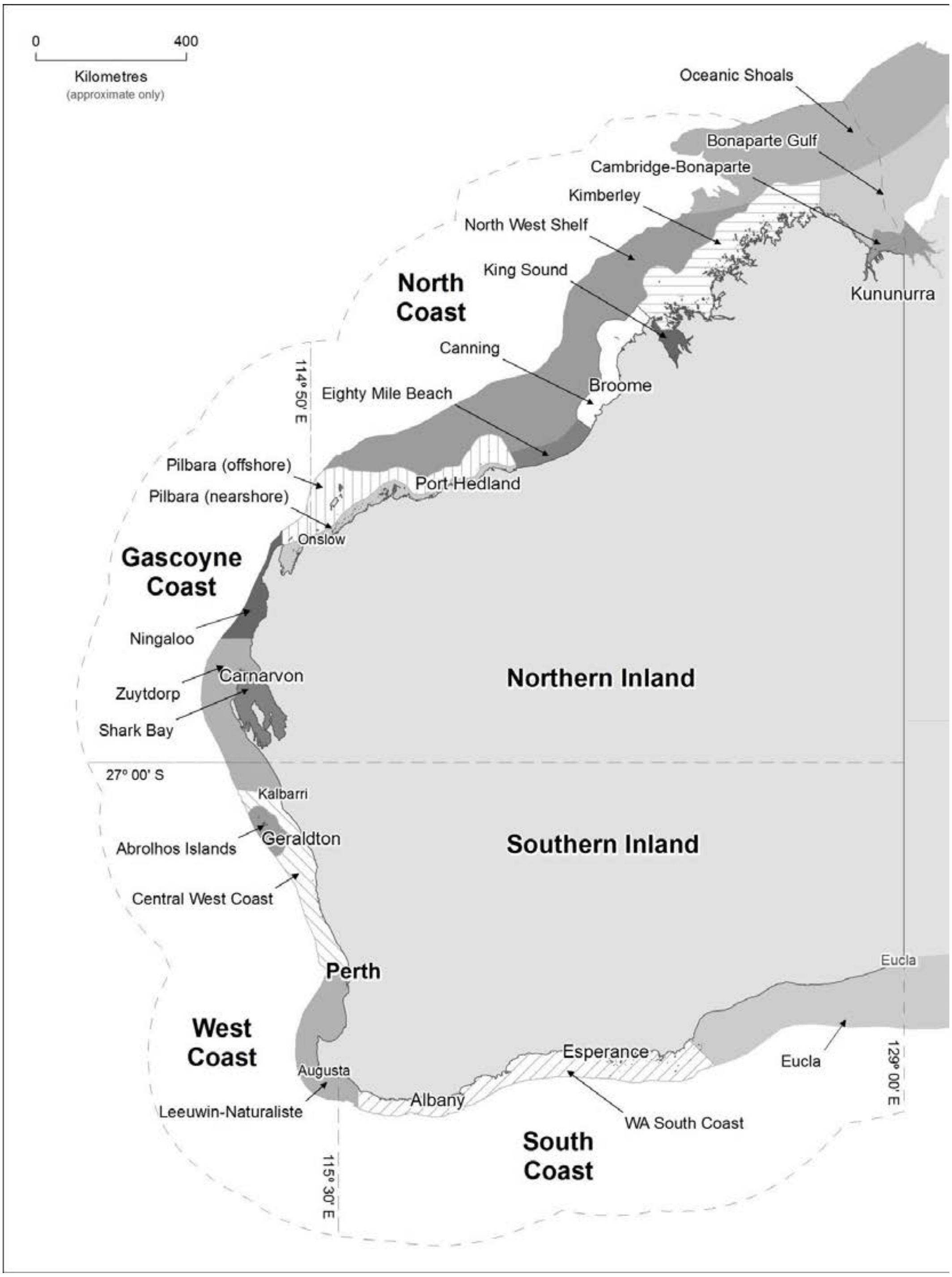

**Figure 3.1. The octopus resource is predominantly comprised of *Octopus* aff. *tetricus* caught by commercial and recreational fisheries in the West Coast Bioregion and South Coast Bioregion**

The SWB are known for their high species diversity and endemism. Temperate species dominate in the south-eastern part of the region, while tropical species become progressively more common in the north. Of the known species, more than 1000 species of macroalgae, 17 – 22 species of seagrass, 600 species of fish, 110 species of echinoderm and 189 species of ascidians have been recorded in the south-west marine region (i.e. from Shark Bay, WA, to Kangaroo Island, South Australia; Commonwealth of Australia 2008). A global study of coral reef biodiversity hotspots also found that while the west coast of WA from Ningaloo Reef to Rottnest Island has moderate to high species richness, it is also one of the global hotspots for endemism (Roberts et al. 2002). The Great Australian Bight along the south coast is also known to have one of the world's most diverse soft sediment ecosystems, with over 360 species of sponge, 138 species of ascidians and 93 species of bryozoans (Commonwealth of Australia 2008).

There are a number of ocean currents in the SWB, including the Leeuwin Current, the deeper subsurface Leeuwin Undercurrent on the west coast, the Flinders Current on the south coast and the seasonal coastal Capes and Cresswell Currents (Commonwealth of Australia 2008). The Leeuwin Current is considered to be a main influence on biological communities within the bioregions because of its extent and its significant impact on biological productivity. The Leeuwin Current is shallow and narrow (less than 300 m deep and 100 km wide) and transports warm, low-nutrient water from the tropics southward along the shelf break and outer parts of the shelf (Church et al. 1989; Smith et al. 1991; Ridgway and Condie 2004). Although the Current flows year-round, it is strongest in the autumn/winter (April to August). The current is variable in strength from year-to-year, flowing at speeds typically around one knot but up to three knots on some occasions. Annual variation in current strength is reflected in variations in Fremantle sea levels and is related to El Niño-Southern Oscillation (ENSO) events in the Pacific Ocean (Fletcher and Santoro 2015).

The Leeuwin Current suppresses predictable large-scale upwellings on the west coast, and as a result, plays a role in maintaining low levels of productivity in the region. Consequently, the WCB can only support relatively small fisheries compared with other areas with eastern boundary currents in the world (Commonwealth of Australia 2008). There are some areas of relatively small, periodic upwelling where the Current interacts with the seafloor and other currents, which locally enhance nutrient levels, e.g. at Cape Mentelle. Interactions of the Leeuwin Current with seafloor features also leads to the formation of meso-scale eddies, which occur in predictable locations, such as the western edge of the Abrolhos Islands, south-west of Jurien Bay, the Perth Canyon, south-west of Cape Naturaliste and Cape Leeuwin, and south of Albany and Esperance. These eddies are likely to have a large effect on pelagic production in the Bioregions, driving offshore production by transporting nutrients and entire pelagic communities offshore and generating upwellings of deeper waters that are higher in nutrients (Commonwealth of Australia 2008).

The Leeuwin Current also plays an important role in the distribution of species throughout the bioregions; its warm water transports tropical and sub-tropical species, which become established further south than would otherwise be possible. The most significant impact of the clear, warm, low-nutrient waters of the Leeuwin Current, however, is considered to be on the growth and distribution of temperate seagrasses. These form extensive meadows in protected coastal waters of the region, generally to depths of 20 m but up to 30 m (Fletcher and Santoro 2015).

The ecology of the bioregions is also greatly influenced by the lack of river discharge along the coast. The few significant rivers flow intermittently, with a low overall discharge. Consequently, there is a limited amount of terrigenous nutrient inputs. This low run-off and general low rate of productivity (due to the Leeuwin Current) also results in low turbidity, making the waters of the SWB relatively clear (Commonwealth of Australia 2008).

# 4 Resource Description

## 4.1 Octopus Resource

The WA Octopus Resource is essentially a single-species resource, with the vast majority of capture across all fisheries being *O.* aff. *tetricus*. The *species affinis* nomenclature, i.e. “aff.”, is applied to this species, as it is closest in relation to *Octopus tetricus* found in New Zealand and the south-east coast of Australia, but has not been formally named (Amor 2014). Currently the distribution of *O.* aff. *tetricus* extends continuously from Shark Bay in the north to at least Esperance on the south coast. It occurs over a wide range of nearshore and coastal habitats to depths of 70 m including rocky reefs, seagrass meadows and sandy substrates. There are occasional reports of fishers in the OIMF catching *O. cyanea* and *O. ornatus*, which are both tropical species found mainly in the waters north of Geraldton, and *Macroctopus maorum* which occurs predominantly on the southern coast of WA.

# 5 Species Description

## 5.1 *Octopus* aff. *tetricus*

**Figure 5.1. The Western Australian common octopus (*Octopus* aff. *tetricus*). Illustration © R. Swainston (www.anima.net.au)**

### 5.1.1 Taxonomy and Distribution

*Octopus* aff. *tetricus* (Subfamily Octopodinae), or the Western Australian Common Octopus, is endemic to the temperate waters of Western Australia from Shark Bay to Esperance (Edgar 1997) (Figure 5.2). It is closely related to the cosmopolitan *O. vulgaris* species complex, and to *O. tetricus* on the east coast of Australia and New Zealand, but has been conclusively identified as a separate species through genetic and morphometric studies (Amor et al., 2014; Guzik et al., 2005), with a species name yet to be ascertained. Hence its taxonomic delineation contains the species *affinis* designation of ".aff".

The species has an extended pelagic larval phase so it is assumed to be a single stock in WA.

**Figure 5.2 Distribution of *Octopus* aff. *tetricus***

### 5.1.2 Life History

The sub-sections below provide an overview of the life history characteristics of *O.* aff. *tetricus* with a summary of the relevant biological parameters used in stock assessments presented in Table 5.1.

#### 5.1.2.1 Life Cycle

*Octopus* aff. *tetricus* is a short-lived (up to 1.5 years), medium-sized (up to 4 kg), octopus that completes its life cycle in nearshore and continental shelf waters of southwest WA. *O.* aff. *tetricus* has a merobenthic life cycle; females lay ~100,000 eggs that take ~30 days to hatch then spend ~50 days in the water column as paralarvae before settling on the benthos (Hart et al. 2016). Octopus are hypothesised to move into protected inshore waters after settlement, with females later moving to rocky temperate reefs to mature and find appropriate lairs to brood their eggs (Leporati et al. 2015).

**Table 5.1. Summary of biological parameters for *Octopus* aff. *tetricus***

| Parameter | Value(s) | Comments / Source(s) |
|---|---|---|
| Growth parameters | Growth curve (1): $ML\ (mm) = a\ Age\ (days)^b$ | |
| $a$ | Females 3.622, Males 6.339 | Leporati and Hart (2015) |
| $b$ | Females 0.649, Males 0.545 | Leporati and Hart (2015) |
| | Growth curve (2): $ML_t\ (mm) = L\infty\ (1-e^{(-k(t-t0))})$ | |
| $L\infty$ (mm) | Females 218, Males 190 | Unpublished data |
| $k$ | Females 1.476, Males 1.966 | Unpublished data |
| $t_0$ | Females 0.0004, Males 0.017 | Unpublished data |
| Maximum age (days) | Females 677, Males 542 | Leporati et al. (2015) |
| Maximum size (g) | Females 4460, Males 2079 | Leporati et al. (2015) |
| Natural mortality, $M$ (year$^{-1}$) | 2.36 | Hart et al. (2016) |
| Reproduction | Semelparous, egg-layer | |
| Maturity parameters | | Logistic |
| $A_{50}$ (days) | Females 379, Males 243 | Leporati et al. (2015) |
| $L_{50}$ (mm) | Females 182, Males 128 | Leporati et al. (2015) |
| Fecundity | > 100 000 eggs | Joll (1976) |
| Spawning frequency | Year-round with peaks in autumn and spring. | |

### 5.1.2.2 Habitats and Movements

After settlement *O.* aff. *tetricus* occupy a variety of nearshore habitats in depths up to 70 m including rocky reefs, seagrass meadows, and sandy substrates (Edgar 1997; Norman and Reid 2000). Paralarvae have been collected at depths up to 140 m on the continental shelf and up to 65 km offshore, although most are caught in the upper 50 m (Joll 1983).

Knowledge of movement and behaviour of *O.* aff. *tetricus* is limited and has largely been inferred from characteristics of the commercial catch. Shelter pots, a passive gear type that is set in shallower water, catch a high proportion of immature females. This is thought to be due to larger female octopuses outcompeting smaller (and male) octopuses in the shallow (5-15 m) and refuge-limited habitats that shelter pots are typically set in (Leporati et al. 2015).

Trigger traps on the other hand capture predominantly mature males. This may be attributed traps being an active gear type and the tendency of males to actively hunt and look for females (Leporati et al. 2015). In comparison, females of a similar size are either approaching maturity or tending to eggs. The general lack of highly gravid or spent females in trigger traps suggests that they do not generally use them as lairs, instead using limestone reefs around the 20 m depth contour line to brood their eggs.

Leporati et al. (2015) hypothesised that a plausible depiction of the *O.* aff. *tetricus* life cycle is as follows:

a) paralarvae hatch and are at the mercy of currents for ~ 50 days;

b) they settle on the benthos and then move to protected inshore waters;

c) females move offshore to rocky temperate reefs to mature and find appropriate lairs in which to brood their eggs; and

d) males follow the females and continue to hunt and look for potential mates.

Little is known about the stock structure of *O.* aff. *tetricus*, however due to their extended paralarval phase they are assumed to be a single stock over their distribution.

### 5.1.2.3 Age and Growth

The age and growth of *O.* aff. *tetricus* was investigated in detail as part of the research project by Hart et al. (2016) and has been published in Leoparti and Hart (2015). Octopus age was determined by counting daily growth increments deposited on stylets, an internal calcified structure (Figure 5.3). Daily increment periodicity in stylets was validated by injecting wild caught octopus held in captivity with the fluorescent marker calcein. A relationship was established between stylet weight and number of growth increments for a subset of 251 octopuses, and this relationship used to indirectly age a further 3492 octopuses.

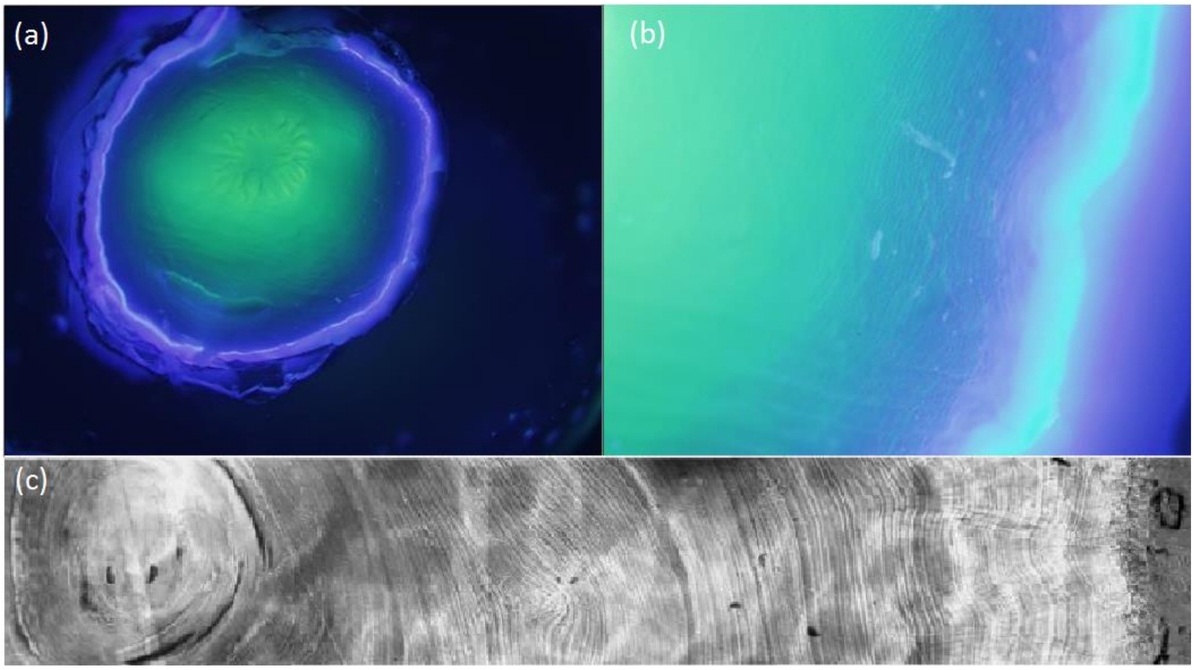

**Figure 5.3 Images of sectioned *Octopus* aff. *tetricus* stylets at (a) 40, (b) 200, and (c) 400 times magnification. Image (c) shows daily stylet increments that were counted to determine age. Images (a) and (b) show the fluorescent marker calcein under UV light that was used for validation of stylet increment periodicity (adapted from Leporati and Hart 2015).**

The relationship between age and mantle length in both male and female octopus indicated rapid growth. It was modelled using a power curve, as opposed to an asymptotic growth curve (Table 5.1, Figure 5.4). *Octopus* aff. *tetricus* grew at a mean rate of 4.4% of bodyweight per day, with maximum ages of females and males of 677 and 542 days respectively. Growth of *Octopus* aff. *tetricus* has also been modelled in a more traditional manner using a von Bertalanffy growth curve (Table 5.1). Preliminary estimates of parameters show females have a larger asymptotic size, which is in agreement with the power curve growth model (Table 5.1).

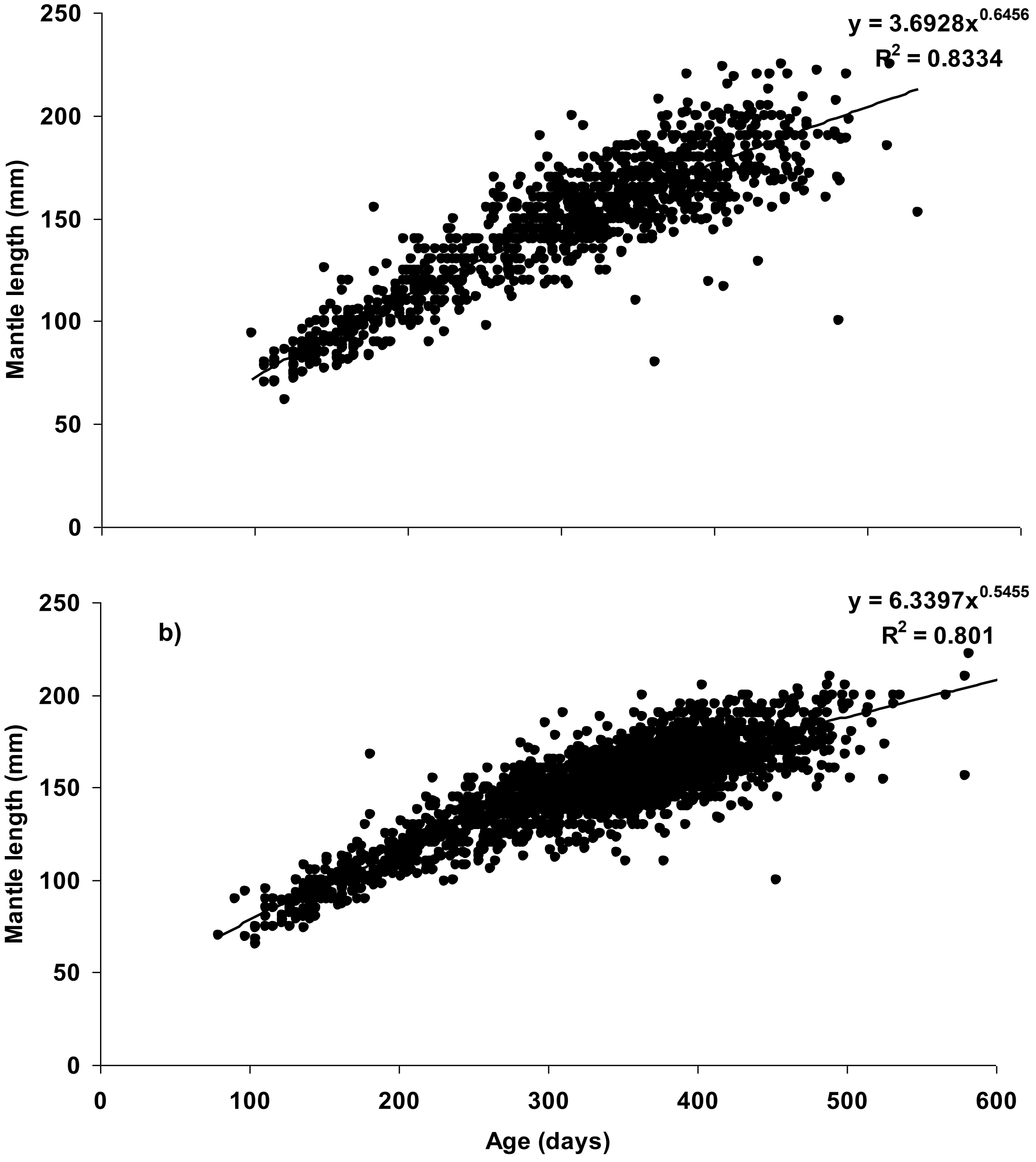

**Figure 5.4 Mantle length (mm) as a function of age (days) in (a) female and (b) male *Octopus* aff. *tetricus* sampled from the OIMF (Source: Leporati and Hart 2015)**

### 5.1.2.4 Natural Mortality

*Octopus* aff. *tetricus* is semelparous and death occurs shortly after egg laying in females and the onset of senility in males (Joll 1983). The factors controlling the onset of these events are not well known but are a major determinant of lifespan.

Natural mortality (*M*) for *O.* aff. *tetricus* has been estimated as 2.36 year$^{-1}$ based on Hoenig's (1983) equation for molluscs and using the maximum observed age of 1.56 years (Hart et al. 2016).

### 5.1.2.5 Reproduction

*Octopus* aff. *tetricus* is a merobenthic octopus; females lay hundreds of thousands of eggs in multiple, small strings of 10 to 12 cm (Joll 1976). Females brood their eggs for around a month, although the timing of embryonic development decreases with increasing temperature (Joll 1976). Paralarval octopuses hatch at a length of 2.5 mm and then spend around 50 days in the water column before settling on the benthos (Joll 1976, Leoparti et al. 2015).

Based on back-calculating ages of a large number of octopuses in the OIMF, spawning occurs year-round (Leporati et al. 2015). The greatest frequency of spawning is during periods of transitional temperature in autumn and spring.

Age at 50% maturity has been estimated as 243 days for males and 379 days for females (Leporati et al. 2015). This provides males with slightly less than a year as a viable mating period. Given females mature later, they have only around a six-month window for spawning. Females are capable of sperm storage for up to four months (Joll 1976), enabling them to mate prior to maturation.

### 5.1.2.6 Factors Affecting Year Class Strength and Other Biological Parameters

Little is known specifically about factors affecting year class strength in *O.* aff. *tetricus*. As a short-lived invertebrate, the population is likely to be strongly influenced by environmental factors, and temperature is known to affect both embryonic development time (Joll 1976) and correlate with growth (Leporati et al. 2015).

Based on their longevity of ~1.5 years, at any given time the population is predominantly comprised of two cohorts corresponding to the peak spawning periods in autumn and spring. As spawning is asynchronous, however, there is still some level of recruitment occurring year-round. Furthermore, as females are capable of storing sperm, they are not expected to be as strictly bound to environmental cues as some other short-lived invertebrates.

### 5.1.2.7 Diet and Predators

*Octopus* aff. *tetricus* feeds on a variety of prey, including: crustaceans, shelled molluscs, fish and other cephalopods. In addition, it is a major predator of pot-caught western rock lobster (*Panulirus cygnus*) in the WCRLF, with predation of lobsters outside of pots considered to be considerably less, due to the slower swimming speeds of octopuses (Joll 1977). The major predators of *O.* aff. *tetricus*, are believed to be small benthic shark species, large teleost species such as the iconic WA dhufish (*Glaucosoma hebraicum*), dolphins and seals. To determine the exact trophic role of *O.* aff. *tetricus,* diet studies need to be conducted.

#### 5.1.2.8 Parasites and Diseases

Parasite and diseases are not known to be an issue for the octopus resource.

### 5.1.3 Inherent Vulnerability

The biological characteristics of *O.* aff. *tetricus* mean this species likely has a relatively low vulnerability to fishing. *Octopus* aff. *tetricus* is fast growing (increasing by 4.4% of their body weight per day) and short-lived (1.5 years), fast maturing (8 – 12 months) with a high natural mortality ($M$ = 2.36 year$^{-1}$) and population turnover. The population is likely to be comprised of predominantly two cohorts at any given time. While these characteristics mean the species is likely able to withstand relatively high levels of fishing mortality, like many invertebrate populations it is also likely to be vulnerable to environmental factors. Characteristics such as year-round spawning and sperm storage may reduce environmental-driven fluctuations in population size to some extent. The trigger trap method of fishing, which is now the main gear type used to exploit the octopus resource, is strongly biased towards capturing males. This characteristic of the fishery should further reduce any potential effects of fishing on spawning stock and recruitment.

# 6 Fisheries / Sectors Capturing Resource

The WA Octopus Resource has historically been exploited by three main commercial fisheries in WA; the OIMF, the CSLPF, and the WCRLF (Figure 6.1). Octopus has always been caught as bycatch by the WCRLF, however, it was not until the development of markets for both bait and human consumption that lobster fishers first started retaining significant quantities during the 1990s and 2000s. Octopus catches by the WCRLF peaked in 2002 at 139 t but then gradually declined to < 20 t as effort was substantially reduced in the fishery and it then moved to quota management in 2010. The OIMF, which was established as the Developmental Octopus Fishery (DOF) in 2001, has grown substantially since 2009 and now annually retains around 200 t, making it the main fishery exploiting the resource. Catch by the CSLPF has been relatively stable at between 20 to 40 t since the mid-2000s. Several other fisheries report negligible quantities of octopus.

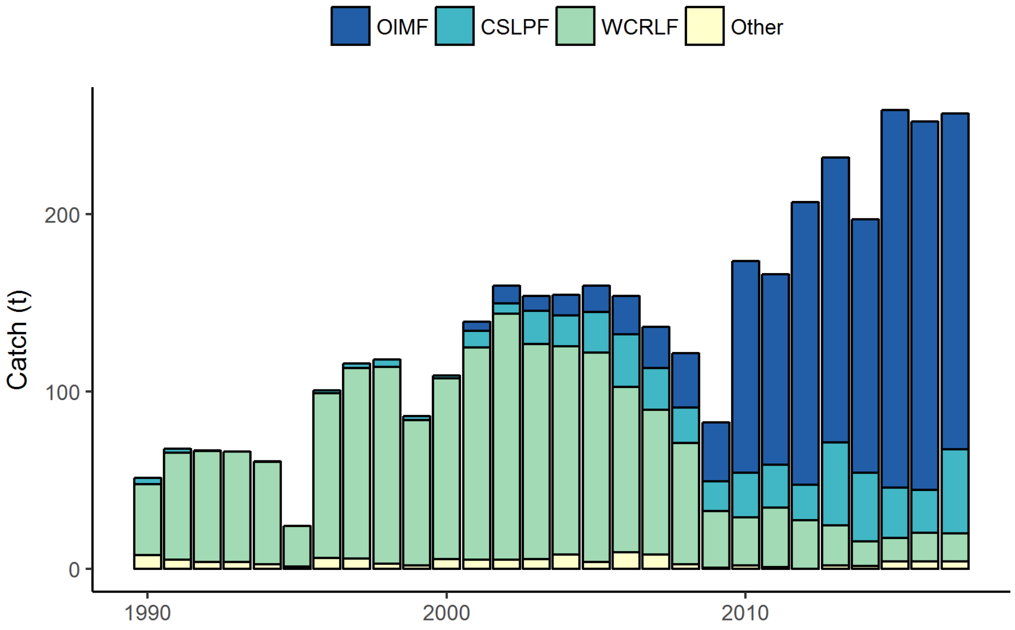

**Figure 6.1 Total commercial catch for the WA Octopus Resource (OIMF, Octopus Interim Managed Fishery; CSLPF, Cockburn Sound Line & Pot Fishery; WCRLF, West Coast Rock Lobster Fishery) between 1990 and 2017**

## 6.1 Octopus Interim Managed Fishery

### 6.1.1 History of Development

The potential of an octopus fishery was first investigated by Japanese researchers from 1979 to 1981 in response to high levels of octopus predation and bycatch in the WCRLF (Joll 1977). A major finding of this research was the existence of a substantial octopus population and the need for an adequate gear type to harvest it (Kimura 1980; Kimura and Isomae 1981; Kimura et al. 1978).

A developmental strategy for octopus fishing was implemented in the late 1990s and the DOF was established as a limited entry fishery in 2001 under exemptions from the *Fish Resources Management Act 1994*. The permitted gear for the fishery was the shelter pot, an open-ended and unbaited fishing gear that provided a refuge for octopus. Shelter pots were set on demersal longlines of approximately 500 pots per line that required a soak time of 15 to 25 days and, due to their design, could only be set in shallow (< 20 m) protected waters.

From 2007 to 2009, fishers in the DOF developed and tested a new gear type known as trigger traps. Trigger traps are a rectangular trap that is typically set in cradles of three and baited with an artificial crab which, when grasped by the octopus, triggers a trap door mechanism over the entrance. This active fishing gear greatly reduced soak time to an average of 11 days, increased catch rates, and enabled fishing in previously inaccessible habitats.

The development of trigger traps provided the impetus to draft an adaptive management strategy for the DOF and during 2011/12 new management arrangements came into place that gave all fishers the opportunity to use the new gear type. The spatial management framework of the fishery was also modified to align it with the northern and southern zones of the WCRLF. The DOF transitioned from an exemption fishery to more formal management arrangements in November 2015 with the introduction of the *Octopus Interim Managed Fishery Management Plan 2015.* This plan will remain in place for a maximum of five years until it transitions to a fully Managed Fishery.

### 6.1.2 Current Fishing Activities

A summary of key attributes of the OIMF is provided in Table 6.1. The fishery encompasses most of the state waters from just north of Kalbarri (27 °S) to the South Australia border (129 °E) and is divided into three fishing zones for management purposes (Figure 6.2). There are currently 32 licences to fish in the OIMF (Table 6.1); 7 in Zone 1, 22 in Zone 2, and 3 in Zone 3 Fishing occurs year-round, with approximately 82% of annual catches taken from Zone 2.

**Table 6.1. Summary of key attributes of the OIMF**

| **Attribute** | |
|---|---|
| Fishing methods | Unbaited traps<br>*Active* trigger traps = 1 unit<br>*Passive* shelter pots = 1/5 units |
| Fishing capacity | Zone 1: 20,550 units<br>Zone 2: 34,908 units<br>Zone 3: 12,213 units |
| Number of licences | 32 |
| Number of vessels | 26 (2018) |
| Size of vessels | 6 – 20 m |
| Number of people employed | 2-4 per vessel |
| Value of fishery | $2.5M (2017) |

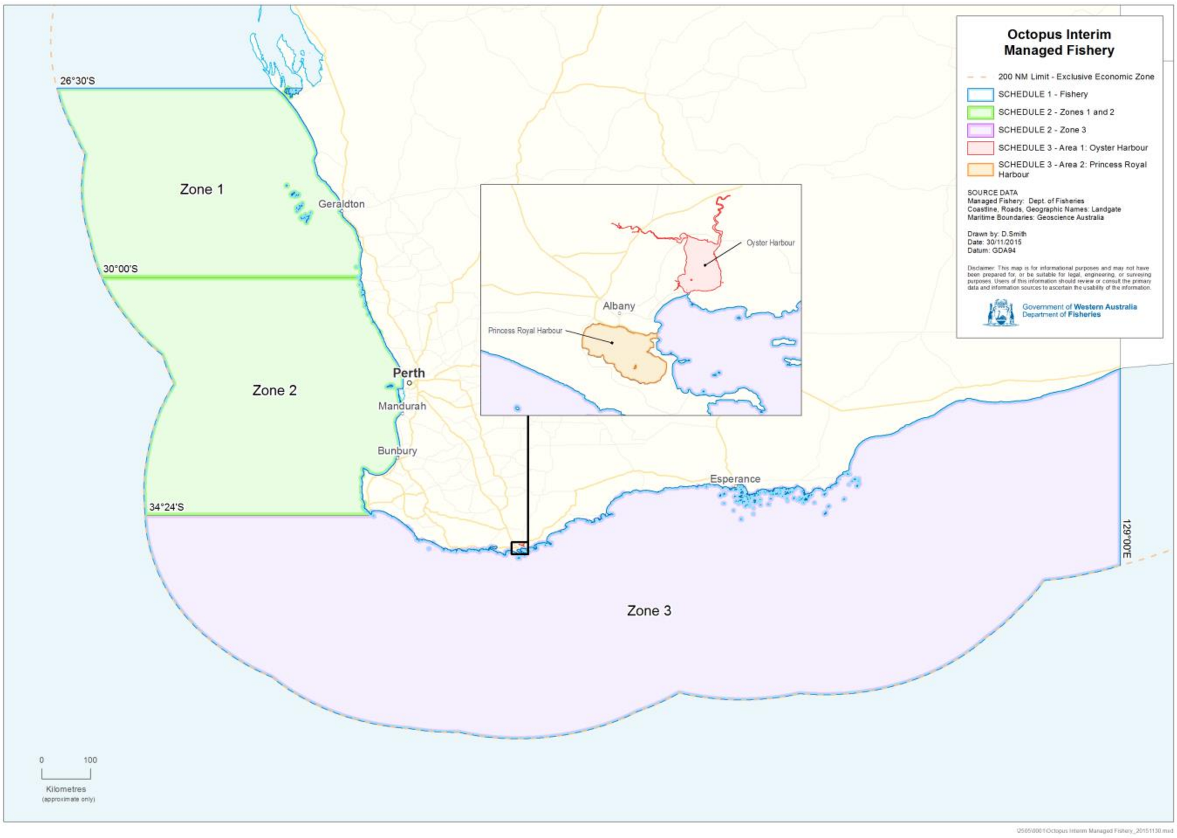

**Figure 6.2. Boundaries of the Octopus Interim Managed Fishery (OIMF)**

### 6.1.3 Fishing Methods and Gear

Two gear types are currently approved for use in the OIMF; shelter pots and trigger traps. Ninety-eight percent of OIMF catches in 2016 were taken using trigger traps, with some fishing with shelter pots still occurring in Zone 3.

Shelter pots are an open-ended passive gear, which relies on octopuses using the pots as hides, in refuge limited environments (Figure 6.3). Shelter pots have an approximate volume of 6 litres, an opening of 16.9 cm$^2$, are generally soaked for 25 days and set on demersal longlines of approximately 500 pots per line (Figure 6.4). Shelter pots are predominantly set at depths shallower than 20 m in protected waters, to prevent loss and burying of gear in sediment by wave action.

**Figure 6.3. Shelter pots used to passively catch octopus**

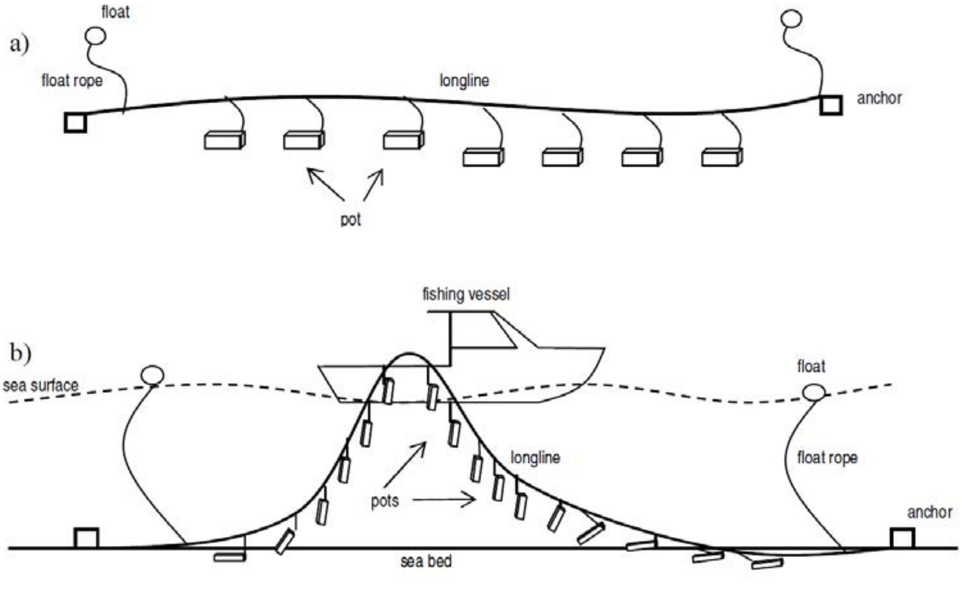

**Figure 6.4. Schematic diagram of (a) the design, and (b) the operation of shelter pots. Trigger pots are also set by the longline method. Source: Larson (2008)**

Trigger traps are considered to be an active gear under the *OIMF Management Plan 2015* (see Section 7.1). They rely on the need of octopuses to find shelter in refuge limited habitats as well as exploiting their hunting instincts and curiosity (Figure 6.5). Trigger traps have an approximate volume of 15 litres, an opening of 12.8 $cm^2$ and a mean soak period of 11 days. A cradle of trigger traps, which generally consists of three (or two) traps, can be either set as a single unit of gear (Figure 6.6) or connected to a demersal longline. Increasingly the fishery has shifted from the use of single lines to long lines, partially as a way to mitigate whale entanglements by reducing the number of lines in the water. In 2017, approximately 90% were set on longlines.

**Figure 6.5 Trigger traps used by the OIMF**

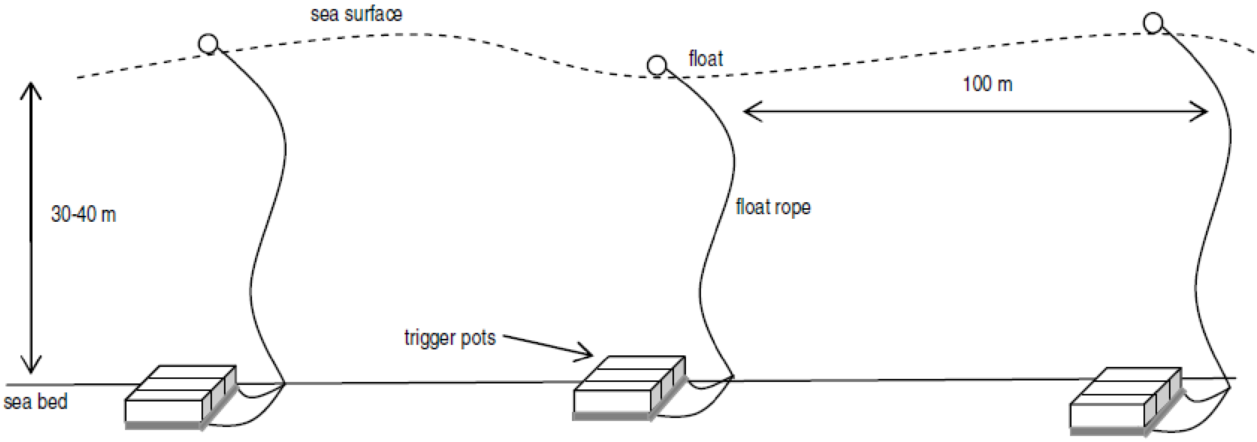

**Figure 6.6. Schematic diagram of trigger pots Source: Larson (2008).**

### 6.1.4 Susceptibility

Under current fishing activities, *O.* aff. *tetricus* has a relatively low susceptibility to exploitation by the OIMF. The fishery is still in a phase of controlled expansion, and the current catch of ~250 t per year is well below the range of 879 to 2261 t that has been estimated to be sustainable (Hart et al. 2016). Less than 5% of the estimated total extent of harvestable area within the fishery is currently harvested (Hart et al. 2016; Hart et al. in press).

The gear type used to target *O.* aff. *tetricus* is strongly biased towards catching maturing male octopuses, and this is assumed to have less of an impact on spawning stock and recruitment than the direct capture of mature females. Each pot or trap is only capable of capturing a single octopus and requires an extended (~11 days for trigger traps) soak time. Under current input management arrangements that limit the number of units that can be fished, there is a maximum number of octopus that can be captured at any given time. The gear and fishery characteristics are unlikely to lead to capture of excess octopus or result in practices such as discarding or high-grading.

## 6.2 Cockburn Sound Line & Pot Managed Fishery

### 6.2.1 History of Development

Cockburn Sound has been a popular area for both commercial and recreational fishing for octopus due to its close proximity to the Perth metropolitan area and the high octopus catch rates experienced there. In 1986, broad restrictions were put into place, resulting in a fleet of 64 fishing units able to access any of the resources in Cockburn Sound. As these restrictions proved to be insufficient, the Minister for Fisheries commenced a consultation process in 1990 that resulted in five managed fisheries being established in Cockburn Sound in 1994. These fisheries were the Cockburn Sound Mussel Fishery, Cockburn Sound Crab Fishery, Cockburn Sound Line and Pot Fishery, Cockburn Sound Fish Net Fishery, and the West Coast Beach Bait and Fish Net Fishery.

The Cockburn Sound (Line and Pot) Fishery (CSLPF) commenced in March 1995 when the *Cockburn Sound (Line and Pot) Managed Fishery Management Plan 1995* came into effect. Thirty-four of the licenced fishers had the capability of catching octopus, with squid and fish also permitted to be taken by line. On May 1st 2015, the octopus component of the CSLPF was transitioned to a pot entitlement scheme. Previously effort was restricted primarily through other means such as limits on vessel size. Eleven of the 13 CSLPF licensees currently have entitlements to fish for octopus, and a total of 13,005 units of entitlement have been granted based on shelter pot fishing efficiencies. With only four vessels actively targeting octopus in the CSLPF in recent years, annual octopus catch has generally fluctuated between 20 and 40 t, although the 2017 catch reached an equal high catch of 47 t.

### 6.2.2 Current Fishing Activities

A summary of key attributes of the CSLPF is provided in Table 6.2. The boundaries of the fishery encompass the waters of Cockburn Sound (Figure 6.7). Under the *Cockburn Sound (Line and Pot) Managed Fishery Management Plan 1995*, fishing is allowed with both baited and unbaited pots, however longline-set unbaited shelter pots have been the gear type historically used by the fishery (Figure 6.3). Fishing for octopus occurs year-round.

### 6.2.3 Fishing Methods and Gear

"Octopus pot" is the permitted gear type for capturing octopus in the CSLPF. Under the CSLPF *Management Plan 1995* this is described as

> *"an unbaited device open at one end or a baited device designed to capture cuttlefish, octopus or squid and approved in writing for that use by the CEO"*

Passive longline-set shelter pots are currently the only gear type used in the CSLPF (Figure 6.3). In earlier years' tyres, clay pots and PVC piping was also used (Department of Fisheries 2005).

### 6.2.4 Susceptibility

Under current management arrangements *O.* aff. *tetricus* is likely to have a low to moderate susceptibility to fishing by the CSLPF. Although the CSLPF is restricted to the waters of Cockburn Sound that has a limited amount of octopus fishing grounds, the broader stock is distributed across a very large area of WA coastline. The shelter pots used by the fishery are biased towards capture of maturing female octopuses.

These characteristics and their potential to lead to localised depletion of octopus in Cockburn Sounds have been noted, and have resulted in a highly precautionary management approach (Department of Fisheries 2010). Historically, in an addition to limited entry, effort was regulated through restrictions on vessel size. Effort has been further constrained in 2015 with the introduction of a fixed octopus entitlement of 13,000 shelter pots. It should also be noted that, despite the potential higher risk to octopus in Cockburn Sound, there is no evidence to suggest overexploitation has occurred.

**Table 6.2. Summary of key attributes of the Cockburn Sound (Line & Pot) Managed Fishery**

| Attribute | |
|---|---|
| Fishing methods | Octopus pot (currently only shelter pots in use) |
| Fishing capacity | 13,005 shelter pots |
| Number of licences | 13 licences (11 with octopus entitlement in 2017) |
| Number of vessels | 4 (2017) |
| Size of vessels | Not restricted |
| Number of people employed | 2–4 per vessel |
| Value of fishery | < $1 million (2017) |

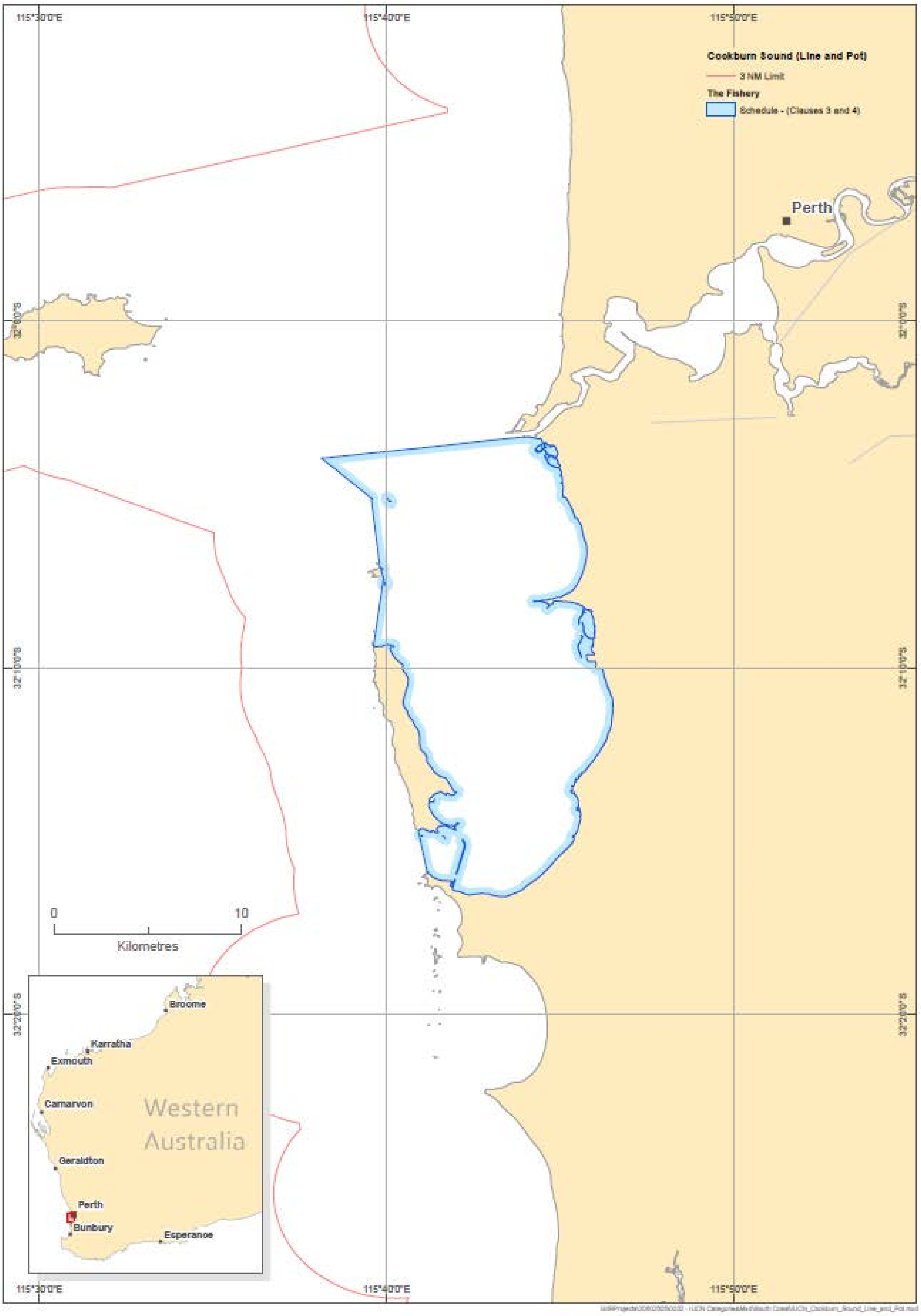

Figure 6.7. Boundaries of the Cockburn Sound Line & Pot Managed Fishery

## 6.3 West Coast Rock Lobster Managed Fishery

### 6.3.1 History of Development

Octopus has always been a bycatch species of the WCRLF and predation by *O.* aff. *tetricus* on pot-caught western rock lobsters continues to have important economic implications (Fletcher et al. 2005, Hart et al. 2016). *Octopus* aff. *tetricus* is the second most commonly retained species by the WCRLF (Fletcher and Santoro 2015).

The history of the octopus catch by the WCRLF is essentially the same as the OIMF, since the development of the octopus fishery was motivated by a desire to reduce rock lobster predation and develop a fishery to exploit the apparently large octopus resource in WA waters. The OIMF has, to a large extent, evolved from the WCRLF.

The development of markets for octopus for both bait and human consumption led to increased retention of octopus in the WCRLF during the 1990s and 2000, with catch reaching a historical peak of 139 t in 2002. Since 2009 however, octopus catch has been <40 t and was 16 t in 2017 (Figure 6.1). This reduction in catch is related to the reduction in fishing effort in the late 2000s and then a shift to an Individual Transferable Quota management system in the WCRLF in 2010. The fishery adopted maximum economic yield as its target which has greatly changed the economics of the fishery and means that octopus catch is likely to remain low for the foreseeable future.

### 6.3.2 Current Fishing Activities

A summary of key attributes of the WCRLF and the fishing fleet is provided in Table 6.3. The fishery is situated along the west coast of Australia between 21°44’S and 34°24’S and is managed in three zones: south of latitude 30°S (Zone C), north of latitude 30°S (Zone B) and, within this northern area, a third offshore zone (Zone A) around the Abrolhos Islands. Fishing occurs year-round.

**Table 6.3. Summary of key attributes of the WCRLF**

| Attribute | |
|---|---|
| Fishing methods | Baited pot |
| Fishing capacity | 69,000 lobster pots |
| Number of licences | 233 (2015) |
| Number of vessels | 231 actively fishing |
| Size of vessels | 17 – 25 m |
| Value of fishery | < $1M (octopus component) |

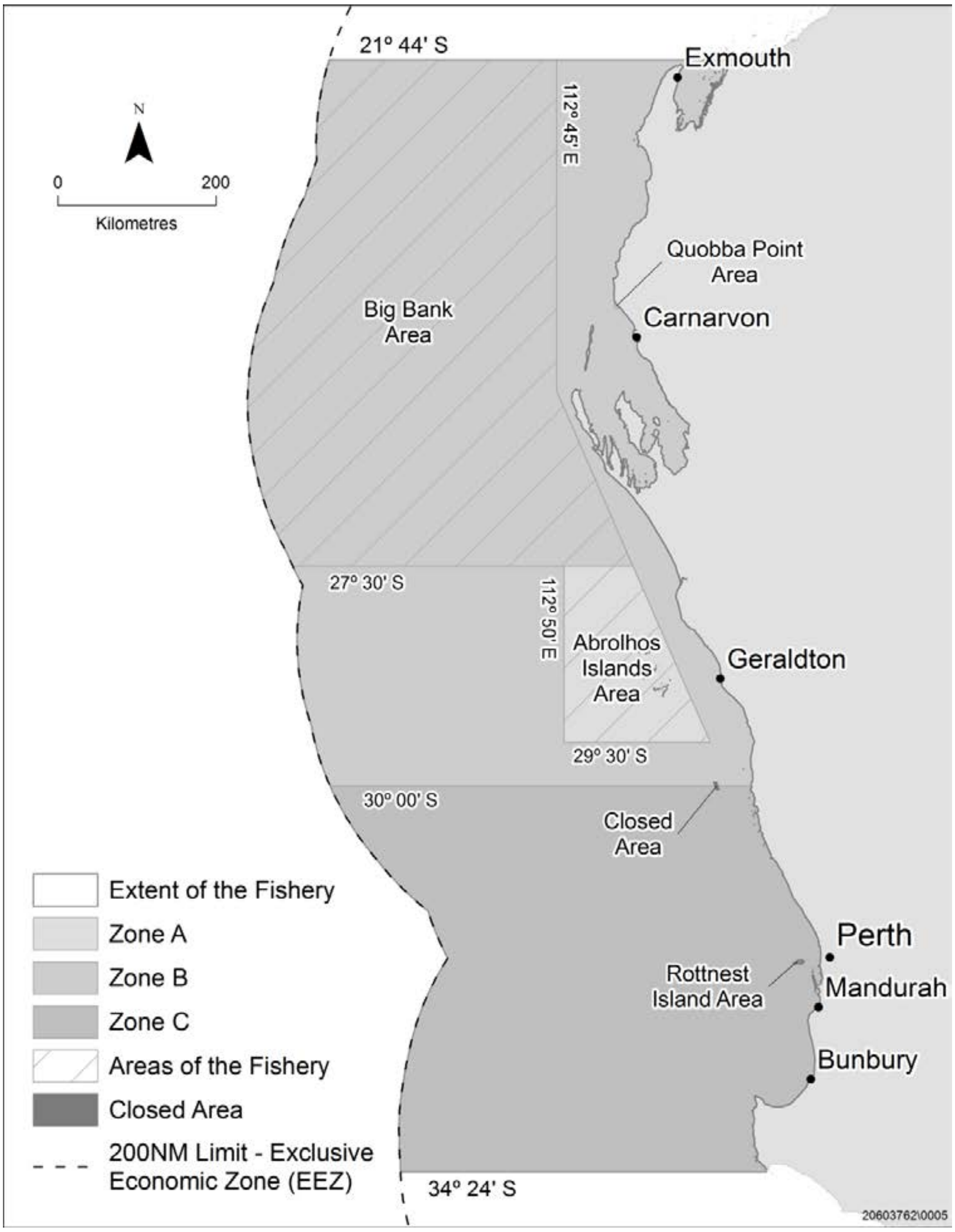

**Figure 6.8 Boundaries of the WCRLF and its Management Zones**

### 6.3.3 Fishing Methods and Gear

The WCRLF uses baited batten or beehive style pots to capture rock lobsters (see de Lestang et al. 2016 for more detail).

### 6.3.4 Susceptibility

*Octopus* aff. *tetricus* has a low susceptibility to capture by the WCRLF. The baited pots used to capture rock lobster are not particularly efficient at capturing octopus due to their large escape gaps. The shift to a quota management system has greatly reduced effort in the fishery overall, as well as the retention of octopus specifically. Capture by the WCRLF now represents a minor component of the total catch of the octopus resource.

## 6.4 Other Commercial Fisheries

Numerous trap and trawl fisheries in WA catch and retain octopus, however, their combined catch has never exceeded 10 tonnes (Figure 6.1). Any impact from such fishing is assumed to be negligible.

## 6.5 Recreational Fishery

### 6.5.1 History of Development

Recreational octopus fishing is permitted throughout WA and predominantly consists of bycatch from recreational lobster pots and targeted octopus fishing, mostly by SCUBA divers. In 2015, a two-year trial was initiated that allows Recreational Fishing from Boat Licence Holders to use a modified version of the commercial octopus trigger trap to target octopus from boats. Recreational fishers are subject to a range of conditions and are permitted to use a maximum of six octopus traps. The exemption has been extended until 2020.

### 6.5.2 Current Fishing Activities

An estimate of the 2015/16 annual octopus catch by boat-based recreational fishers in WA was 1379 individuals, of which 1159 were retained (Ryan et al. 2017). Eighty-eight percent of the catch was taken in the West Coast Bioregion.

### 6.5.3 Fishing Methods and Gear

There is limited targeted fishing for octopus by recreational fishers in WA, although they may still be caught and retained when fishing using a variety of gears. A smaller version of the trigger trap used by commercial fishers has been developed for use by recreational fishers that can be deployed from boats in cradles of two (Figure 6.9). The specifications for use and deployment of this gear are outlined in Exemption Number 2927. The low recreational catch (Ryan et al. 2017) suggests the exemption has not yet resulted in a large increase in recreational fishing for octopus.

**Figure 6.9 Example of the octopus trigger traps available for use by recreational fishers**

### 6.5.4 Susceptibility

Recreational fishing for octopus in WA is limited and catch is low. Any impacts from this sector are likely to be negligible.

## 6.6 Customary Fishing

Octopus is not a primary target of Indigenous Australians in WA (Department of Fisheries 2005). There is no quantitative information available on catch, which is likely to be negligible relative to commercial levels.

## 6.7 Illegal, Unreported or Unregulated Fishing

Octopus is a low to moderate value species and is unlikely to be the focus of illegal fishing activities. There may be some unreported octopus catch in fisheries where it is caught as bycatch, but this is likely to be negligible.

# 7 Fishery Management

## 7.1 Management System

The harvest strategy for the octopus resource of WA is, essentially, a *constant exploitation approach*, where the annual catch varies in proportion to variations in stock abundance. To implement this strategy, fisheries capturing octopus are managed using a range of input controls. These include limited entry, gear restrictions with limits on pot allocations, and spatial regulations that restrict fishers to specific zones.

## 7.2 Harvest Strategy

A harvest strategy for the octopus resource outlines the long and short-term objectives for management (DPIRD 2018). It also provides a description of the performance indicators used to measure performance against these objectives, reference levels for each performance indicator, and associated control rules that articulate pre-defined, specific management actions designed to maintain the resource at target levels.

The harvest strategy for the WA Octopus Resource is predominantly based around the monitoring of the performance of the OIMF, which catches the vast majority of octopus in WA and is likely to increase its total share of the catch in the future. The OIMF is currently in a phase of controlled expansion, with fishing practices changing continuously as fishers adapt to the use of trigger traps and seek to optimize fishing operations within the constraints of the current management arrangements.

In the absence of a population model, the key performance indicator for monitoring stock status is the standardised commercial catch rate (SCPUE) of octopus caught using trigger traps in Zones 1 and 2 of the OIMF (see Section 9.3.4). The SCPUE is assumed to represent a robust index of abundance for the stock and is compared annually against reference levels that have nominally been set at 40, 30, and 20% of initial catch rates, $SCPUE_0$ (Table 7.1).

These levels are intended to be consistent with current internationally accepted benchmarks (Mace 1994; Caddy and Mahon 1995; Gabriel and Mace 1999; Wise et al. 2007).

The initial year for setting reference levels was 2010, when the first substantial (> 100 t) catches occurred in the OIMF (Figure 9.6). Although it can be argued that 2010 was not the "virgin year" for the fishery, as catch records extend back to the early 1990s, the spatial distribution of the harvest was markedly different in the new trigger trap fishery. It had been largely confined to the shallower habitats within 15 km of the safe anchorage areas, particularly south of Perth such as Fremantle and Mandurah anchorages. Catch of *Octopus* aff. *tetricus* in the 1990s and early 2000s was mostly byproduct of the harvest for western rock lobster, and covered a wider distribution than the 10-50 m depth contour, particularly north of Perth. The catch rate abundance index is also well supported by a number of ancillary indices using an overall weight-of-evidence assessment to monitor stock status (see Section 9.4).

**Table 7.1. Summary of the performance indicator, reference levels and control rules for the WA Octopus Resource**

| Management Objective | Performance Indicator(s) | Reference Levels | Control Rules |
|---|---|---|---|
| To maintain spawning stock biomass of each retained species above $B_{MSY}$ to maintain high productivity and ensure the main factor affecting recruitment is the environment. | Annual standardised commercial catch rate (SCPUE) of octopus caught in trigger traps within Zones 1 and 2 | **Target:** 0.62 kg per potlift | No management action required |
| | | **Threshold:** 0.46 kg per potlift | If the Threshold is breached, a review is triggered to investigate the reasons for the variation. If sustainability is considered to be at risk, appropriate management action will be taken to reduce the total catch by up to 50%. |
| | | **Limit:** 0.31 kg per potlift | If the Limit is breached, management strategies to further protect the breeding stock will be implemented (50 – 100 % reduction of total catch). |

## 7.3 External Influences

External influences include other activities and factors that occur within the aquatic environment that may or may not impact on the productivity and sustainability of fisheries resources and their ecosystems. The relevant external influences included here are environmental factors and market influences.

### 7.3.1 Environmental Factors

As a short-lived, invertebrate species, environmental factors are presumed to have a strong influence on the WA Octopus Resource. Little is known about what these may be specifically, and there have not been any environmentally-linked changes in catch or catch rate of any commercial fisheries identified to date. Given that the octopus resource is, at any given time, essentially comprised of only two cohorts (see Section 5.1), environmental perturbations could be expected to result in major fluctuations in population size.

#### 7.3.1.1 Climate Change

A risk assessment of WA's key commercial and recreational finfish and invertebrate species has demonstrated that climate change is having a major impact on some exploited stocks (Caputi et al. 2015). This is primarily occurring through changes in the frequency and intensity of ENSO events, decadal variability in the Leeuwin Current, increase in water temperature and salinity, and change in frequency and intensity of storms and tropical cyclones affecting the state (Caputi et al. 2015). In 2010/11, a very strong Leeuwin Current resulted in unusually warm ocean temperatures in coastal waters of south-western WA (Pearce et al. 2011). This "marine heatwave" altered the distribution and behaviour (e.g. spawning activity and migration) of some species and caused widespread mortalities of others.

A risk screening of 35 of WA's key commercial and recreational finfish and invertebrate species revealed *O.* aff. *tetricus* to have the lowest overall sensitivity to climate change (Caputi et al. 2015). Many of the biological processes of octopuses are highly influenced by environmental variables, suggestive of a high sensitivity to climate change. Countering this, merobenthic octopuses such as *O.* aff. *tetricus* are likely to be highly resilient.

### 7.3.2 Market Influences

The large biomass of *O.* aff. *tetricus* found in WA waters has long been recognised, with exploratory fishing surveys between the Australian and Japanese governments undertaken as early as 1978 (Anonymous 1986). Attempts at large-scale development of the resource have only recently gained traction with the invention of the octopus trigger trap, which overcomes the main hurdle to commercial viability – finding fishing method that is efficient enough to be financially viable. As the OIMF continues to expand and evolve in its fishing methods market influences may still have and important bearing on its long-term viability.

# 8 Information and Monitoring

## 8.1 Range of Information

There is a range of information available to support the assessment and harvest strategy for the WA Octopus Resource (see Table 8.1). Currently fishery-dependent sources (e.g. logbooks) make up the majority of information used. The harvest strategy is further underpinned by a recently completed major research project that investigated several aspects of the biology of *O.* aff. *tetricus*, as well as historical studies on the biology of the species.

**Table 8.1. Summary of information available for assessing the Octopus Resource**

| Data type | Fishery-dependent or independent | Purpose / Use | Area of collection | Frequency of collection | History of collection |
|---|---|---|---|---|---|
| Commercial catch and effort statistics (CAES returns, logbooks) | Dependent | Monitoring of commercial catch and effort trends, calculation of catch rates and the location of fishing | 60 × 60 nm (CAES)<br>GPS location (logbook) | Monthly (CAES)<br>Daily (logbook) | Logbook since 2000 |
| Octopus predation rate | Dependent | Not used for Octopus Resource | WCRLF | By trip | Since 1980 |
| VMS data | Dependent | Not used for Octopus Resource | WCRLF | | |
| Recreational catch and effort estimates | Dependent | Monitoring of recreational catch and effort trends | State-wide | Biennial | Since 2011 |
| Biological information | Dependent and independent | Patterns of growth and reproduction, gear efficiency, octopus density and suitable habitats | Resource level | Opportunistic, currently monthly | Since 1970s |

## 8.2 Monitoring

### 8.2.1 Commercial Catch and Effort

All fishers operating in the OIMF and CSLPF are required to fill out a vessel-specific daily catch and effort logbook. The logbook captures the following information, for each line of shelter pots or cradles of trigger traps hauled during a single days fishing: GPS location data for the start and end of each line, number of cradles or pots hauled, days soaked, depth and the number of octopus caught (see Appendix 1). Each logbook also provides a total weight (kg) for the days fishing, following weighing at a processing plant.

Comprehensive records of commercial catch and effort are also available for the WCRLF, which is the most valuable commercial fishery in WA. These are described in detail in the relevant Resource Assessment Report (de Lestang et al. 2016).

### 8.2.2 Recreational Catch and Effort

A state-wide survey was implemented in 2011 to collect information on private (non-charter), boat-based recreational fishing in WA (Ryan et al. 2013, 2015, 2017). This survey uses three complementary components, off-site phone diary surveys, on-site boat ramp surveys and remote camera monitoring, to collect information on fishing catch, effort, location and other demographic information every two years.

### 8.2.3 Fishery-Dependent Monitoring

In addition to catch and effort data, fishery-dependent information have also been collected from a biological monitoring program undertaken in the OIMF and CSLP fisheries.

The biological program measures the size, weight, reproductive scheduling, and age of harvested animals to inform a weight-of-evidence assessment of octopus. A substantial amount of biological information on *O.* aff. *tetricus* was collected as part of FRDC Project 2010/200 (Hart et al. 2016). For the ageing aspect of that study (see Section 5.1.2.3), sampling was confined to monthly biological samples acquired from the OIMF during February 2008 – June 2012, from waters between 31°S and 33°S on the WA coast at depths of 5 – 40 m. Both shelter pots and trigger traps were used to collect samples. A total of 3,492 octopuses were dissected during the sampling period. Data on the reproductive biology of octopus (see Section 5.1.2.5) was also collected from the individuals aged, and was supplemented with data from earlier work by Larsen (2008) and Franken (2010).

### 8.2.4 Fishery-Independent Monitoring

There is no ongoing fishery-independent monitoring of the WA Octopus Resource, however, a number of surveys have been undertaken to estimate catchability of trigger traps and provide estimates of stock density and population size.

#### 8.2.4.1 Depletion Experiment

Between April and July in 2013, a depletion experiment was conducted five nautical miles off the coast of Mandurah (Figure 8.1) to estimate the catchability of trigger traps and obtain fishery-independent estimates of stock density (Hart et al. 2016; see also Section 0). A total of 72 cradles of trigger traps were deployed at two separate sites, located approximately 5 km apart to minimise inter-grid sampling effects. Each grid was set in a 6×6 cradle configuration with approximate equal distancing between cradles. The first grid (A) encompassed a total area of 1.35 km$^2$, the second grid (B) was 0.77 km$^2$ in area (Figure 8.1). Both areas were of a similar habitat and depth range of 25 – 28 m.

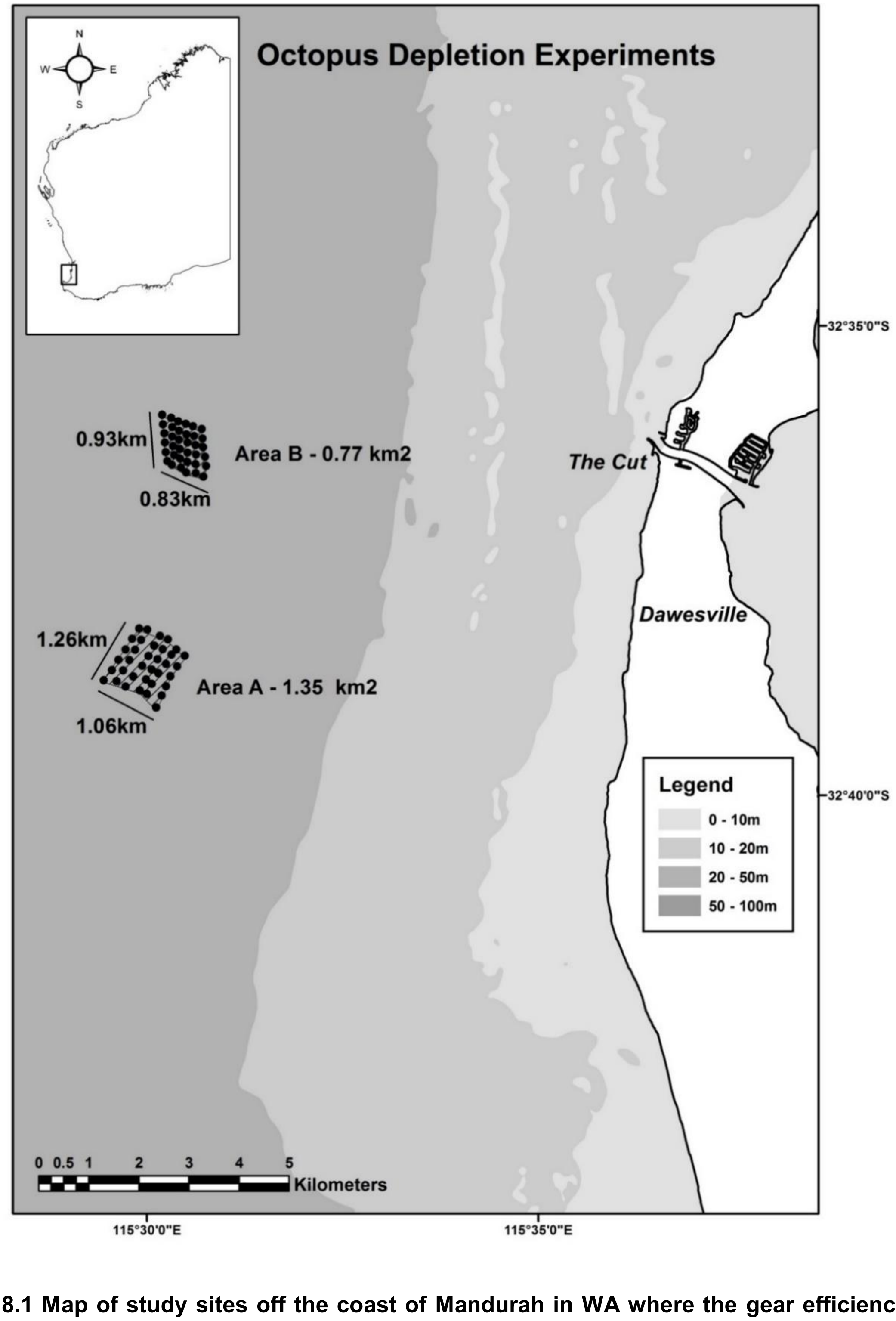

**Figure 8.1 Map of study sites off the coast of Mandurah in WA where the gear efficiency and density experiments for *Octopus* aff. *tetricus* were undertaken in 2013**

Within each experimental area, 36 trigger traps were set and hauled in a systematic spatial pattern that achieved uniform coverage. Trap density was designed to mimic as close as possible the densities set in the commercial fishery. All traps were set and hauled ten times in exactly the same GPS location over the duration of the experiment, which was 84 days. The trap soak period was consistently 7 days, except for weeks five and six when poor weather extended the soak periods to 17 and 11 days respectively. The total experimental period was kept shorter than three months to allow for a greater chance of the "closed population" assumption being met, as required for the traditional Leslie and Delury depletion estimators (see Section 0).

Leslie and DeLury depletion methods (Leslie and Davis 1939; DeLury 1947) were applied to estimate the catchability coefficient (*q*) of trigger traps and the density of octopus at the two sampling sites. While acknowledging that the assumption of the population being completed closed was unlikely true, it was assumed that the positive influence of immigration on abundance was balanced by the negative effects of natural mortality and emigration.

The Leslie method utilises cumulative catch data and an abundance index based on catch rate at time *t* ( $y_t$ ) in the following model:

$$y_t = qN_1 - qK_{t-1}$$

where *q* is the catchability coefficient, $N_1$ is initial population size and $K_{t-1}$ is the cumulative catch (in numbers) taken prior to time *t*. The DeLury method utilises cumulative effort data and an abundance index based on log-transformed catch rate at time *t* ( $y_t$ ) in the following model:

$$\log_e[y_t] = \log_e[qN_1] - qE_t$$

where $E_t$ is fishing effort (days fished). A linear regression was performed across all sampling dates, both methods and both grids to determine population density and catchability (Hilborn and Walters 1992; Pierce and Guerra 1994).

As well as the traditional methods for estimating variability in *q*, a third method utilising a bootstrapping technique was also tested (Hart et al. in press). Catch data per trap (range: 0 to 4 octopus) were randomly sampled with replacement for each of the 10 sampling periods of the depletion experiment and the cumulative time series analysed by regression to generate one random estimate of *q*. The process was repeated 5000 times to generate a median *q* and upper and lower 95% confidence intervals. The 5000 random samples of *q* were also used to estimate variability in population surveys undertaken at Dongara and Busselton (see below).

#### 8.2.4.2 Population Surveys

Two larger areas of 300 km$^2$ were more recently surveyed at the northern (Dongara) and southern (Busselton) ends of the OIMF (Figure 8.2) to provide estimates of population densities (Hart et al. in press; see also Section 0). A systematic sampling regime was applied across the 10 – 50 m depth contours, with a total of 66 sites surveyed (33 per area). At each site, 25 trigger traps were set in a grid pattern with a distance of approximately 100 to 150 m between traps (Figure 8.2). This survey method was equivalent to that used in the depletion experiment, so that the estimates of catchability could be applied. Traps were soaked for 6 – 14 days (mean soak = 8.9 days). All octopus caught were counted and weighed.

Estimates of the total area surveyed per site was based on the length and width of the survey area obtained from the GPS coordinates of the array of 25 traps. A constant of 50 m was added to the length and width estimate of each site, on the assumption that average target radius for the octopus traps was 50 m.

Numbers and biomass caught were compared between sites, and density estimates were obtained with the following equation

$$D_i = U_i / (qS_i) / A_i$$

where $D_i$ is the density (numbers per km$^2$) or biomass density (kg per km$^2$) at site $i$, $U_i$ is numbers or kg caught at site $i$, $q$ = catchability (per day) of the trigger traps drawn from a random sample, $S_i$ is the number of days the traps were soaked for at site $i$, and $A_i$ is area surveyed at site $i$. Mean area surveyed per site was 0.40 km$^2$ (± 0.09 SE) in Dongara, and 0.62 km$^2$ (± 0.05 SE) in Busselton, for a total survey area of 34 km$^2$ across the 66 sites.

A bootstrapping function was used to estimate the variability in total density and biomass density at each area (Hart et al. in press). Each of the 33 sample sites per population was randomly sampled with replacement to generate one random estimate of density using the above equation. The process was repeated 5000 times to generate a median density (or biomass density) and upper and lower 95% confidence intervals for each area. Resampling procedures were carried out using Visual Basic macros in Excel.

#### 8.2.4.3 Spatial Extent of the Fishery

Arc GIS software was used to calculate the spatial extent of area fished across the OIMF relative to the total harvestable octopus habitat. Although earlier analyses (see Hart et al. 2016) focused on areas across the west and south coasts of WA, estimates derived from more recent data (Hart et al. in press) have focused on the western component of the fishery (i.e. Zones 1 and 2), where the majority of fishing is undertaken. To provide a conservative maximum area estimate of the stock distribution on the west coast, the total available habitat between the 10-50 m depth range (excluding marine protected areas and other "no fishing zones") was estimated.

Estimates of the actual area in which octopus were harvested between 2010 and 2017 were calculated from the spatially explicit daily logbook data reported by each commercial fishing vessel (Hart et al. in press). The start and end GPS points of a group of cradles deployed over a single fishing day were used to determine linear distance of fished area. The width of the fishing area was then estimated by dividing the distance by the number of cradles hauled. To account for fishers returning to the same grounds and overlapping effort, the area fished by each line was combined to form a polygon using the statistical software package R, with the overlap subtracted. An assumption of equal catchability between cradles was applied, discarding variables such as mechanical issues with the gear (e.g. faulty doors, fouling on the bait crab, burying of pots after storms) and the influence of small-scale habitat differences.

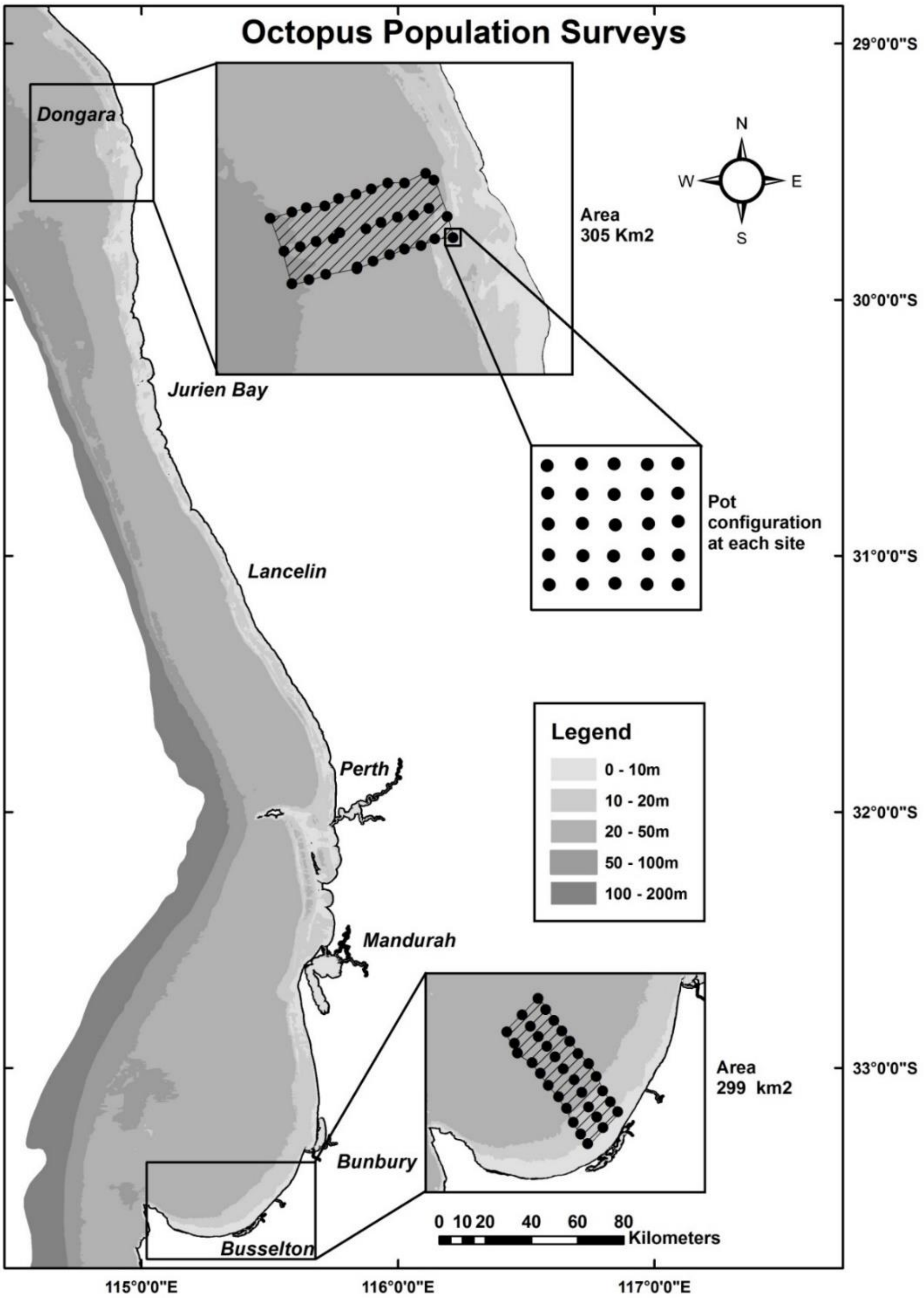

**Figure 8.2 Map of study sites off Dongara and Busselton in WA where population surveys for *Octopus* aff. *tetricus* were undertaken.**

# 9 Stock Assessment

## 9.1 Assessment Principles

The different methods used by the Department to assess the status of aquatic resources in WA have been categorised into five broad levels, ranging from relatively simple analysis of catch levels and standardised catch rates, through to the application of more sophisticated analyses and models that involve estimation of fishing mortality and biomass (Fletcher et al. 2017). The level of assessment varies among resources and is determined based on the level of ecological risk, the biology and population dynamics of the relevant species, the characteristics of the fisheries exploiting the species, data availability and historical level of monitoring.

Irrespective of the types of assessment methodologies used, all stock assessments undertaken by the Department take a risk-based, weight-of-evidence approach (Fletcher 2015). This requires specifically the consideration of each available line of evidence, both individually and collectively, to generate the most appropriate overall assessment conclusion. The lines of evidence include the outputs that are generated from each available quantitative method, plus any qualitative lines of evidence such as biological and fishery information that describe the inherent vulnerability of the species to fishing. For each species, all of the lines of evidence are then combined within the Department's ISO 31000 based risk assessment framework (see Fletcher 2015; Appendix 2) to determine the most appropriate combinations of consequence and likelihood to determine the overall current risk status.

## 9.2 Assessment Overview

In the absence of a population model, the annual assessment of *O.* aff. *tetricus* is based primarily on an analysis of commercial catch rates in the OIMF, which are assumed to be an index of abundance and used as a proxy for spawning biomass. The logbook data are standardised using a generalised linear model (GLM) to account for the effects of year, month, vessel, soak time, distance between traps, and depth on catch rates (see Section 9.3.3). The annual standardised catch rates are compared to reference points specified in the harvest strategy (DPIRD 2018).

### 9.2.1 Peer Review of Assessment

The final report for FRDC project 2010/200 (Hart et al. 2016), which contains the rationale for the current development and expansion of the OIMF, underwent peer review prior to publication. A key part of this study was a depletion experiment conducted during 2013 that was used to estimate the catchability of octopus to trigger traps that has enabled the estimation of population densities and biomass to inform what level of catch is likely to be sustainable in the fishery (see Section 0). Additionally, two peer-reviewed manuscripts on the biology of *Octopus* aff. *tetricus* have been published in Fisheries Research, Leporati and Hart (2015), and Leporati et al. (2015), and a third one is under preparation.

The OIMF is currently pursuing third party certification against the Marine Stewardship Council (MSC) standard for sustainable fishing (V2.0).

## 9.3 Analyses and Assessments

### 9.3.1 Data Used in Assessment

Logbook data
Recreational fishing survey data
Fishery-dependent data
Fishery-independent survey data

### 9.3.2 Catch and Effort Trends

#### 9.3.2.1 Commercial Catches

Octopus has been retained as byproduct of the WCRLF since around 1990, with catches often exceeding 100 t in the late 1990s and early 2000s (Table 9.1; see also Figure 6.1). Targeted fishing for octopus was first established in 2001, although fishing effort during the first nine years of the DOF was constrained to a small number of operators using shelter pots in relatively shallow inshore waters (Hart et al. 2016). Octopus catch by the WCRLF declined during this same time period due to a reduction in effort.

It was not until licensees of the (then) DOF developed and trialled a new trigger trap design that target catches of octopus increased substantially, from 33 t in 2009 to a peak of 213 t in 2015 (Table 9.1). This new gear type enabled deployment in previously inaccessible habitats and they have considerably shorter soak periods at a mean of 11 days, yielding considerably higher catch rates (Hart et al. 2016). It has been estimated that a single cradle of trigger traps catches on average 14 times more octopus than a single shelter pot (Hart et al. 2016).

Over the past five years octopus catches have remained relatively stable at around 200-250 t, with just under 80% taken by the OIMF, 15% caught by the CSLPF and the remainder representing byproduct in the WCRLF and other fisheries (Table 9.1). The OIMF achieved its 3-highest catches in the last three years while CSLPF had it equal-highest catch in 2017. Estimates of recreational octopus catches are presented in Section 9.3.2.3.

Within the OIMF, approximately 80% of the annual catch is currently taken in Zone 2, followed by around 15% in Zone 1 and 5% from Zone 3 on the south coast of WA (Figure 9.1). Since 2013, the majority of the total catch (around 97%) by the OIMF has been taken by trigger traps and only a very small proportion has been taken by shelter pots, primarily in Zone 3 of the fishery (Figure 9.1).

**Table 9.1** **Total reported catch (t) of *Octopus* aff. *tetricus* by all commercial fisheries in WA (OIMF, Octopus Interim Managed Fishery; CSLPF, Cockburn Sound Line & Pot Managed Fishery; WCRLF, West Coast Rock Lobster Managed Fishery).**

| Year | WCRLF | CSLPF | OIMF | Other | Total |
|---|---|---|---|---|---|
| **1990** | 40 | 4 | | 8 | 51 |
| **1991** | 60 | 3 | | 5 | 68 |
| **1992** | 62 | | | 4 | 66 |
| **1993** | 62 | | | 4 | 66 |
| **1994** | 58 | | | 3 | 60 |
| **1995** | 23 | | | 1 | 24 |
| **1996** | 93 | 1 | | 6 | 100 |
| **1997** | 107 | 3 | | 6 | 116 |
| **1998** | 111 | 4 | | 3 | 118 |
| **1999** | 82 | 2 | | 2 | 86 |
| **2000** | 102 | 1 | | 6 | 109 |
| **2001** | 119 | 10 | 5 | 5 | 139 |
| **2002** | 139 | 6 | 10 | 5 | 159 |
| **2003** | 121 | 19 | 9 | 5 | 154 |
| **2004** | 117 | 17 | 12 | 8 | 154 |
| **2005** | 118 | 23 | 15 | 4 | 160 |
| **2006** | 93 | 29 | 22 | 9 | 154 |
| **2007** | 82 | 23 | 23 | 8 | 136 |
| **2008** | 68 | 20 | 31 | 3 | 122 |
| **2009** | 32 | 17 | 33 | 1 | 82 |
| **2010** | 27 | 25 | 119 | 2 | 174 |
| **2011** | 34 | 24 | 108 | 1 | 166 |
| **2012** | 27 | 20 | 160 | | 207 |
| **2013** | 23 | 47 | 161 | 2 | 232 |
| **2014** | 14 | 39 | 143 | 2 | 197 |
| **2015** | 13 | 28 | 213 | 4 | 259 |
| **2016** | 16 | 24 | 208 | 4 | 252 |
| **2017** | 16 | 47 | 189 | 4 | 256 |

#### 9.3.2.2 Commercial Effort

Commercial effort in the Octopus fisheries is measured by two indices, days fished (Figure 9.2) and cradles set or number of trap lifts (Figure 9.3). Days fished in the CSLP fishery has oscillated around 300 days per year since 2002, with increases in 2005 and 2006, and 2013 and 2014 (Figure 9.2). The allocation of a major increase in effort quota's in 2010 led to an escalation in fishing effort in the OIMF, with the number of days fished increasing from 217 in 2009, to 506 days in 2010. Effort in the OIMF was 1052 days in 2017. This was accompanied by the number of vessels in the fishery increasing from six to 17 and effort expanding into previously unfished waters (Figure 9.4; see Section 9.3.3 below). The total number of cradles (each with three trigger traps) set annually in the OIMF has shown a steady increase from less than 100,000 in 2011 to a record-high of 250,000 in 2017 (Figure 9.3).

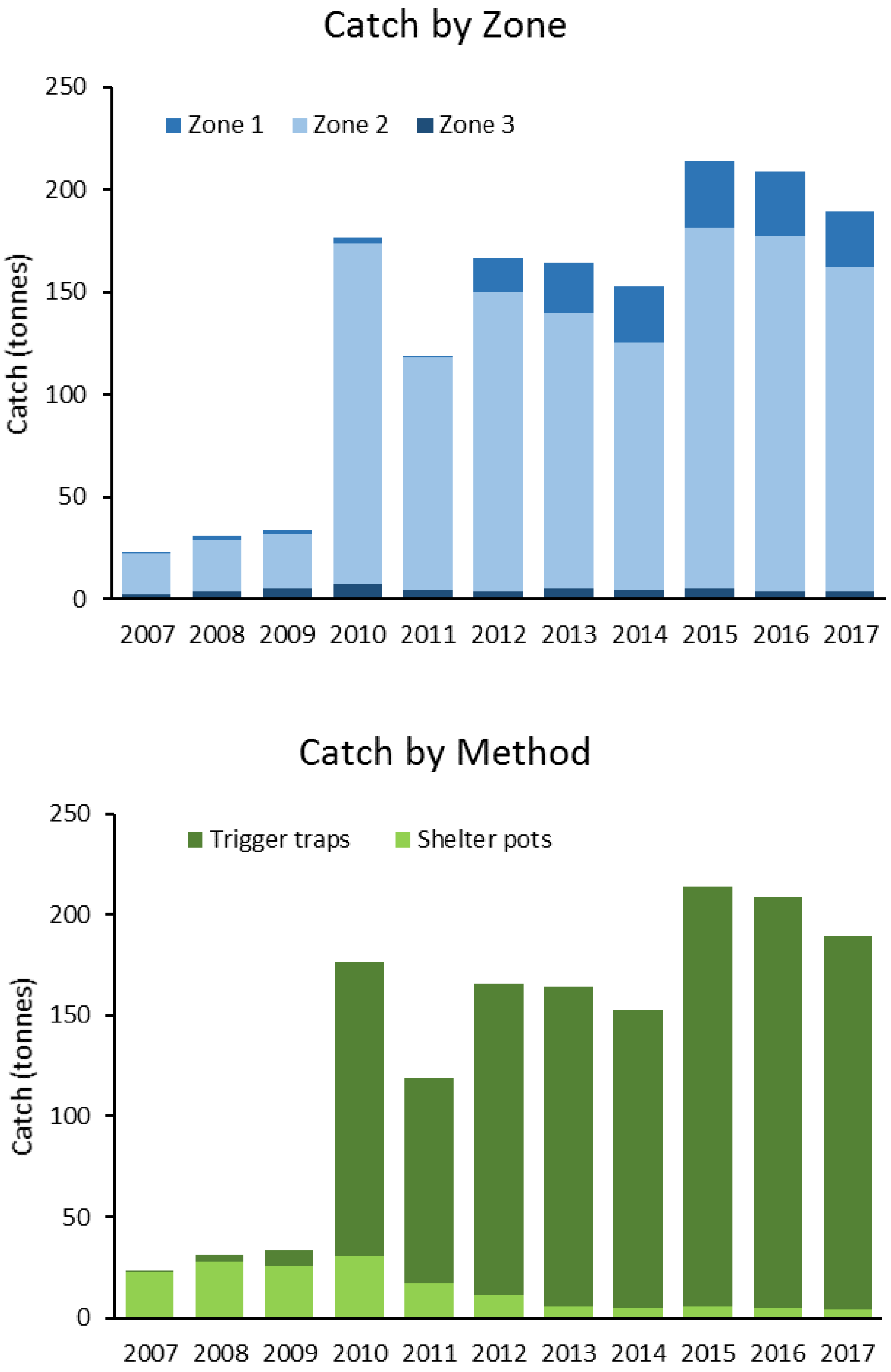

**Figure 9.1 Total octopus catch (t) by the OIMF between 2007 and 2017 separated by zone (top plot) and fishing method (bottom plot)**

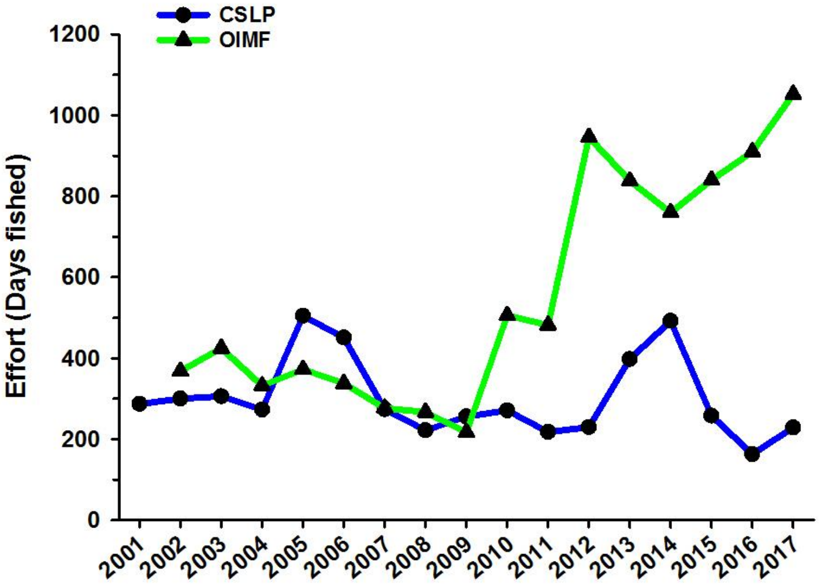

**Figure 9.2. Annual fishing effort (days fished) in CSLP and the OIMF fisheries between 2002 and 2017.**

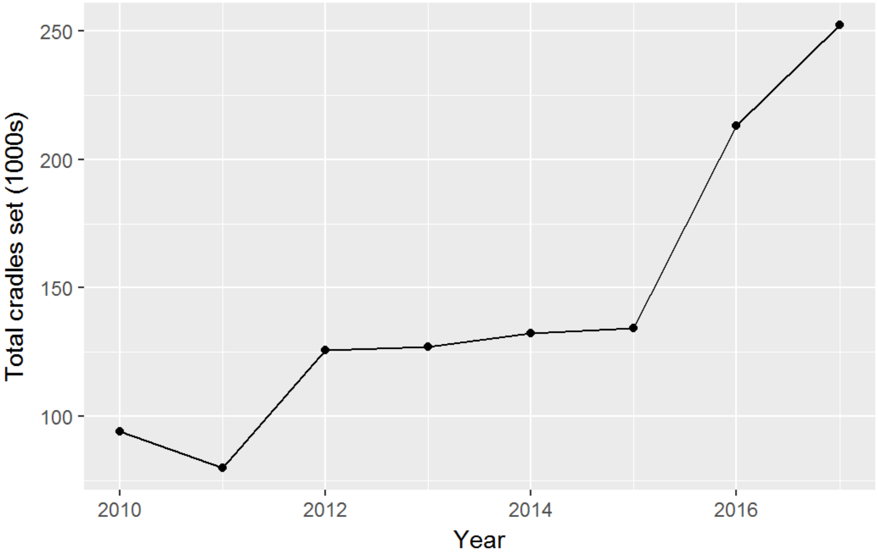

**Figure 9.3. Annual fishing effort (cradles set, in 1000s) by the OIMF between 2010 and 2017**

### 9.3.2.3 Recreational Catches

The annual recreational octopus catch by boat-based fishers in WA in 2015/16 was estimated at 1,379 individuals (95% CIs: 834-1,924; Ryan et al. 2017), which corresponds to approximately 1-2 t. Sixteen percent of this catch was reported as released. The majority (88%) of catches was taken in the West Coast Bioregion (Ryan et al. 2017).

### 9.3.2.4 Recreational Effort

There is no estimate of recreational fishing effort for octopus in WA.

### 9.3.2.5 Conclusion

| | |
|---|---|
| *Octopus* aff. *tetricus* | Octopus have been retained as byproduct in the commercial rock lobster fishery since the 1990s, with annual catch peaking at 139 t in 2002 before declining to < 20 t as a result of reduced effort. Targeted fishing for octopus was first established in 2001 but was initially constrained to a small number of operators using shelter pots in relatively shallow inshore waters. It was not until the introduction of trigger traps that target catches of octopus increased substantially, from 33 t in 2009 to 213 t in 2015. For the past five years, total commercial octopus catches have typically ranged between 200 and 250 t annually as the developing fishery undergoes a planned increase in catch and effort. Approximately 70-80% of the catch is taken by the OIMF, 15% by the CSLPF and the remainder is byproduct in the WCRLF and a small number of other fisheries.<br>Surveys of boat-based recreational fishers indicate that around 1-2 t of octopus is caught annually, of which 84% is retained.<br>**The relatively stable annual catches of octopus landed in the past five years, following an initial phase of a planned increasing catch and effort as the fishery developed, provides no evidence of unacceptable stock depletion.** |

### 9.3.3 Spatial Effort Distribution

Despite this substantial increase in effort, the spatial extent of fishing by the OIMF in Zones 1 and 2 has remained relatively stable since 2012 (Figure 9.4). Based on the assumption that each cradle of trigger traps has an approximate ‘catching radius’ of 50 m, the total area fished annually (i.e. cradle area multiplied with the total number of traplifts) and the areal footprint (accounts for fishers returning cradles back in the same locations after lifts) has only increased slightly during the past three to four years (Figure 9.5a, b). This is primarily as a result of a reduction in the amount of line used between cradles, with the trigger traps now being set closer together (Figure 9.5c).

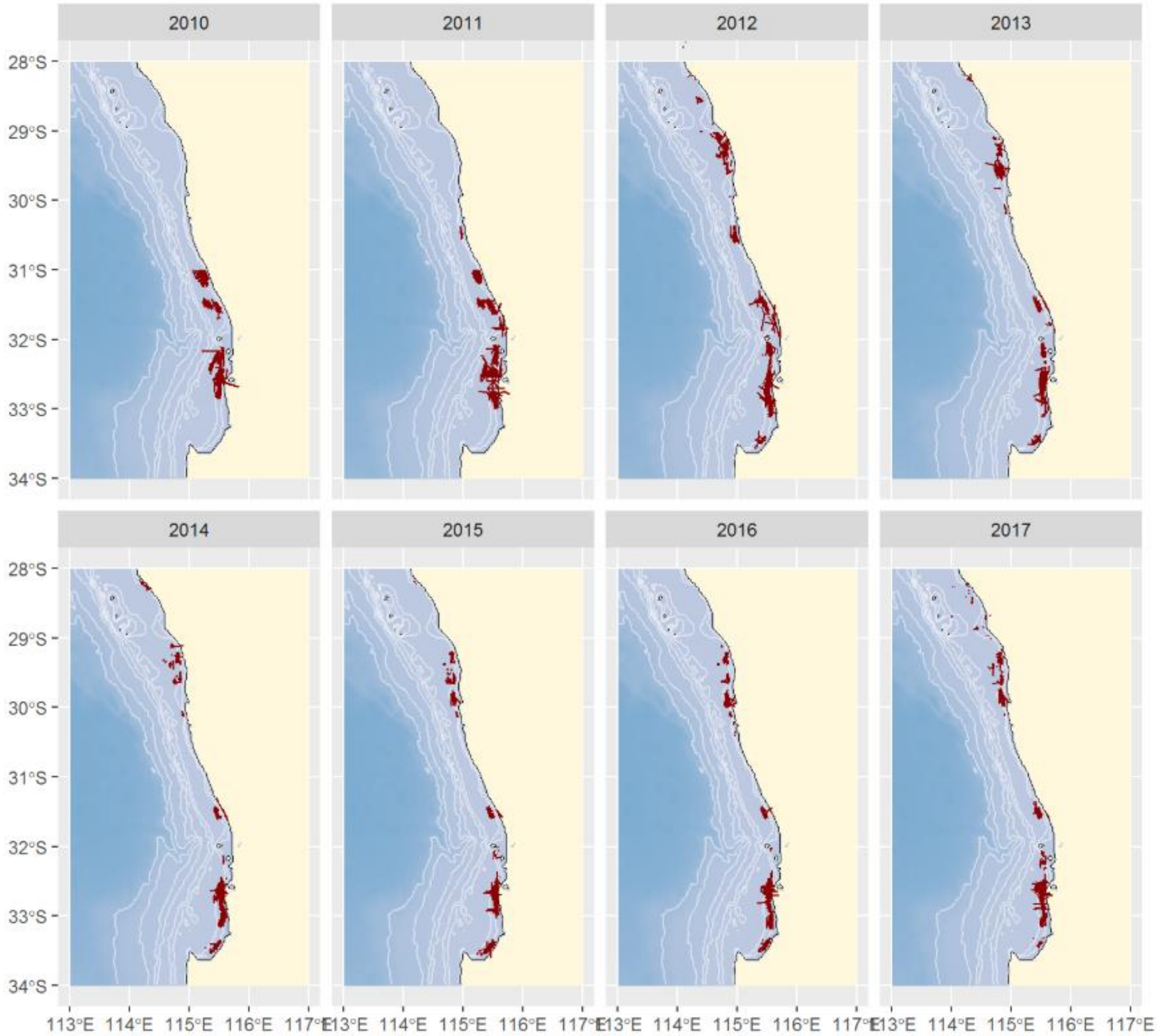

**Figure 9.4 Maps showing the spatial changes in fishing effort in the DOF/OIMF between 2010 and 2017. Red lines indicate areas fished.**

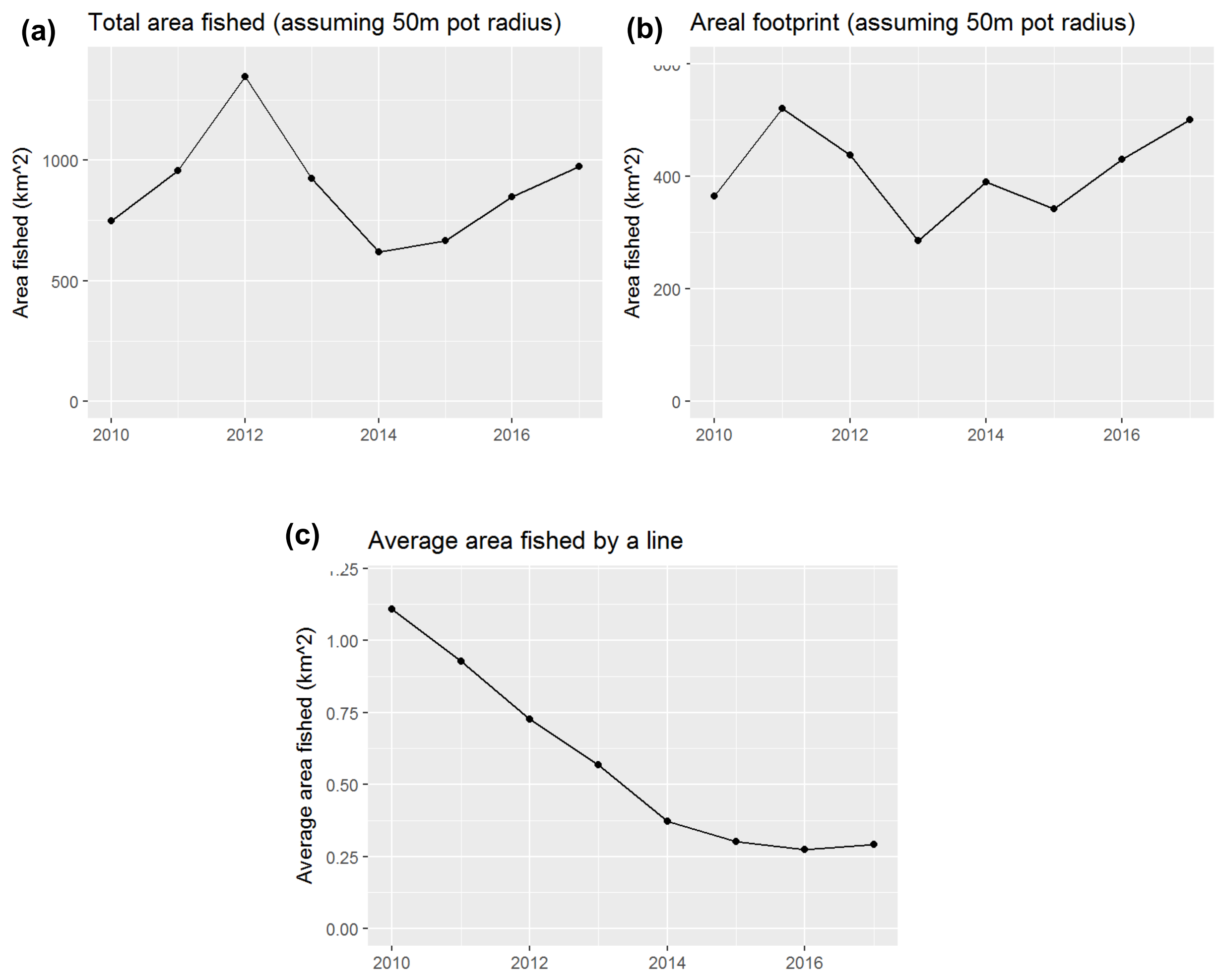

**Figure 9.5. (a) Area fished, (b) areal footprint and (c) average area fished by a line (all in km$^2$) by the OIMF between 2010 and 2017**

### 9.3.3.1 Conclusion

| | |
|---|---|
| *Octopus* aff. *tetricus* | The GPS locations of trap lifts recorded in daily logbooks by fishers in the OIMF shows an expansion of the area fished between 2010 and 2012 as the introduction of trigger traps led to a substantial increase in effort and allowed fishing in deeper waters than previously possible, out to around the 50 m depth contour. Despite an increase in the number of traps hauled since 2010, the areal footprint of the fishery remained relatively constant at around 300-500 km$^2$ as a consequence of a reduction in the distance between traps. It is estimated that only 2% of the estimated total harvestable habitat in the West Coast Bioregion is harvested annually by the OIMF.<br>The four active operators in the CSLPF are restricted to fishing the shallow and protected waters of Cockburn Sound, an area of approximately 100 km$^2$.<br>Historical catches of octopus as byproduct of the rock lobster fishery covered a wider distribution than the 10-50 m depth contour, particularly north of Perth.<br>**The logbook data do not indicate that fishers are moving into new unfished areas to maintain catch rates, as would be expected if localised stock depletion was occurring.** |

### 9.3.4 Fishery-Dependent Catch Rate Analyses

Due to the greater number of active vessels and spatial extent of fishing effort in the OIMF compared to the CSLPF, analyses of fishery-dependent catch rates focus on catch and effort data from the OIMF since the introduction of trigger traps as the main gear type. The catch rate standardisation uses data from Zones 1 and 2 of the fishery, as Zone 3 only provides 6% of the total catch, and no trigger traps have as yet been introduced in this fishery. This is expected to change in 2019 as a large trap allocation has been leased and fishing of trigger traps commences.

The standardised catch per unit effort (SCPUE) is assumed to represent an index of abundance for *O.* aff. *tetricus* and is used as a proxy for spawning biomass. This performance indicator is compared annually against reference levels that have nominally been set at 40, 30, and 20% of the initial (2010) catch rate, as outlined in the harvest strategy for the resource (DPIRD 2018).

The SCPUE index has declined from 2010 to 2013, the initial 3 years of the trigger trap fishery, increased between 2013 and 2015, and decline between 2015 and 2017. Currently it is at its lowest level, however remains above the target reference level (Figure 9.6).

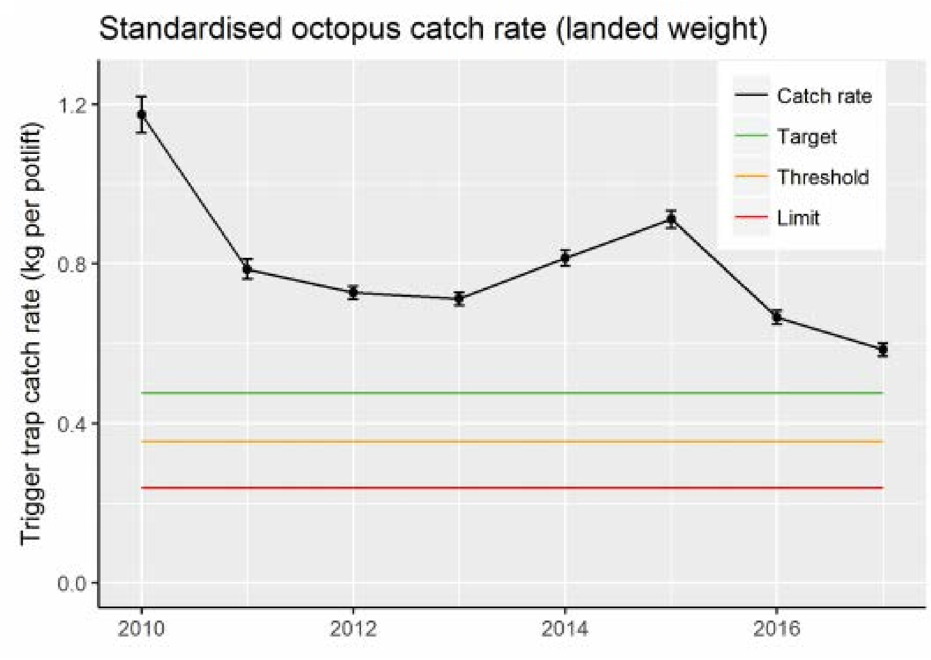

**Figure 9.6 Standardised catch rate performance measure and associated target, threshold and limit levels of *Octopus* aff. *tetricus* caught in the OIMF (Zone 1 and 2).**

#### 9.3.4.1 Catch Rate Standardisation

The *Octopus* aff. *tetricus* logbook data from Zone 1 and 2 of the OIMF are standardised using a GLM to account for the effects on catch rates of year, month, vessel, soak time, distance between traps, and depth. Spatial area is not examined in this analysis because it is confounded with vessel.

$$log_e(U_{i,j,k,l,m,n} + 0.1) = \alpha_i + \beta_j + \gamma_k + \delta_l + \tau_m + \varphi_n + \varepsilon$$

where

$U_{i,j,k,l,m,n,p}$ is the CPUE (kg octopus / trap) for year *i*, month *j*, vessel *k*, soak time *l*, distance *m*, and depth *n*.

$\alpha_i$ is is fishing year; *i* (2010-2017)

$\beta_j$ is month; *j* (1 – 12)

$\gamma_k$ is vessel; *k* (18 vessels)

$\delta_l$ is soak time in days between setting and hauling traps; *l* (6 categories; <7, 7, 8-9, 10-12, 13-15, >15)

$\tau_m$ is distance in metres between pots; *m* (5 categories; <20, 20-29, 30-49, 50-99, 100-150, >150; distance = line length / number of pots (line length calculated using start and end GPS points)

$\varphi_n$ is depth category in metres; *n* (6 categories; <20, 20-24, 25-29, 30-34, 35-39, 40+).

The resultant model is applied to the catch and effort data of each individual line of octopus traps. Average number of octopus trigger traps per line is 198.

There was a significant effect of depth on fishery catch rates (Table 9.2; Figure 9.7d). However, the effect was relatively minor (<1% of variation explained) compared to temporal changes in catch rate (Table 9.2; Figure 9.7a). Both the annual (Figure 9.7a) and monthly (Figure 9.7b) catch rates from the fishery fleet show a greater contribution to variability in catch rates than the effect of depth. Differences between vessels, although significant, were relatively small, and most of the 18 vessels in the fishery achieved an average catch rate in the order of 1 kg per pot lift (Figure 9.7c). Number of days the trigger traps were soaked for significantly increased catch rates up until 9-10 days (Figure 9.7e). Beyond a 10-day soak, there was no increase in catch rates (Figure 9.7e). Catch rates increased with an increasing distance between pots, up to about 50-100 m, when it appeared to reach an asymptote (Figure 9.7f).

**Table 9.2 ANOVA results for the effect of Year, Month, Vessel, Soak days, Distance, and Depth on catch rates (kg potlift$^{-1}$) of *Octopus* aff. *tetricus*. Data has been log (x+0.1) transformed. (Source: Hart et al. in press). Type III SS.**

| Source of variability | d.f. | SS | MS | F | *P* |
|---|---|---|---|---|---|
| Year | 7 | 79.1 | 11.3 | 78.4 | <0.001 |
| Month | 11 | 49.4 | 4.53 | 31.5 | <0.001 |
| Vessel | 17 | 47.3 | 2.78 | 19.3 | <0.001 |
| Soak Days | 5 | 5.13 | 1.03 | 7.12 | <0.001 |
| Distance | 5 | 26.3 | 5.25 | 36.2 | <0.001 |
| Depth | 5 | 5.35 | 1.07 | 7.43 | <0.001 |
| Residual | 4577 | 659.8 | 0.14 | | |

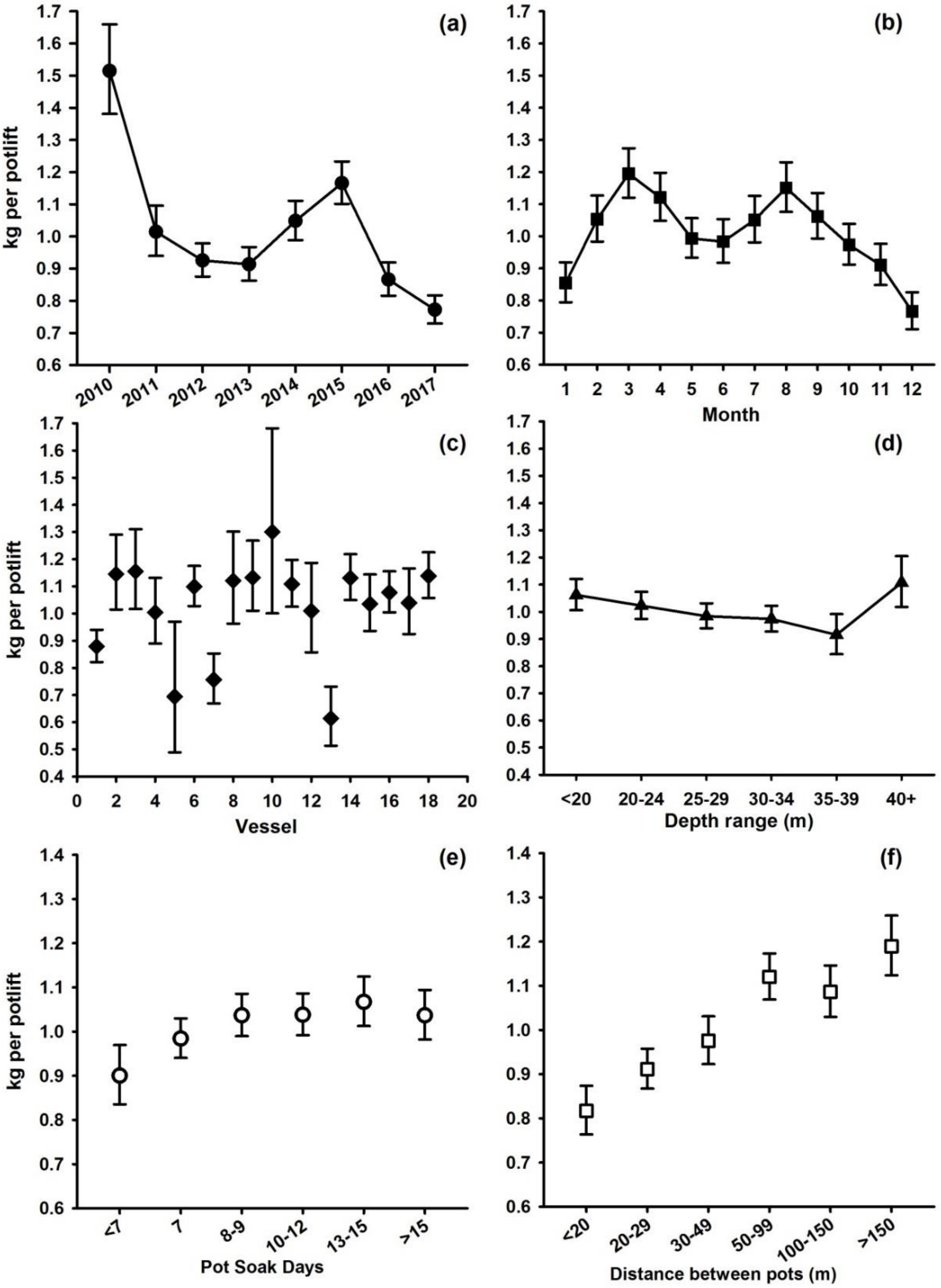

**Figure 9.7 Effect of (a) year, (b) month, (c) vessel, (d) depth, (e) soak time, and (f) distance between traps on catch rates (kg trap$^{-1}$) in the *Octopus* aff. *tetricus* fishery in Western Australia. Error bars are 95% CL. (Source: Hart et al. in press)**

### 9.3.4.2 Conclusion

| | |
|---|---|
| *Octopus* aff. *tetricus* | The annual standardised catch rates in Zones 1 and 2 of the OIMF, based on daily logbook data from 2010 when the trigger trap fishery started, is consider to represent a robust index of abundance for the stock. After accounting for the effects of month, vessel, soak time, distance between traps and depth, the standardised index indicates a gradual decline in the stock after trigger traps were introduced, as would be expected in a developing fishery. The performance indicator is still above the target reference level that has been specified as 40% of the catch rate in the first year of the trigger trap fishery.<br>**There is no evidence from catch rate data to suggest unacceptable stock depletion to date.** |

## 9.3.5 Trends in Age and Size Structures

Monthly biological samples of octopus were collected using both shelter pots and trigger traps between February 2008 and June 2012, from waters between 31°S and 33°S on the WA coast at depths of 5–40 m. A total of 7,344 octopuses were dissected during the sampling period, with shelter pots and trigger traps constituting 40% and 60% of the sampling effort, respectively. The methods used for aging the sampled octopus have been described by Leporati and Hart (2015).

The two gear types were found to select for different parts of the population (Leporati et al. 2015). Shelter pots catch a mixture of immature females and immature/mature males, mostly <1 kg total weight (Figure 9.8; Figure 9.9). In contrast, trigger traps caught octopus >1 kg total weight, of which 75% of the total catch were mature males (Figure 9.8; Figure 9.9). Male domination of trigger trap catches was across all years and months (Leporati et al. 2015). However, a distinct monthly pattern was evident, with an increase in the proportion of females during March/April (autumn) and the highest proportion of males during October/November (spring) (Figure 9.10), which suggests this is the major brooding and hatching season for females and they are not available to the fishery. For shelter pots, biological sample data was not complete for all seasons across all years (Leporati et al. 2015).

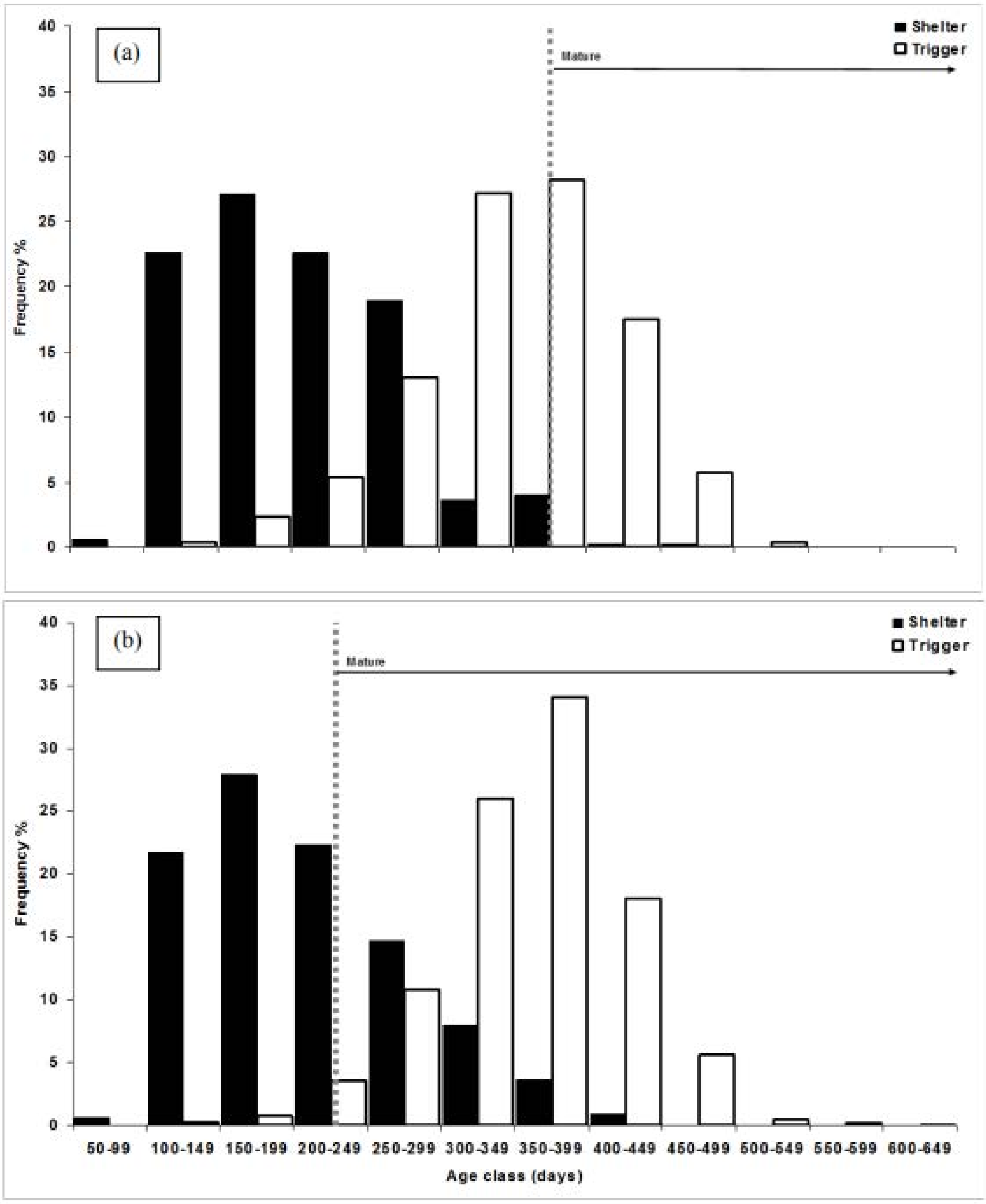

**Figure 9.8 Percentage frequency for 50 day age classes of (a) female and (b) male *Octopus* aff. *tetricus* caught in shelter pots (back bars) and trigger traps (white bars). Dashed lines represent age at 50% maturity at 379 days for females and 243 days for males (Source: Leporati et al. 2015)**

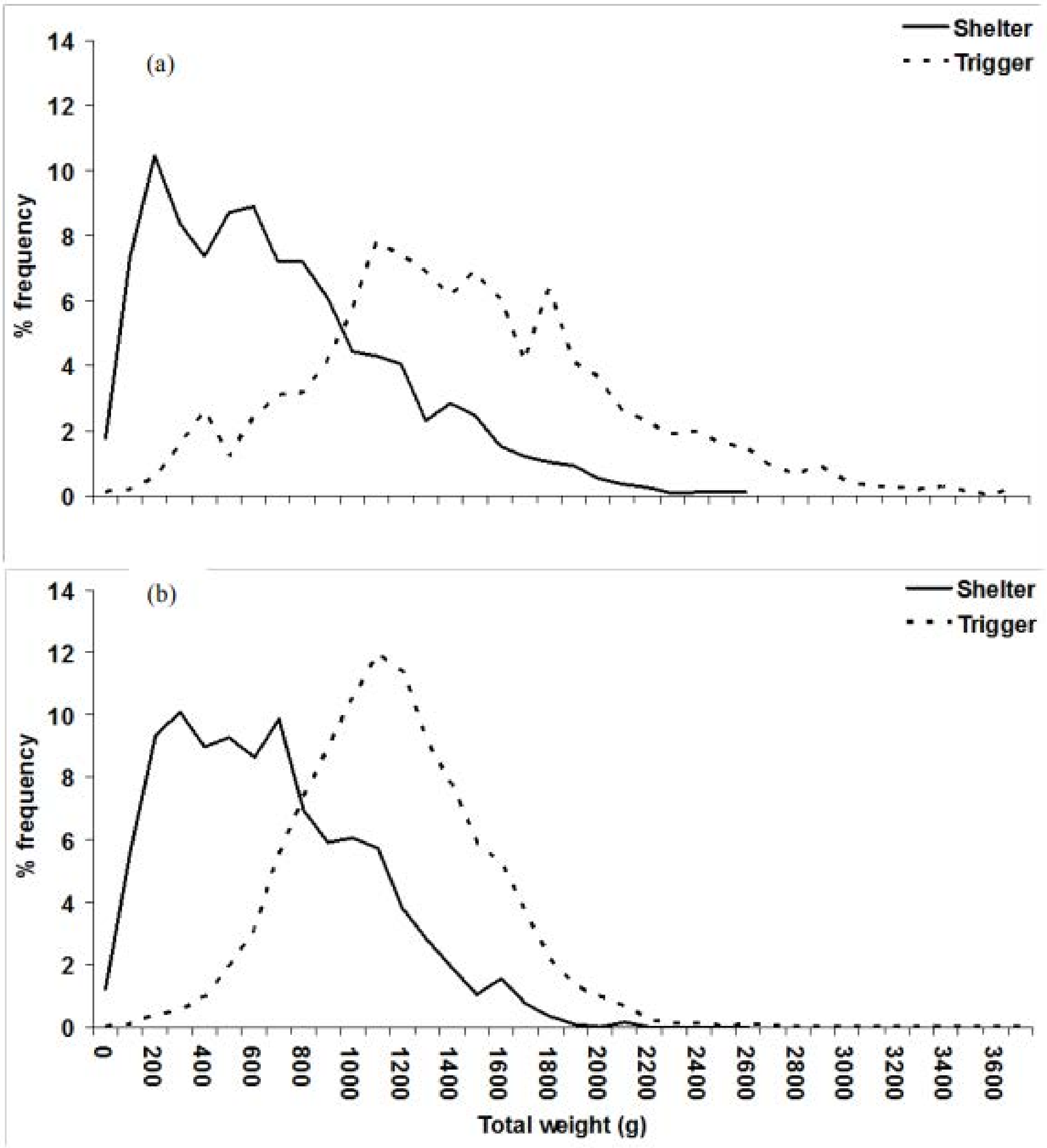

**Figure 9.9 Percentage frequency for total weight of (a) female and (b) male *Octopus* aff. *tetricus*, in 200 g size classes, for shelter pots (black line) and trigger traps (broken line). (Source: Leporati et al. 2015)**

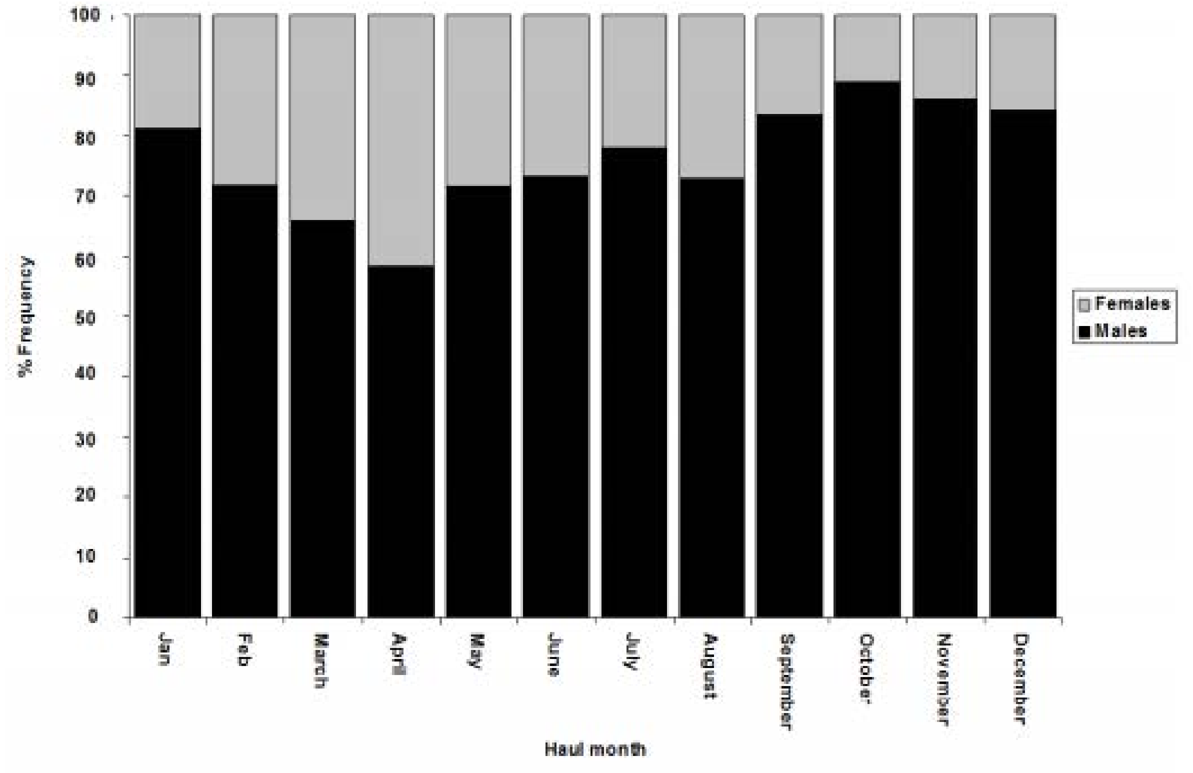

**Figure 9.10 Percent frequency of male and female *Octopus* aff. *tetricus* caught each month with trigger traps, during 2008 to 2012 (n = 4544). (Source: Leporati et al. 2015)**

#### 9.3.5.1 Conclusion

| | |
|---|---|
| *Octopus* aff. *tetricus* | Available age and size composition data of octopus catches demonstrate that shelter pots and trigger traps select for very different parts of the stock. Shelter pots set primarily in shallow and protected waters caught mainly octopus <1 kg, including a mix of immature females and immature and mature males. Trigger traps caught octopus >1 kg total weight, of which 75% of the total catch were mature males. The male domination of trigger trap catches was evident across all sampling years (2012-2014) and months, however, an increase in the proportion of females occurred in autumn during March and April.<br>**The age and size composition data provide no evidence of unacceptable stock depletion.** |

### 9.3.6 Productivity Susceptibility Analysis

Productivity Susceptibility Analysis (PSA) is a semi-quantitative risk analysis originally developed for use in Marine Stewardship Council (MSC) assessments to score data-deficient stocks, i.e. where it is not possible to determine status relative to reference points from available information (Hobday et al. 2011; MSC 2014). The PSA approach is based on the assumption that the risk to a stock depends on two characteristics: (1) the productivity of the species, which will determine the capacity of the stock to recover if the population is depleted, and (2) the extent of the impact on the stock due to fishing, which will be determined by the susceptibility of the species to fishing activities (see Appendix 3).

Although a valuable tool for determining the overall inherent vulnerability of a stock to fishing, the PSA is limited in its usefulness for providing stock status advice. This is because of the simplicity and prescriptiveness of the approach, which means that risk scores are very sensitive to input data and there is no ability to consider management measures implemented in fisheries to reduce the risk to a stock. Consequently, the PSA is used by the Department to produce a measure of the vulnerability of a stock to fishing, which is then considered within the overall weight of evidence assessment of stock status.

The sections below outline the PSA scores for the WA octopus resource.

### 9.3.6.1 Productivity

As described in more detail in Section 5, *O.* aff. *tetricus* is a short-lived, rapidly maturing, demersal egg layer with a high fecundity, and likely to occupy a relatively high trophic position (Table 9.3). They would likely have compensatory density dependence at low population sizes. Please refer to Appendix 3 for tables describing how the scores for the individual Productivity attributes were derived from available biological information on this species.

**Table 9.3. PSA productivity scores for *O.* aff. *tetricus***

| Productivity attribute | *Octopus* aff. *tetricus* |
|---|---|
| Average maximum age | 1 |
| Average age at maturity | 1 |
| Reproductive strategy | 2 |
| Fecundity | 1 |
| Trophic level | 3 |
| Density dependence | 1 |
| Total productivity (average) | 1.50 |

### 9.3.6.2 Susceptibility

The susceptibility of the octopus resource to commercial fishing by the OIMF, CSLPF and WCRLF, and to fishing by the recreational sector is outlined in Table 9.4.

Relative to the very large distribution of the *O.* aff. *tetricus* stock inhabiting waters off the western and southern WA coasts (Figure 5.2), each commercial fishery that targets this species only fish across a small spatial area. The extent of harvestable area within the OIMF has been estimated to be around 34,000 km$^2$, of which only <5% is currently fished (Hart et al. 2016; Hart et al. in press). The CSLPF is limited to fishing the inshore waters of Cockburn Sound. As the commercial WCRLF and the recreational sector has the potential to retain octopus from a larger area of the stock, the areal overlap for these two fisheries have been given a precautionary score of 3 (i.e. the overlap of effort may exceed 30% of the stock distribution).

With all four fisheries/sectors catching octopus in demersal pots and retain the majority of catches, both the vertical overlap and the post-release mortality have been scored as high (Table 9.4). The catch composition of the two target fisheries (OIMF and CSLPF) has been found to differ, with shelter traps used primarily by the CSLPF found to more commonly retain smaller, immature octopus (Leporati et al. 2015). In contrast, the trigger traps employed by the majority of fishers in the OIMF are biased towards catching larger male octopus. The baited pots used by the WCRLF to catch rock lobster are not particularly efficient at capturing octopus due to their large escape gaps. Selectivity in the CSLPF has consequently been assigned a higher score compared to the other three fisheries (Table 9.4).

**Table 9.4. PSA susceptibility scores for each fishery/sector that impact on *O.* aff. *tetricus* in WA**

| **Susceptibility attribute** | **OIMF** | **CSLPF** | **WCRLF** | **Recreational Fishery** |
|---|---|---|---|---|
| Areal overlap | 1 | 1 | 3 | 3 |
| Vertical overlap | 3 | 3 | 3 | 3 |
| Selectivity | 2 | 3 | 2 | 2 |
| Post-capture mortality | 3 | 3 | 3 | 3 |
| Total susceptibility (multiplicative) | 1.43 | 1.65 | 2.33 | 2.33 |

### 9.3.6.3 Conclusion

Based on the productivity and susceptibility scores, the overall weighted (by fishery / sector catches) PSA score for the WA octopus resource was 2.13, which represents a low risk.

| | |
|---|---|
| *Octopus* aff. *tetricus* | The biological characteristics of *O.* aff. *tetricus*, including rapid growth, short lifespan and early maturity, suggest that this highly productive species has a relatively low vulnerability to fishing. Year-round spawning, sperm storage and a strong bias of the trigger traps to catching males is likely to add further protection to the stock and may reduce environmental-driven fluctuations in population size that are common with other invertebrates.<br>As less than 5% of the estimated total harvestable area within the West Coast Bioregion currently fished by the OIMF, which retains more than 80% of catches, the overall susceptibility of the species to fishing is also considered low.<br>With a productivity score of 1.50 and susceptibility scores ranging between 1.43 and 2.33 for the different fisheries/sectors that exploit the stock, the derived Productivity Susceptibility Analysis (PSA) score is 2.13.<br>**The low vulnerability indicates that the risk of unacceptable stock depletion is low under current management arrangements and fishing effort**. |

## 9.3.7 Estimation of Population Size

### 9.3.7.1 Depletion Experiment

A total of 733 individuals of *Octopus* aff. *tetricus* weighting 1,117 kg total weight were harvested during this experiment (Hart et al. in press). Of these, 400 came from Site A and 333 from Site B. In both areas a significant depletion occurred; increasing catch and increasing effort had a significant negative effect on density as measured by catch rates (Figure 9.11).

Fishing efficiency (proportion harvested / trap / day) of the trigger traps was estimated around 0.010 - 0.012 (1 – 1.2%) of the exploitable population of *Octopus* aff. *tetricus* (Figure 9.12a; Hart et al. in press). On average, the traps are set for 10 days within the fishery resulting in a mean *q* of 10-12% per trap lift. Population size was similar between the two sites, around 600 individuals (Figure 9.12b). However, population density varied between sites. Site A carried a lower density than Site B, around 500 *O.* aff. *tetricus* per km$^2$, compared to 800 *O.* aff. *tetricus* per km$^2$ in Site B (Figure 9.12c). Overall a greater depletion was achieved in Site A compared to Site B (Figure 9.12d), although the mean estimates were within 95% confidence limits of each other.

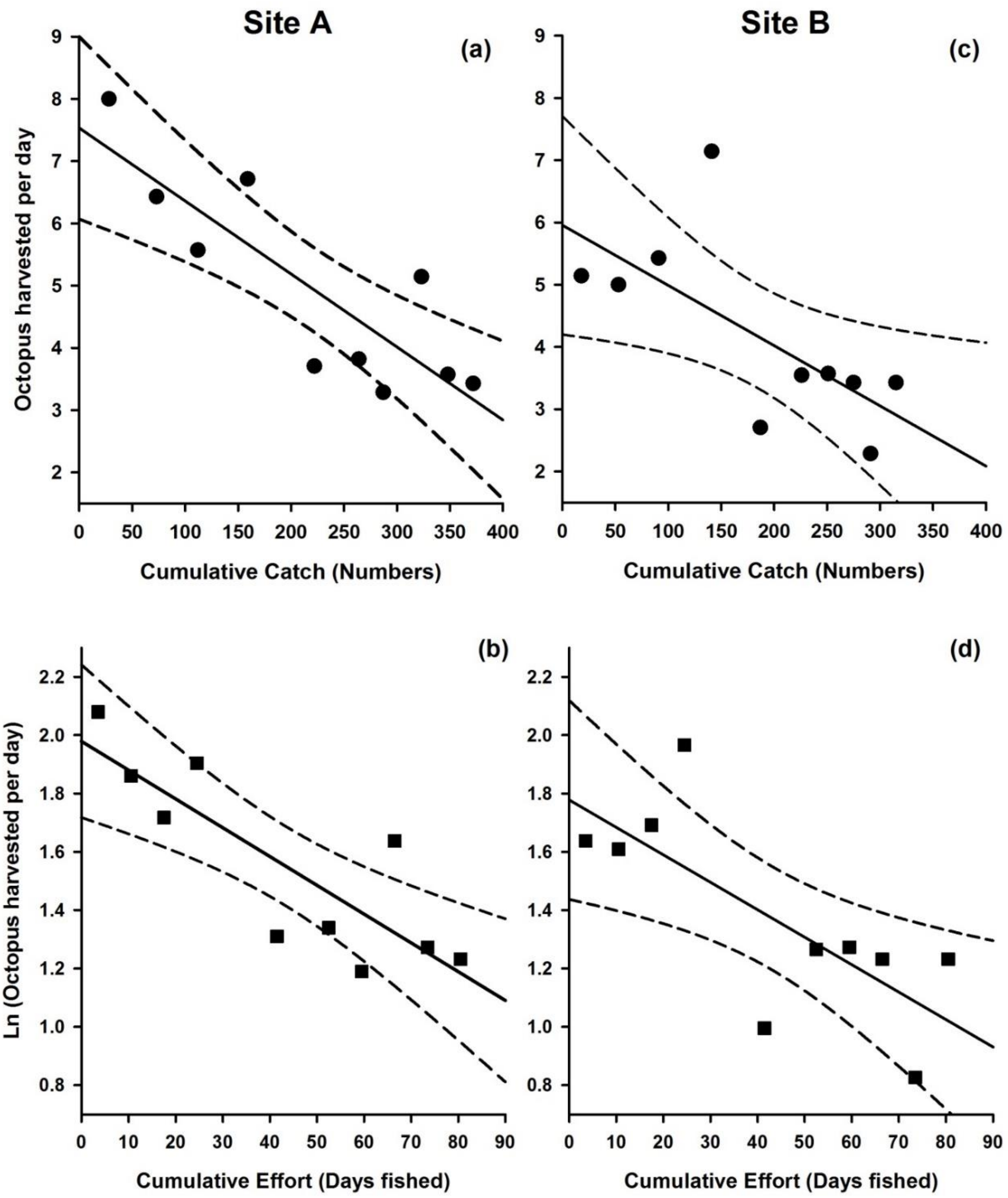

Figure 9.11 Leslie (circles; a and c) and DeLury (squares; b and d) depletion estimators for population size of *Octopus* aff. *tetricus* at two sites off Mandurah in WA. (Source: Hart et al. in press)

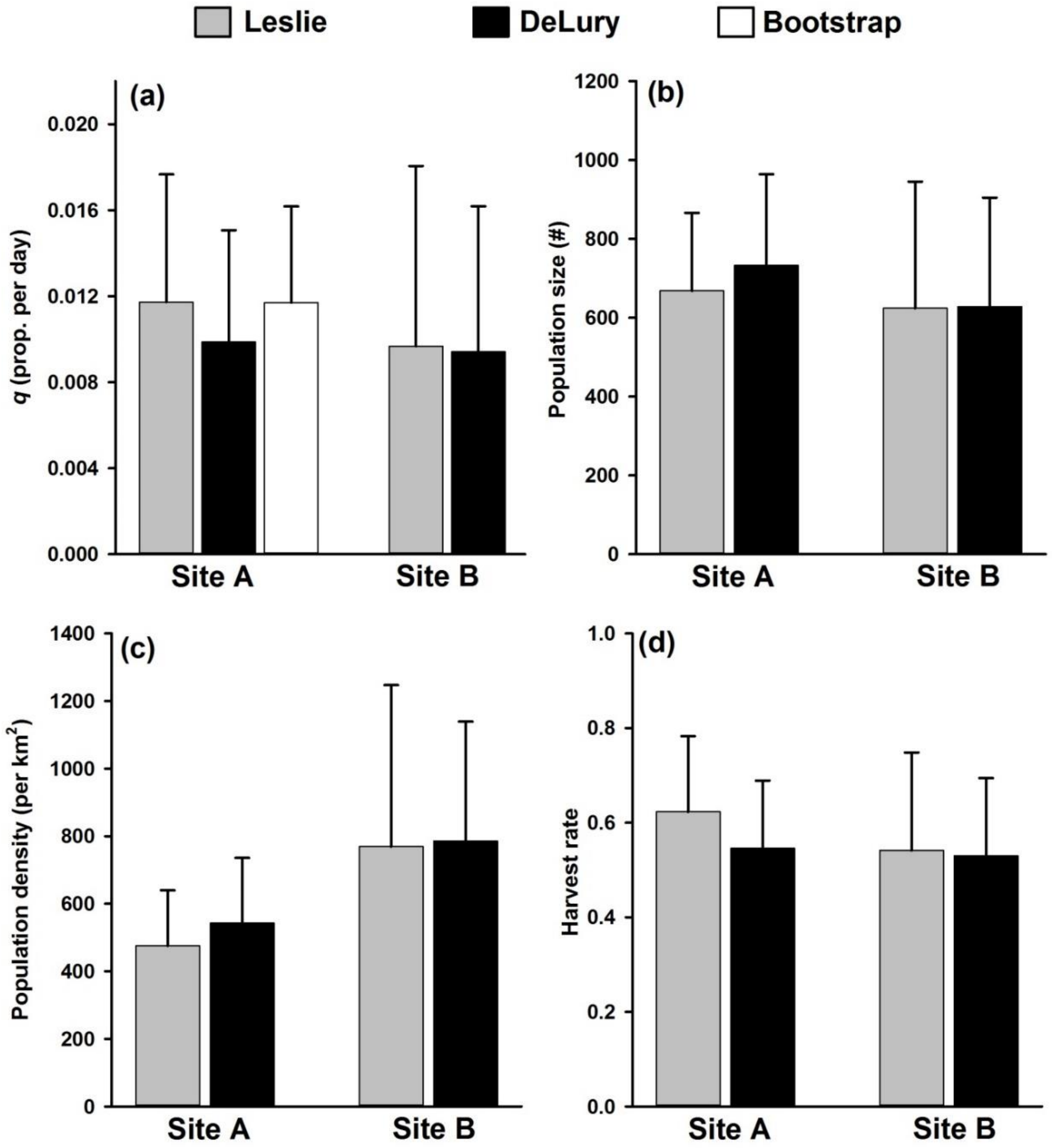

**Figure 9.12 Estimates of (a) *q* (proportion harvested / trap / day) of *Octopus* aff. *tetricus* populations targeted by the "trigger trap" fishing gear; (b) Population size (numbers) by experimental site (c) Population density (# per km$^2$), and (d) Harvest rate (proportion taken over entire experiment). Legend defines estimation method (details in methods). Error bars are 95% CL. (Source: Hart et al. in press)**

### 9.3.7.2 Population Surveys

Total quantity of *O.* aff. *tetricus* counted in the 34 km$^2$ of habitat surveyed across the 10-50 m depth profile at Busselton and Dongara was 1,293 octopus (Hart et al. in press). Assuming these populations to be representative, and the number counted was 8.9% of the population (based on the average trap soak time of 8.9 days and *q* of 0.01 per day), would result in a broad population estimate of 10.7 million octopus across the entire 25,000 km$^2$ of estimated harvestable habitat (see below).

Catch rates in numbers per site were significantly higher at Dongara, compared to Busselton (Figure 9.13a). Catch rates in kg per hour were similar (Figure 9.13b). When converted to density and biomass density using *q* and area surveyed per site, there was a large difference between sites, due to the smaller areas ($A_i$) surveyed in the Dongara (mean $A_i = 0.4$ km$^2$; $n = 33$), compared to the Busselton (mean $A_i = 0.62$ km$^2$) population. Density (Figure 9.13c) and biomass density (Figure 9.13d) were significantly higher at Dongara compared to Busselton.

There was no effect of depth on number of octopus caught at each site (Figure 9.14). The median estimates for the Dongara population was 265,000 octopus (Figure 9.15a), and 330 t biomass (Figure 9.15b) with a mean weight of 1.24 kg. In comparison, the median estimates for the Busselton population were 97,000 octopus (Figure 9.15c) and 142 t (Figure 9.15d) biomass with a mean weight of 1.46 kg.

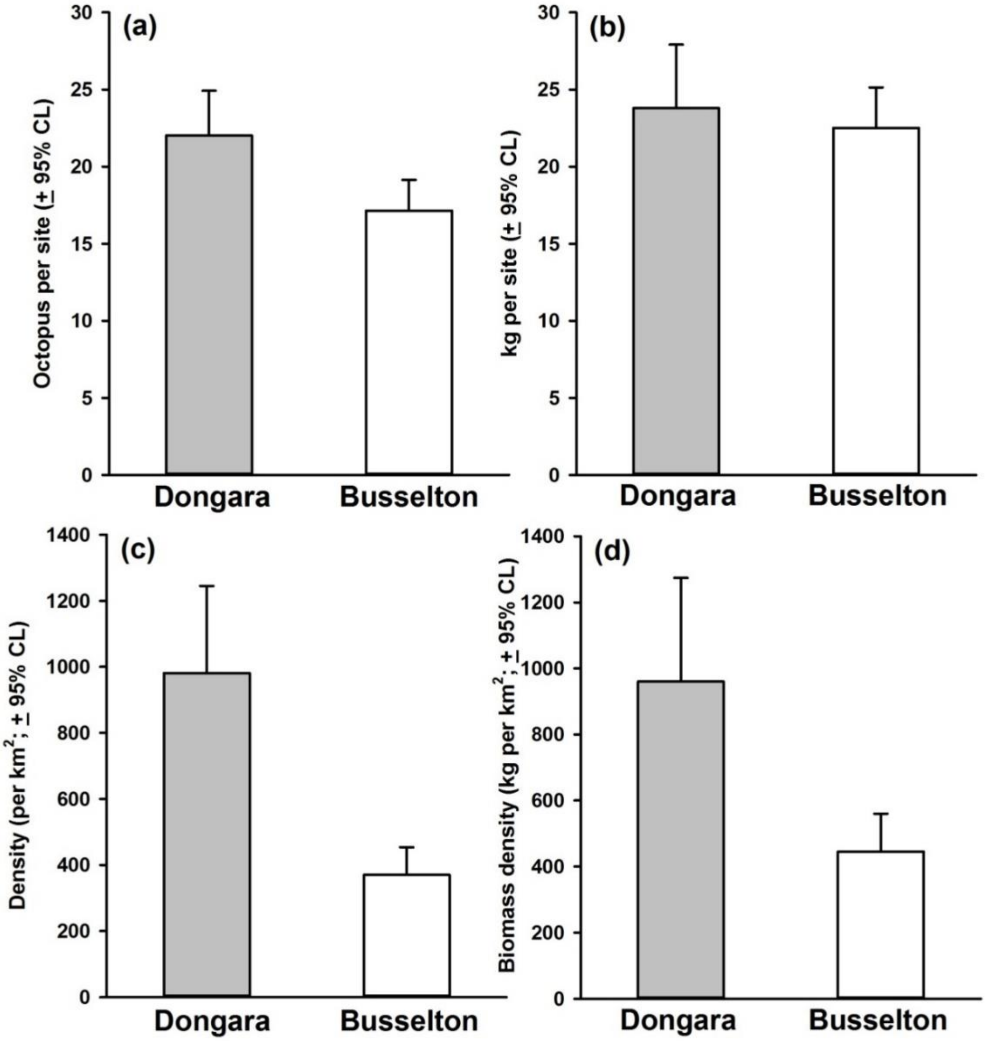

**Figure 9.13 A comparison of catch rates, density and biomass metrics for *Octopus* aff. *tetricus* from the Dongara and Busselton survey areas (see Figure 3 for maps). Catch rate in numbers (a) and kg (b), and density in numbers per km$^2$ (c), and kg per km$^2$ (d). Error bars are 95% CL. (Source: Hart et al. in press)**

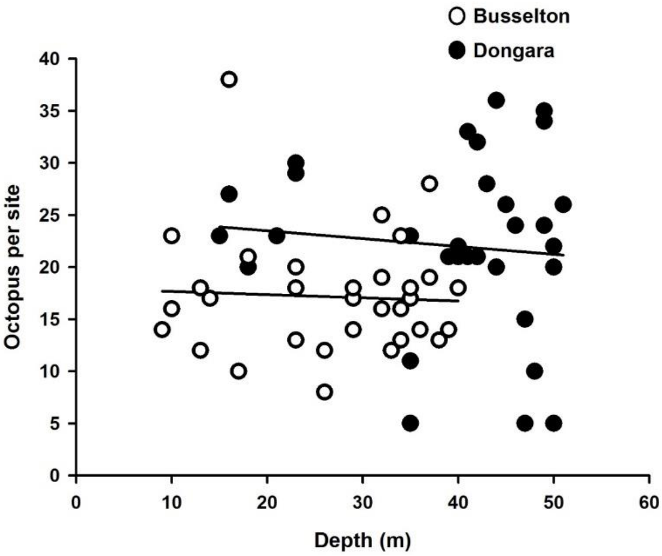

Figure 9.14 Relationship between catch rate of *Octopus* aff. *tetricus* (numbers per site) and depth (m) for the Dongara and Busselton survey areas. (Source: Hart et al. in press)

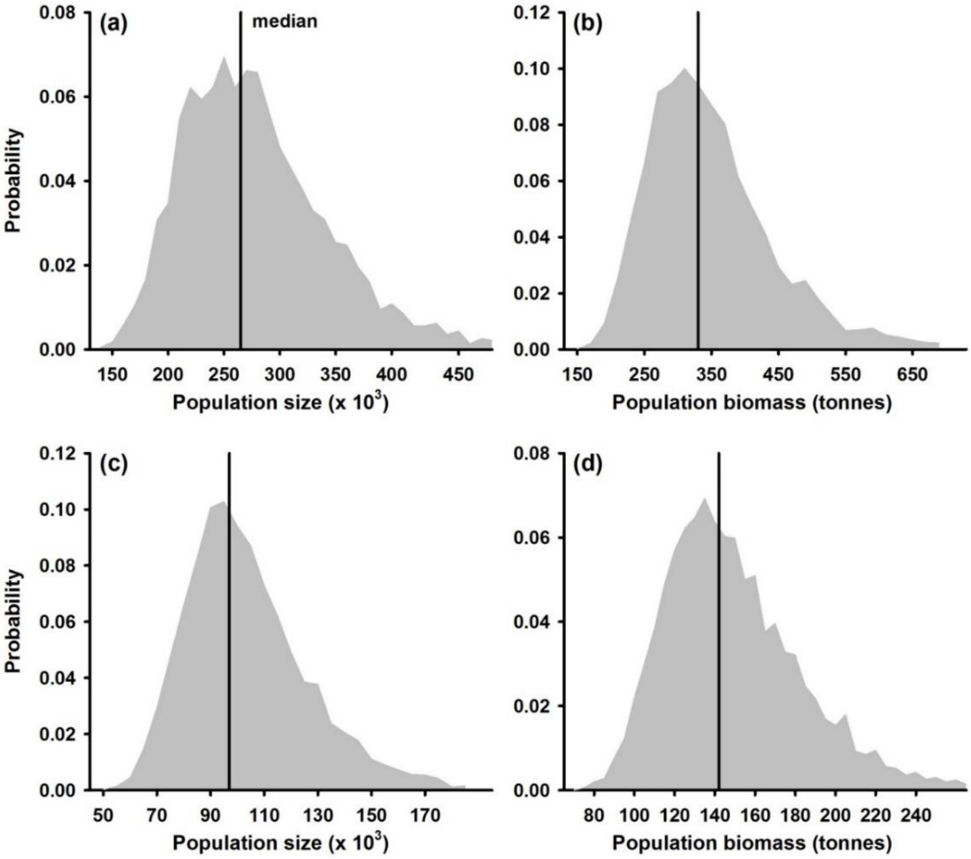

Figure 9.15 Probability estimates of density and biomass of *Octopus* aff. *tetricus* from a 300 $km^2$ area of habitat in the Dongara and Busselton regions; (a) Dongara population estimates; (b) Dongara biomass estimates; (c) Busselton population estimates; (d) Busselton biomass estimates. Median estimates provided for each population (black vertical line), and probability distributions from a bootstrap function (n = 5000). (Source: Hart et al. in press)

### 9.3.7.3 Spatial Extent of Fishery

The total harvestable habitat in Zones 1 and 2 of the OIMF was estimated at approximately 25,000 km$^2$ (Hart et al. in press). This compares to an earlier estimate for the south coast (Zone 3) of just below 10,000 km$^2$ (Hart et al. 2016).

Total area fished annually between 2010 to 2017 varied between 600 and 1400 km$^2$ (Figure 9.16a; Hart et al. in press). The areal footprint (accounting for areas fished repeatedly within the year) varied between 300 and 500 km$^2$, which did not substantially alter between 2010 and 2017 (Figure 9.16a). Although effort substantially increased from 100,000 traps hauled in 2010, to 250,000 traps hauled in 2017 (Figure 9.16b), the mean distance between traps declined substantially from 125 m in 2010 to 50 m in 2016 (Figure 9.16b). This reflects the assessment of CPUE which shows highest catch rates are achieved when the distance between traps is >50 m (Figure 9.7f). The area fished varied between 2.5 and 5.5% of total habitat area on the west coast, while the areal footprint varied between 1.5 and 2% of total habitat area (Figure 9.16d).

Density of harvest (numbers per km$^2$) varied between 100 and 300 octopus per km$^2$, and biomass density of harvest varied between 200 and 400 kg per km$^2$ (Figure 9.16c; Hart et al. in press). These estimates are less than the fishery-independent estimates of biomass from the two lightly exploited areas at the northern and southern edges (Dongara and Busselton) of the OIMF (median of 800 kg per km$^2$), yet confirm a potentially large unexploited biomass on the west coast.

### 9.3.7.4 Accounting for Uncertainty

Uncertainty in estimates of catchability ($q$) and total density and biomass density at each surveyed area was estimated using bootstrapping methods (see Hart et al. in press).

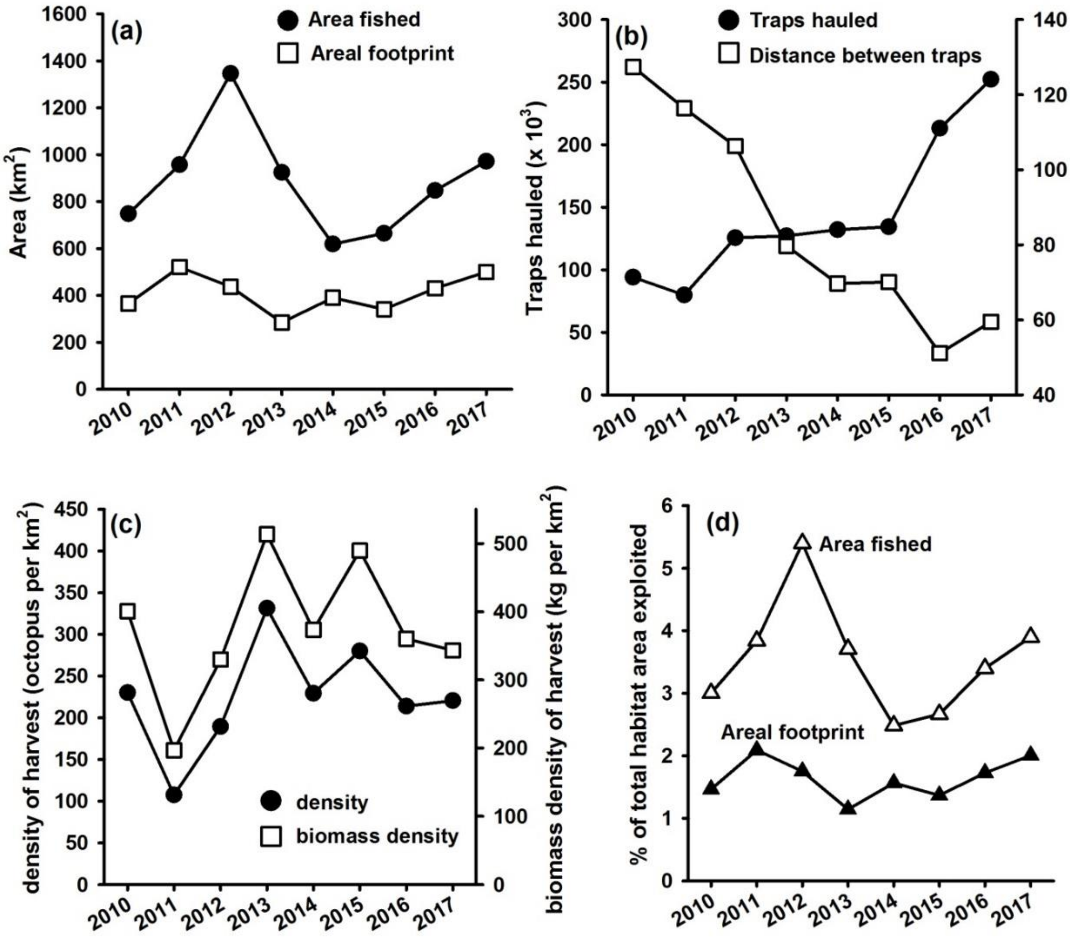

**Figure 9.16 Spatial metrics in the evolution of the *Octopus* aff. *tetricus* fishery between 2010 and 2017; including (a) total area fished and areal footprint of the fishery (km$^2$); (b) traps hauled and mean distance (metres) between traps; (c) harvest density and harvest biomass density (kg per km$^2$); (d) area fished and areal footprint as a % of the total habitat (~25,000 km$^2$ in 10 – 50 m depth range) on the west coast. (Source: Hart et al. in press)**

### 9.3.7.5 Conclusion

| | |
|---|---|
| *O.* aff. *tetricus* | A broad estimate of the octopus population inhabiting the West Coast Bioregion, where the majority of catches are taken, has been derived from fishery-independent data collected during a number of population surveys undertaken within the area. The analyses suggest that the harvestable population (i.e. the component selected by trigger traps) could comprise more than 10 million octopus across the 25,000 km$^2$ of harvestable habitat, based on observed population densities at two survey sites and an estimated daily catchability of trigger traps of 1% from a depletion experiment.<br>**Available estimates of population densities and biomass, when compared to the current level of catch, provide no evidence of unacceptable stock depletion.** |

## 9.4 Stock Status Summary

Presented below is a summary of each line of evidence considered in the overall weight of evidence assessment of the stocks that comprise the WA Octopus Resource, followed by the management advice and recommendations for future monitoring of the species.

### 9.4.1 *Octopus* aff. *tetricus*

#### 9.4.1.1 Weight of Evidence Risk Assessment

| Category | Lines of evidence (Consequence / Status) |
|---|---|
| Catch | Octopus have been retained as byproduct in the commercial rock lobster fishery since the 1990s, with annual catch peaking at 139 t in 2002 before declining to < 20 t as a result of reduced effort. Targeted fishing for octopus was first established in 2001 but was initially constrained to a small number of operators using shelter pots in relatively shallow inshore waters. It was not until the introduction of trigger traps that target catches of octopus increased substantially, from 33 t in 2009 to 213 t in 2015. For the past five years, total commercial octopus catches have typically ranged between 200 and 250 t annually. Approximately 70-80% of the catch is taken by the OIMF, 15% by the CSLPF and the remainder is byproduct in the WCRLF and a small number of other fisheries.<br>Surveys of boat-based recreational fishers indicate that around 1-2 t of octopus is caught annually, of which 84% is retained.<br>**The relatively stable annual catches of octopus landed in the past five years, following an initial phase of increasing catch as the fishery developed, provides no evidence of unacceptable stock depletion.** |
| Spatial effort distribution | The GPS locations of trap lifts recorded in daily logbooks by fishers in the OIMF shows an expansion of the area fished between 2010 and 2012 as the introduction of trigger traps led to a substantial increase in effort and allowed fishing in deeper waters than previously possible, out to around the 50 m depth contour. Despite an increase in the number of traps hauled since 2010, the areal footprint of the fishery remained relatively constant at around 300-500 km$^2$ as a consequence of a reduction in the distance between traps. It is estimated that only 2% of the estimated total harvestable habitat in the West Coast Bioregion is harvested annually by the OIMF.<br>The four active operators in the CSLPF are restricted to fishing the shallow and protected waters of Cockburn Sound, an area of approximately 100 km$^2$.<br>Historical catches of octopus as byproduct of the rock lobster fishery covered a wider distribution than the 10-50 m depth contour, particularly north of Perth.<br>**The logbook data do not indicate that fishers are moving into new unfished areas to maintain catch rates, as would be expected if localised stock depletion was occurring.** |

|  |  |
|---|---|
| Catch rates | The annual standardised catch rates in Zones 1 and 2 of the OIMF, based on daily logbook data from 2010 when the trigger trap fishery started, is consider to represent a robust index of abundance for the stock. After accounting for the effects of month, vessel, soak time, distance between traps and depth, the standardised index indicates a gradual decline in the stock after trigger traps were introduced, as would be expected in a developing fishery. The performance indicator is still above the target reference level that has been specified as 40% of the catch rate in the first year of the trigger trap fishery.<br>**There is no evidence from catch rate data to suggest unacceptable stock depletion to date.** |
| Age and size composition | Available age and size composition data of octopus catches demonstrate that shelter pots and trigger traps select for very different parts of the stock. Shelter pots set primarily in shallow and protected waters caught mainly octopus <1 kg, including a mix of immature females and immature and mature males. Trigger traps caught octopus >1 kg total weight, of which 75% of the total catch were mature males. The male domination of trigger trap catches was evident across all sampling years (2012-2014) and months, however, an increase in the proportion of females occurred in autumn during March and April.<br>**The age and size composition data provide no evidence of unacceptable stock depletion.** |
| Vulnerability (PSA) | The biological characteristics of *O.* aff. *tetricus*, including rapid growth, short lifespan and early maturity, suggest that this highly productive species has a relatively low vulnerability to fishing. Year-round spawning, sperm storage and a strong bias of the trigger traps to catching males is likely to add further protection to the stock and may reduce environmental-driven fluctuations in population size that are common with other invertebrates.<br>As less than 5% of the estimated total harvestable area within the West Coast Bioregion currently fished by the OIMF, which retains more than 80% of catches, the overall susceptibility of the species to fishing is also considered low.<br>With a productivity score of 1.50 and susceptibility scores ranging between 1.43 and 2.33 for the different fisheries/sectors that exploit the stock, the derived Productivity Susceptibility Analysis (PSA) score is 2.13.<br>**The low vulnerability indicates that the risk of unacceptable stock depletion is low under current management arrangements and fishing effort**. |
| Population size | A broad estimate of the octopus population inhabiting the West Coast Bioregion, where the majority of catches are taken, has been derived from fishery-independent data collected during a number of population surveys undertaken within the area. The analyses suggest that the harvestable population (i.e. the component selected by trigger traps) could comprises more than 10 million octopus across the 25,000 km$^2$ of harvestable habitat, based on observed population densities at two survey sites and an estimated daily catchability of trigger traps of 1% from a depletion experiment.<br>**Available estimates of population densities and biomass, when compared to the current level of catch, provide no evidence of unacceptable stock depletion.** |

| Consequence (Stock Depletion) Level | Likelihood | | | | Risk Score |
|---|---|---|---|---|---|
| | L1 Remote (<5%) | L2 Unlikely (5- <20%) | L3 Possible (20- <50%) | L4 Likely (≥50%) | |
| C1 Minimal | | | | X | 4 |
| C2 Moderate | | X | | | 4 |
| C3 High | NA | | | | - |
| C4 Major | NA | | | | - |

C1 (Minor Depletion): **Likely L4** – With the standardised catch rate index being above the target level and all other lines of evidence (including spatial footprint of fishing and available information on population density and biomass) indicative of low exploitation pressure on a very large overall population, it is highly likely that the stock has only experienced minimal depletion to date.

C2 (Moderate Depletion): **Unlikely L2 -** All of the lines of evidence are consistent with the stock level to be at an acceptable level (see above). Although fishery-independent sampling will be needed to more accurately estimate stock biomass, the current estimates suggest that it is unlikely that the stock has experienced a moderate depletion to date.

C3 (High Depletion): **NA** – Not plausible given available lines of evidence.

C4 (Major Depletion): **NA** – Not plausible given available lines of evidence.

#### 9.4.1.2 Current Risk Status

Based on the information available, the current risk level for *O.* aff. *tetricus* in WA is estimated to be LOW (C1 × L4). The low risk reflects acceptable level of fishing pressure and estimates of population size. All the lines of evidence are consistent with a low level of risk, hence the overall Weight of Evidence assessment indicates the status of the *O.* aff. *tetricus* stock is adequate and that current management settings are maintaining risk at an acceptable level.

#### 9.4.1.3 Future Monitoring

Priorities for further work include more detailed investigation of the efficiency of the fishing gear, in-depth analysis of the population genetics to establish connectivity patterns throughout the state, increased within year fishery sampling to estimate selectivity and mortality and provide data for a biomass dynamics model. There is also a planned expansion phase of the fishery as the trap allocations are presently not fully utilised. This will be reviewed every 3 years.

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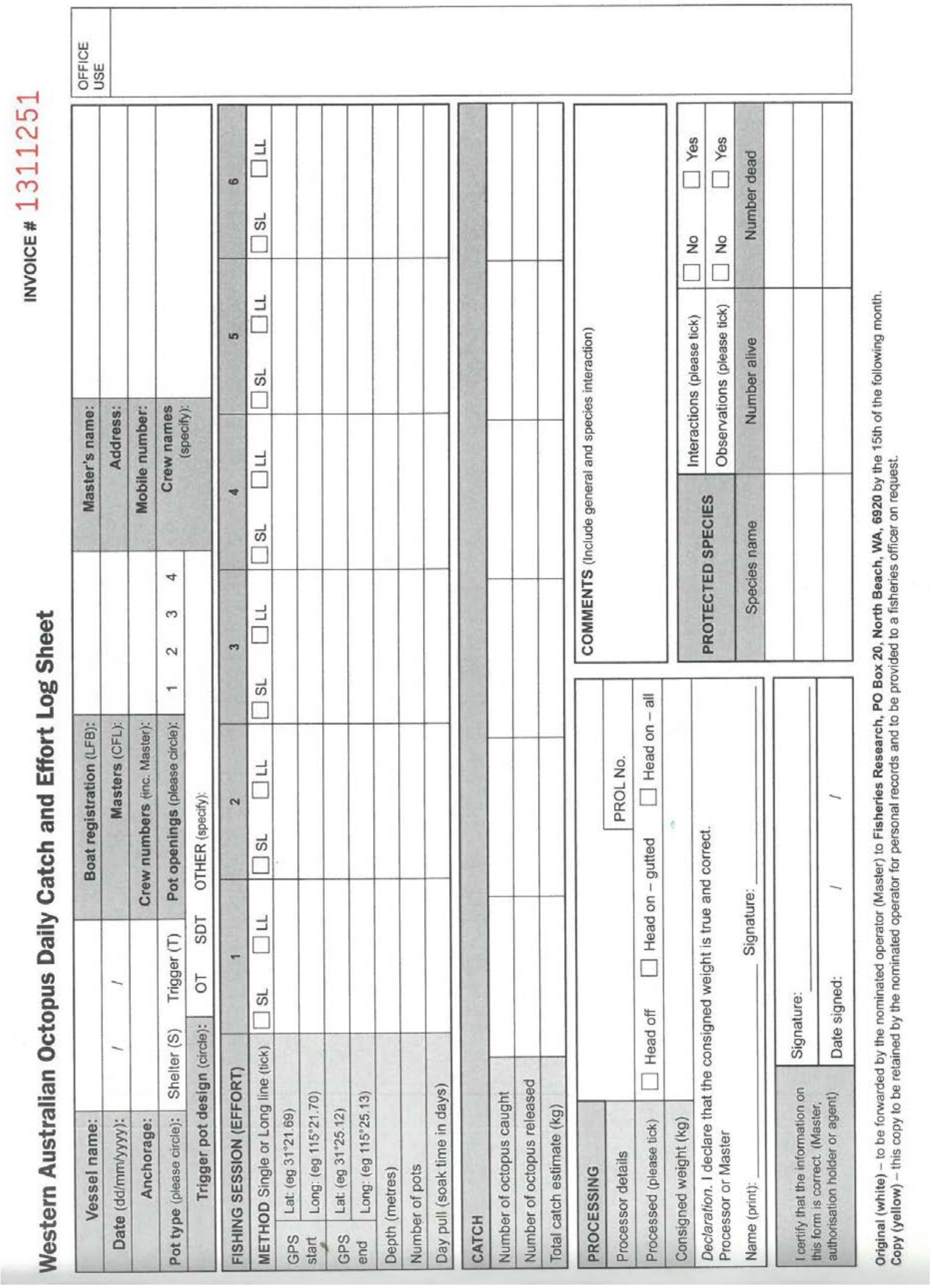
# 11 Appendix 1

## Octopus Interim Managed Fishery (OIMF) and Cockburn Sound Line and Pot Fishery Daily Logbook



**Western Australian Octopus Daily Catch and Effort Log Sheet**

INVOICE # 1311251

| | | | | | |
|---|---|---|---|---|---|
| **Vessel name:** | | **Boat registration** (LFB): | | **Master's name:** | |
| **Date** (dd/mm/yyyy): | / / | **Masters** (CFL): | | **Address:** | |
| **Anchorage:** | | **Crew numbers** (inc. Master): | | **Mobile number:** | |
| **Pot type** (please circle): | Shelter (S) Trigger (T) | **Pot openings** (please circle): | 1 2 3 4 | **Crew names** (specify): | |
| **Trigger pot design** (circle): | OT SDT OTHER (specify): | | | | |

OFFICE USE

| FISHING SESSION (EFFORT) | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **METHOD** Single or Long line (tick) | ☐ SL ☐ LL | ☐ SL ☐ LL | ☐ SL ☐ LL | ☐ SL ☐ LL | ☐ SL ☐ LL | ☐ SL ☐ LL |
| GPS start Lat: (eg 31°21.69) | | | | | | |
| GPS start Long: (eg 115°21.70) | | | | | | |
| GPS end Lat: (eg 31°25.12) | | | | | | |
| GPS end Long: (eg 115°25.13) | | | | | | |
| Depth (metres) | | | | | | |
| Number of pots | | | | | | |
| Day pull (soak time in days) | | | | | | |

| CATCH | | | | | | |
|---|---|---|---|---|---|---|
| Number of octopus caught | | | | | | |
| Number of octopus released | | | | | | |
| Total catch estimate (kg) | | | | | | |

**PROCESSING**

| | | |
|---|---|---|
| Processor details | | PROL No. |
| Processed (please tick) | ☐ Head off ☐ Head on – gutted | ☐ Head on – all |
| Consigned weight (kg) | | |

*Declaration*. I declare that the consigned weight is true and correct.
Processor or Master
Name (print): ____________________ Signature: ____________________

| | |
|---|---|
| I certify that the information on this form is correct. (Master, authorisation holder or agent) | Signature: ____________________ |
| | Date signed: / / |

**COMMENTS** (Include general and species interaction)

| **PROTECTED SPECIES** | Interactions (please tick) | ☐ No ☐ Yes |
|---|---|---|
| | Observations (please tick) | ☐ No ☐ Yes |
| Species name | Number alive | Number dead |
| | | |
| | | |
| | | |

**Original (white)** – to be forwarded by the nominated operator (Master) to **Fisheries Research, PO Box 20, North Beach, WA, 6920** by the 15th of the following month.
**Copy (yellow)** – this copy to be retained by the nominated operator for personal records and to be provided to a fisheries officer on request.

# 12 Appendix 2

## Consequence, Likelihood and Risk Levels (based on AS 4360 / ISO 31000) modified from Fletcher et al. (2011) and Fletcher (2015)

### CONSEQUENCE LEVELS

As defined for major target species

1. Minor – Fishing impacts either not detectable against background variability for this population; or if detectable, minimal impact on population size and none on dynamics

   Spawning biomass > Target level ($B_{\mathrm{MEY}}$)

2. Moderate – Fishery operating at maximum acceptable level of depletion

   Spawning biomass < Target level ($B_{\mathrm{MEY}}$) but > Threshold level ($B_{\mathrm{MSY}}$)

3. High – Level of depletion unacceptable but still not affecting recruitment levels of stock

   Spawning biomass < Threshold level ($B_{\mathrm{MSY}}$) but >Limit level ($B_{\mathrm{REC}}$)

4. Major – Level of depletion is already affecting (or will definitely affect) future recruitment potential/ levels of the stock

   Spawning biomass < Limit level ($B_{\mathrm{REC}}$)

### LIKELIHOOD LEVELS

These are defined as the likelihood of a particular consequence level actually occurring within the assessment period (5 years was used)

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

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

| Risk Levels | Description | Likely Reporting & Monitoring Requirements | Likely Management Action |
|---|---|---|---|
| 1 Negligible | Acceptable; Not an issue | Brief justification – no monitoring | Nil |
| 2 Low | Acceptable; No specific control measures needed | Full justification needed – periodic monitoring | None specific |
| 3 Medium | Acceptable; With current risk control measures in place (no new management required) | Full Performance Report – regular monitoring | Specific management and/or monitoring required |
| 4 High | Not desirable; Continue strong management actions OR new / further risk control measures to be introduced in the near future | Full Performance Report – regular monitoring | Increased management activities needed |
| 5 Severe | Unacceptable; If not already introduced, major changes required to management in immediate future | Recovery strategy and detailed monitoring | Increased management activities needed urgently |

## References

Fletcher, W.J (2015). Review and refinement of an existing qualitative risk assessment method for application within an ecosystem-based management framework. *ICES Journal of Marine Science* 72(3): 1043-1056.

Fletcher, W.J., Shaw, J., Gaughan, D.J. and Metcalf, S.J. (2011). Ecosystem Based Fisheries Management case study report – West Coast Bioregion. Fisheries Research Report No. 225. Department of Fisheries, Western Australia. 116 pp.

# 13 Appendix 3

## Productivity Susceptibility Analysis (PSA) Scoring Tables

| Productivity attribute | High productivity<br>Low risk<br>Score = 1 | Medium productivity<br>Medium risk<br>Score = 2 | Low productivity<br>High risk<br>Score = 3) |
|---|---|---|---|
| Average maximum age | <10 years | 10-25 years | >25 years |
| Average age at maturity | <5 years | 5-15 years | >15 years |
| Average maximum size (not to be used when scoring invertebrates) | <1000 mm | 1000-3000 mm | >3000 mm |
| Average size at maturity (not to be used when scoring invertebrates) | <400 mm | 400-2000 mm | >2000 mm |
| Reproductive strategy | Broadcast spawner | Demersal egg layer | Live bearer |
| Fecundity | >20,000 eggs per year | 100-20,000 eggs per year | <100 eggs per year |
| Trophic level | <2.75 | 2.75-3.25 | >3.25 |
| Density dependence (only to be used when scoring invertebrates) | Compensatory dynamics at low population size demonstrated or likely | No depensatory or compensatory dynamics demonstrated or likely | Depensatory dynamics at low population sizes (Allele effects) demonstrated or likely |

| Susceptibility attribute | Low susceptibility<br>Low risk<br>Score = 1 | Medium susceptibility<br>Medium risk<br>Score = 2 | High susceptibility<br>High risk<br>Score = 3) |
|---|---|---|---|
| Areal overlap (availability)<br>i.e. overlap of fishing effort with stock distribution | <10% overlap | 10-30% overlap | >30% overlap |
| Encounterability<br>i.e. the position of the species / stock within the water column / habitat relative to the position of the fishing gear | Low encounterability / overlap with fishing gear | Medium overlap with fishing gear | High encounterability / overlap with fishing gear<br>(Default score for target species in a fishery) |
| Selectivity of gear type<br>i.e. potential of gear to retain species | a) Individual < size at maturity are rarely caught | a) Individual < size at maturity are regularly caught | a) Individual < size at maturity are frequently caught |
| | b) Individual < size can escape or avoid gear | b) Individual < half the size can escape or avoid gear | b) Individual < half the size are retained by gear |
| Post-capture mortality<br>i.e. the chance that, if captured, a species would be released and that it would be in a condition permitting subsequent survival | Evidence of majority released post-capture and survival | Evidence of some released post-capture and survival | Retained species or majority dead when released |

# 14 Appendix 4

## Ecosystem Based Fisheries Management (EBFM) Risk Assessment of the Octopus Interim Managed Fishery and the Cockburn Sound (Line and Pot) Managed Fishery

April 2018

Fisher, E.A., Webster, F.J., Hart, A.

## 14.1 Risk Assessment Overview

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

This report provides an overview of an ecological risk assessment undertaken in April 2018 for the two main commercial octopus fisheries in WA; the Octopus Interim Managed Fishery (OIMF) and the Cockburn Sound (Line and Pot) Managed Fishery (CSLPF), which target *Octopus* aff. *tetricus* using unbaited traps (shelter pots and trigger traps). The assessment focused on evaluating the ecological impact of these fisheries on all retained species, bycatch, ETP species, habitats and the broader ecosystem. The impact of other fisheries that retain *O.* aff. *tetricus* in WA, including the West Coast Rock Lobster Managed Fishery (WCRLF) and the recreational fishing sector, were considered only when assessing the overall impact of fishing on the target stock.

The risk assessment methodology utilises a consequence-likelihood analysis, which involves the examination of the magnitude of potential consequences from fishing activities and the likelihood that those consequences will occur given current management controls. The assessment was initially undertaken by Departmental research staff, updating the results of previous risk assessments of the WA octopus fisheries undertaken in 2005 and 2010 (Department of Fisheries 2005; 2010; see Appendix A). Following review and endorsement by industry and other relevant stakeholders, this current risk assessment will help inform the recently developed harvest strategy for the WA octopus resource.

## 14.2 WA Octopus Fisheries

The sections below provide the background information relevant to assessing the ecological impacts of the OIMF and CSLPF, including an overview of fishing methods, summaries of recent catches and a description of the broader ecosystem within which the fisheries operate. Other key documents that should be referred to for more detailed information relating to these fisheries and their management include the *Resource Assessment Report for the Octopus Resource of Western Australia* (Hart et al. 2018) and the *Octopus Resource of Western Australia Harvest Strategy 2018 – 2023* (DPIRD 2018).

### 14.2.1 Current Fishing Activities

The *O.* aff. *tetricus* resource predominantly occurs within the West and South Coast Bioregions of WA, which extend from near Shark Bay (~26 °S) to the South Australia border (129 °E). Although the species occurs in depths up to 70 m, it is commercially targeted by the OIMF mainly in coastal waters less than 50 m deep, between Kalbarri and Geographe Bay

(Figure 14.1). Octopus fishing by the CSLPF is limited to the shallow waters of Cockburn Sound (~32 °S).

There have been around 15 vessels in the OIMF and another four with entitlement to fish for octopus in the CSLPF that have been actively targeting the octopus resource using traps over recent years.

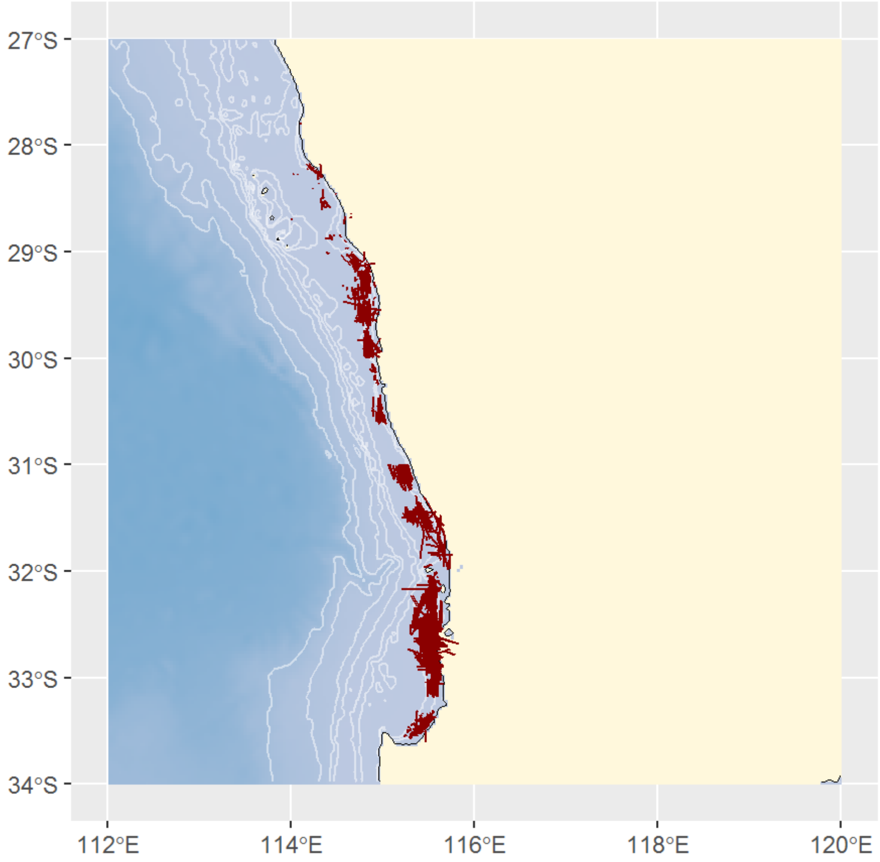


**Figure 14.1. Spatial footprint of the OIMF between 2010 and 2017.**

### 14.2.2 Fishing Gear and Methods

The OIMF and CSLPF are currently permitted to retain octopus only using unbaited traps[1]. Shelter pots, which are predominantly used by fishers in the CSLPF, are an open-ended gear-type that relies on octopuses using the trap for shelter in refuge-limited environments. The pots are typically set on demersal longlines of approximately 500 pots per line in protected waters less than 20 m deep, to prevent loss and burying of gear in sediment by wave action. Shelter pots are generally soaked for 25 days.

Active trigger traps were first approved for use in the (then) Developing Octopus Fishery (DOF) in 2006 and is now the main gear type used by operators in the current OIMF. Trigger

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[1] Note that a trial of using baited traps in the OIMF has been approved but is not within the scope of this risk assessment.

traps exploit the natural hunting instincts and curiosity of octopus, using plastic crabs to lure individuals into the trap, which have a mean soak period of 11 days. The plastic crabs are connected to a device that, when triggered, closes the door of the trap. Ten to 50 cradles (two or three individual traps) are typically connected to a demersal longline but can also be set as a single unit of gear. In 2017, approximately 90% were set on longlines.

Lost fishing gear is occasionally reported by fishers in their logsheets, with a total of 307 traps recorded as lost between 2012 and 2018. The majority (217) were lost in 2018 due to a winter of unusual storm activity and big swells. An FRDC-funded project (2017-147) is currently underway to develop a predictive warning system that would allow fishers to get their traps out of the water when such swell conditions are anticipated. Ghost fishing by lost traps is considered to have a negligible impact on the octopus stock as a trap, once triggered by an individual and the door is closed, would inhibit other animals of entering.

### 14.2.3 Retained Catches

#### 14.2.3.1 *Octopus* aff. *tetricus*

Historically, the majority of octopus caught in WA was as byproduct from rock lobster fishing, with a peak of 139 t retained by the WCRLF in 2002. Targeted octopus catches by the CSLPF and the DOF first increased gradually to 50 t in 2006, however, it was not until a widespread shift to using trigger traps that a substantial increase in catch was observed, reaching 170 t in 2010 (Hart et al. 2016). Since then, the total commercial catch has generally fluctuated around 200-250 t annually (Table 14.1).

Over the past five years, more than 90% of the total commercial catch of octopus has been retained by the OIMF and CSLPF (Table 14.1). Annual retained catches by the OIMF have fluctuated between 143 t and 213 t since 2013, averaging 182 t. Catches by the CSLPF have remained relatively stable over the same time period, averaging 37 t annually (Table 14.1). As well as the WCRLF, a number of other trap and trawl fisheries in WA catch and retain some octopus as a byproduct, however, their combined catch has never exceeded 10 t and averaged 3 t between 2013 and 2017.

**Table 14.1. Summary of retained commercial catches of *Octopus* aff. *tetricus* over the past five years**

| Fishery | Retained catch (t) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | Average | % of total |
| OIMF | 160.6 | 142.8 | 212.7 | 207.7 | 189.3 | 182.6 | 76.3% |
| CSLPF | 46.7 | 38.6 | 28.3 | 23.9 | 47.3 | 37.0 | 15.5% |
| WCRLF | 22.6 | 13.9 | 13.4 | 16.2 | 16.0 | 16.4 | 6.9% |
| Other | 1.9 | 1.7 | 4.2 | 4.3 | 4.1 | 3.2 | 1.4% |
| **Total** | **231.8** | **197.0** | **258.6** | **252.1** | **256.7** | **239.2** | |

Recreational fishing for octopus, predominantly as byproduct from recreational lobster pots or targeted by SCUBA diving occurs throughout WA. An estimate of the 2015/16 annual octopus catch by boat-based recreational fishers was 1379 individuals, of which 1159 were retained (Ryan et al. 2017). Eighty-eight percent of the catch was taken in the West Coast Bioregion.

#### 14.2.3.2 Other species

Fishers in the OIMF are only permitted to retain octopus species, whilst operators in the CSLPF can also retain any cuttlefish (Sepioidea) and squid (Teuthoidea) caught in traps or by line fishing. As both shelter pots and trigger traps are purpose-designed for catching octopus, other species are captured only very rarely.

There are few octopus species other than *O.* aff. *tetricus* with the potential to be caught in commercial octopus traps in WA. *Octopus cyanea* and *O. ornatus* are both tropical species found mainly in the waters north of Geraldton, while *Macroctopus maorum* occurs predominantly on the southern coast of WA (Hart et al. 2016). Although these species can be retained by fishers in the OIMF and the CSLPF, commercial catch records and information from gear trials indicate that they comprise less than 0.1% of total octopus catches.

### 14.2.4 Bycatch

Bycatch in the OIMF and CSLPF is limited due to the highly selective nature of the fishing gear used. Shelter pots used by the CSLPF are unbaited and require an opening at one end, which allows species to come and go freely. Thus, there are very few non-octopus species caught in the shelter traps at the time of retrieval. Trigger traps are designed to capture only octopuses strong enough to set off the trap and trigger the door to close. Other species are able to come and go through the open trap door.

There is currently no statutory requirement for commercial fishers to report discarded catches. Some bycatch data is available from fishery-independent monitoring using 72 cradles (three traps per cradle) of trigger traps deployed in in coastal waters off Mandurah over a three-month period (April – June) in 2013. A total of 1,117 kg of octopus was caught from 2160 individual trigger traplifts during this period. Bycatch, which was all caught in un-triggered traps and thus returned to the water unharmed, comprised

- 25 bastard red cod (*Pseudophycis breviuscula*);
- 15 cobbler (*Cindoglanis macrocephalus*);
- Two blue-ringed octopus (*Hapalochlaena* sp.); and
- One eel (unidentified).

Based on the estimated weights of 25 cm *P. breviuscula* and *C. microcephalus*, using weight-length relationships from Fishbase.org, and assuming the two blue-ringed octopus and the eel had a combined weight of 1 kg, bycatch represented 5% of the total catch from the traplifts (octopus 95%, bastard red cod 3.3%, cobbler 1.6%, and other species 0.1%).

Previous risk assessments of the WA octopus fisheries (see Department of Fisheries 2005; 2010) have also considered other potential bycatch species, including:

- Juvenile octopus;
- Crabs, including blue swimmer crabs (*Portunus armatus*),
  sand crabs (*Ovalipes austaliensis*) and spider crabs;
- Shell species, including specimen shells, pip and razor shells;
- Mussels;
- Starfish;
- Cephalopods (eggs);
- Seagrass; and
- Algae

Although the 2005 and 2010 risk assessments assessed the impact of discarded juvenile octopus, and any brooding females with eggs, separately from the retained component of the catch, all captures of *O.* aff. *tetricus* are now considered collectively in the overall assessment of stock status. Further, as previous risk assessments suggest that seagrass and algae captured in traps comprise dead fronds that have drifted into fishing gear, or may have been dislodged from the substrate as the traps are retrieved, these components have been considered in this assessment as impact on habitats rather than as bycatch.

### 14.2.5 Endangered, Threatened and Protected (ETP) Species

The OIMF and CSLPF have the potential to interact with a number of ETP species. Although the trigger traps and shelter pots are highly selective in nature, the lines to the surface represent a possible source of entanglement. There is a statutory requirement for commercial fishers to record any interactions with ETP species in their logbooks, however, recent records by the OIMF and CSLPF consist mainly of observations (of cetaceans and one white shark) rather than physical contact and entanglement with the fishing gear.

Reports by the Department of Biodiversity, Conservation and Attractions (DBCA; formerly Department of Parks and Wildlife) of whale interactions with octopus fishing gear include a southern right whale (*Eubalaena australis*) in Warnbro Sound in 1994 and 13 humpback whales (*Megaptera novaeangliae*) since 2010. The southern right whale and one of the humpback whales successfully freed themselves from the gear without requiring assistance. With regards to the 12 humpback whale entanglements (Figure 14.2), eight individuals were successfully disentangled from the fishing gear and there have been no directly observed mortalities of the four whales that evaded rescue.

A Code of Practice for reducing whale entanglements in the octopus fishery was developed in 2014, with a number of mitigation measures to minimise the risk of entanglements written into the *Octopus Interim Managed Fishery Management Plan 2015*. These legislated management measures specify that, during the period commencing 1 May and ending on

14 November each year, the masters of authorised boats fishing in Zone 1 or Zone 2 of the OIMF must

a) where using multiple traps or cradles, set all traps or cradles in longline formation consisting of a minimum of 20 traps or cradles per longline; or

b) where using single traps or cradles, ensure that –

    i. there is no rope on the surface of the water, other than that which is part of the float rig; and

    ii. at least one third of the line is held vertically in the water.

Whale entanglements in both octopus and rock lobster fishing gear have led scientists from DPIRD and DBCA to develop a whale rescue tool that tracks the real-time location of whales entangled in fishing gear. The satellite buoy technology now allows responders to remotely monitor the whale before safely attempting a disentanglement[2]. Ten trackable buoys have been provided to specialist whale disentanglement teams at strategic locations between Esperance and Broome, including three in Perth.

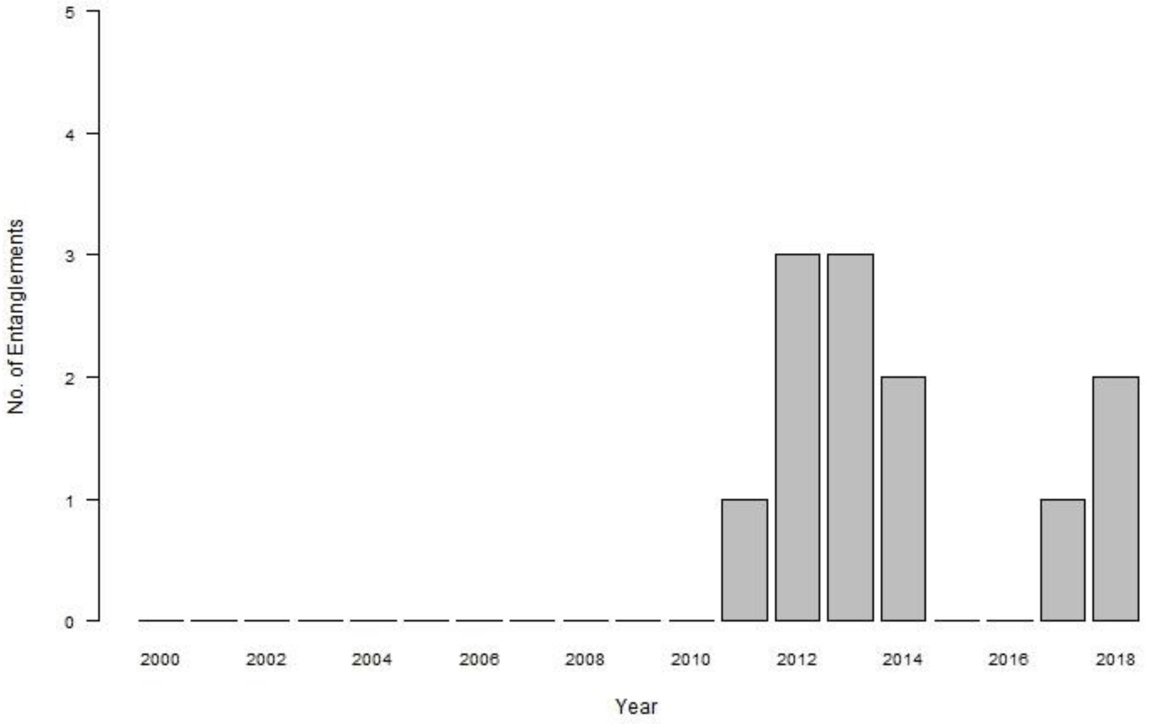

**Figure 14.2. Number of recorded humpback whale entanglements with octopus fishing gear since 2000.**

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[2] See http://www.fish.wa.gov.au/About-Us/News/Pages/Technology-breakthrough-for-whale-disentanglements.aspxb for more detail

In addition to whales, other ETP species that have the potential to be entangled in octopus fishing gear and have been considered in this current risk assessment include:

- Dolphins;
- Dugongs;
- Sea lions;
- Marine turtles;
- Seabirds (including penguins); and
- Syngnathids.

### 14.2.6 Marine Environment & Habitats

The marine environment of Australia has been classified into bioregions based on common oceanographic characteristics under the Integrated Marine and Coastal Regionalisation of Australia (IMCRA v4.0) spatial framework. The commercial octopus fisheries in WA extend across the West Coast Bioregion and the South Coast Bioregion (Figure 14.3). Both bioregions have a Mediterranean climate, with most rainfall occurring during the winter months (Fletcher et al. 2017). Coastal water temperatures range between 18-24° C off the west coast and 15-21° C off the south coast. Biological communities are mainly comprised of temperate species, which mix with tropical species in the northern regions of the West Coast Bioregion.

Fishing activities by the OIMF have been largely confined to coastal waters less than 50 m deep in the West Coast Bioregion, between Kalbarri and Geographe Bay (Figure 14.1). Fishing to date has particularly focused on habitats within 15 km of the six safe anchorages of Dongara, Two Rocks, Hillarys, Fremantle, Mandurah and Busselton (Hart et al. in press). Fishers in the CSLPF are restricted to the sheltered waters of Cockburn Sound between Fremantle and Mandurah (see Figure 14.3).

The West Coast Bioregion is characterised by exposed sandy beaches and a limestone reef system that creates surface reef lines, often about five kilometres off the coast (Fletcher et al. 2017). Further offshore, the continental shelf habitats are typically composed of coarse sand interspersed with low limestone reef associated with old shorelines. Within the West Coast Bioregion, octopus fishing currently occurs in two main marine ecosystems; The Central West Coast Ecosystem (CWCE) and the Leeuwin-Naturaliste Ecosystem (LNE). A significant portion of the marine habitats of the CWCE and LNE have been mapped to describe both the physical substratum and the biological communities present. Summaries of available information are provided in the sections below.

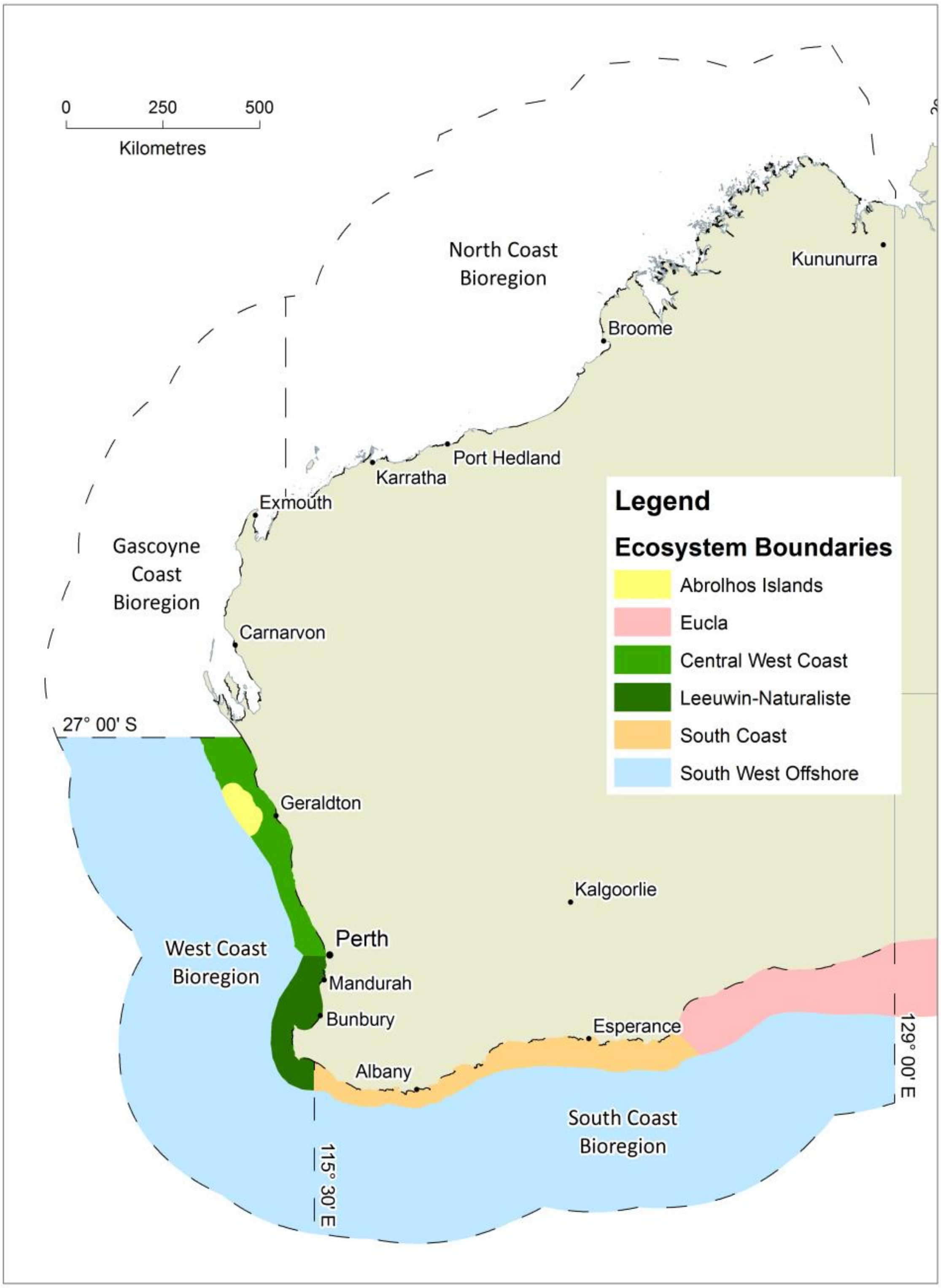

**Figure 14.3.** **Map of the South and West Coast Bioregions in WA, and their associated ecosystems. Note that some IMCRA ecosystem boundaries have been shifted to align with Departmental bioregional boundaries.**

### 14.2.6.1 Ecosystem Descriptions

#### 14.2.6.1.1 Central West Coast Ecosystem

The CWCE extends from the northern boundary of the West Coast Bioregion (27°S) to Perth (31°60’S), excluding the area around the Houtman Abrolhos Islands. The CWCE is a microtidal, relatively high-energy area, with clear water and few rivers. The coastline is characterised by long beaches with occasional limestone cliffs and headlands, with offshore limestone islands and reef complexes (Figure 14.4). The shelf includes a series of nearshore ridges and depressions that form inshore lagoons and supports a variety of benthic habitats including rocky substrates with prolific growths of algae and sponges, rippled sand with clumps of non-calcareous red algae and open rippled sand (Department of Planning and Urban Development 1994; Figure 14.4). Sponges, ascidians, non-calcified red algae and *Ecklonia* are all common to depths of 40 m. Encrusting coralline algae form rhodoliths around limestone nuclei, and branching forms are present to 60 m depth.

The biota of deeper-water habitats at Dongara, Lancelin and Jurien have been assessed to evaluate the effects of western rock lobster fishing on deep-water ecosystems along the west coast (Bellchambers 2010; Bellchambers et al. 2010). Habitat type and biota were classified using towed video in depths of 35 to 75 m. Dongara was identified as a sponge-dominated ecosystem, while Lancelin was macroalgae-dominated, and Jurien Bay was a mixture of sponge and algae. The macroalgae assemblage was dominated by *Ecklonia radiata*, which is likely to be the main source of primary production in the local deep-coastal ecosystems (Bellchambers 2010).

#### 14.2.6.1.2 Leeuwin-Naturaliste Ecosystem

The LNE extends south from Perth (31° 60’ S) to Black Head (115° 57' 41" E), southeast of Augusta, on Australia’s south coast (Figure 14.3). There region includes many estuaries, of which the Peel-Harvey and Leschenault Inlet are large and permanently open to the sea, while Cockburn Sound is a major enclosed marine embayment (Wilson 1994). The shelf along the LNE is narrow and includes features such as limestone ridges, depressions defining an inshore lagoon, a relatively smooth inner shelf plain that meets the South Bank Ridge on the outer shelf and islands providing important habitat. The shelf progressively broadens to form the relatively sheltered waters of Geographe Bay before narrowing once again at Cape Mentelle (Commonwealth of Australia 2008).

In 1993, the major benthic habitats of the Perth metropolitan area coastal waters were mapped using a Geoscan airborn multi-spectral scanner (Department of Environmental Protection 1996). Benthic habitats in the northern LNE comprise nearshore and offshore reefs, as well as sandy and silty areas within Cockburn Sound and Warnbro Sound (Figure 14.5). Cockburn Sound is one of the most intensively used marine embayments in WA and extensive habitat monitoring of the system has shown a loss of vegetated areas over time (DAL 2000; DALSE 2002, 2003, 2004; Kendrick et al. 2002). A ground-truthing survey of parts of the Eastern Shelf of Cockburn Sound indentified both patchy and continuous seagrass beds composed of *Posidonia* spp. and *Halophila* spp. (DALSE 2004). A variety of reef structures were also recorded, ranging from low relief pavement reef, often covered by a thin veneer of sand, to cobble reef and high relief reef.

South of Cockburn Sound is the Shoalwater Islands Marine Park, where limestone ridges and reef platforms are found both along the coast and as a chain of islands and reefs that protect the coast from south-westerly swell and waves (DEC 2007). Underwater structures, including caves, archways, vertical channels, solution pipes, rocky slopes and platforms, are a result of chemical and mechanical weathering. Seagrass meadows consist mainly of *Posidonia* spp., *Amphibolis* spp., *Halophila ovalis* and *Heterozostera tasmanica* and support a diverse assemblage of fish and invertebrates (DEC 2007). Subtidal reefs are dominated by large macrophytes, such as *Ecklonia radiata*. These areas are recognised as being one of the substantial contributors to primary production in the area and attract a range of fish and assemblages of sponges, gorgonians and other invertebrates, including western rock lobster (DEC 2007).

The southern end of the LNE was designated as the Ngari Capes Marine Park in 2012. This region consists of the low-profile, low-energy, sandy shores of Geographe Bay and the high-profile, high-energy, rocky shores of the Naturaliste-Leeuwin Ridge (Figure 14.6). Much of the seabed in Geographe Bay is a sand plain, and the benthic communities of the inner part are dominated by monospecific stands of the seagrass *Posidonia sinuosa* (approximately 70 % of the bay), along with smaller areas of other seagrasses (Walker et al. 1987). The seagrass meadows in Geographe Bay are one of the most extensive in the West Coast Bioregion. There is a rich epiphytic community of algae and invertebrates associated with the seagrass meadows, which is very distinctive and characteristic of southern WA (Wilson 1994).

The deeper water region (> 10 m) off Geographe Bay was mapped as part of the Marine Futures project (Radford et al. 2008). The majority of the area had soft substrate (86 km$^2$). Reef outcrops were identified in the east, along a narrow ridge running east-west, and were patchily distributed in the north-northeast and west, covering a total of 0.1 km$^2$. A mixture of reef and sediment cover was more commonly classified than reef (5 km$^2$) and was widely distributed around the periphery of reef outcrops. The majority of the bay was vegetated, predominantly with seagrass (*Amphibolis* spp. and *Posidonia* spp.) nearshore with an increasing contribution from macroalgae with increasing water depth. Sessile invertebrates were mapped in areas with reef and mixed reef and sediment substrates (Radford et al. 2008).

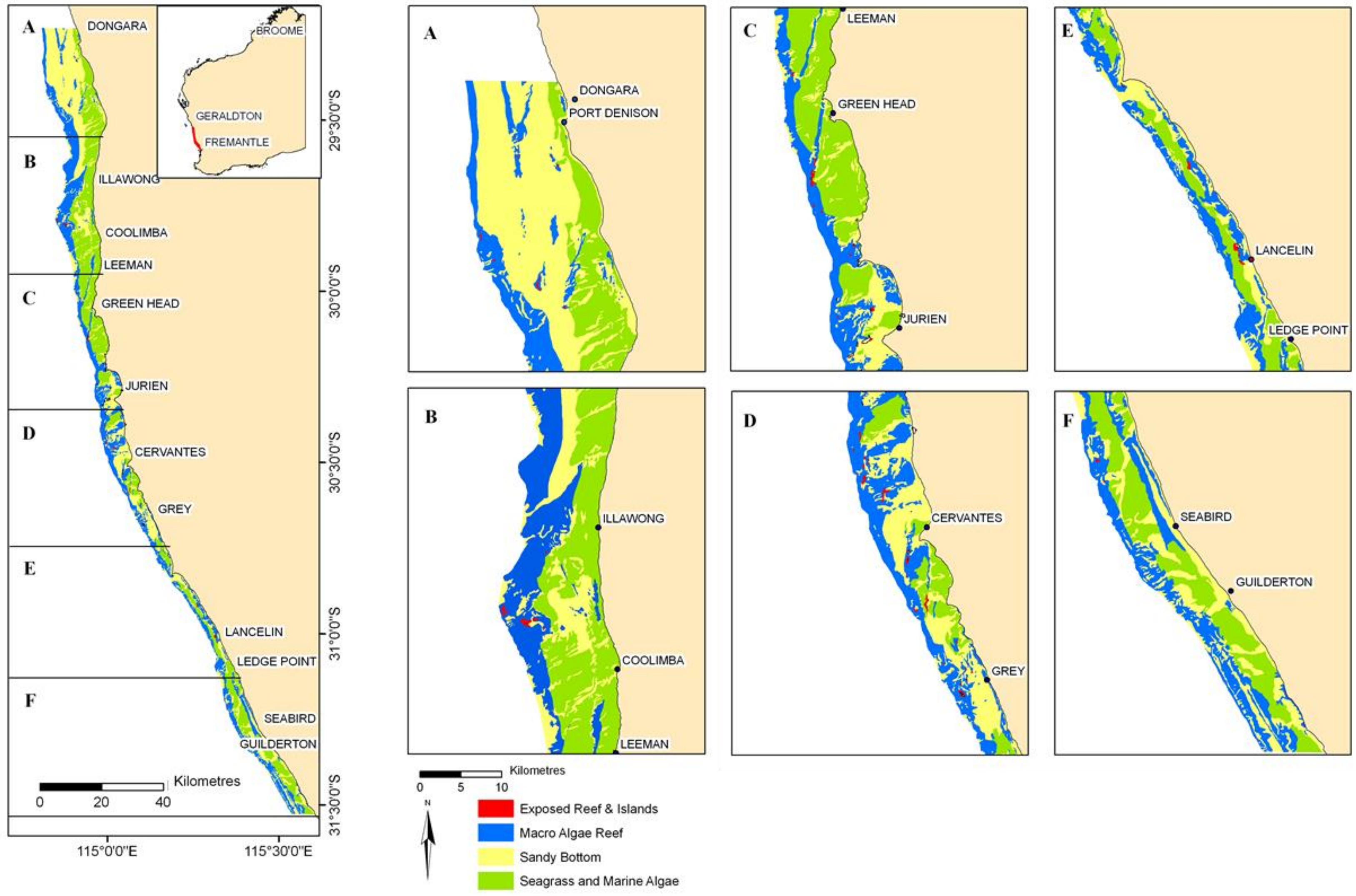

**Figure 14.4. Major benthic habitats of the central west coast (Source: Department of Planning and Urban Development 1994)**

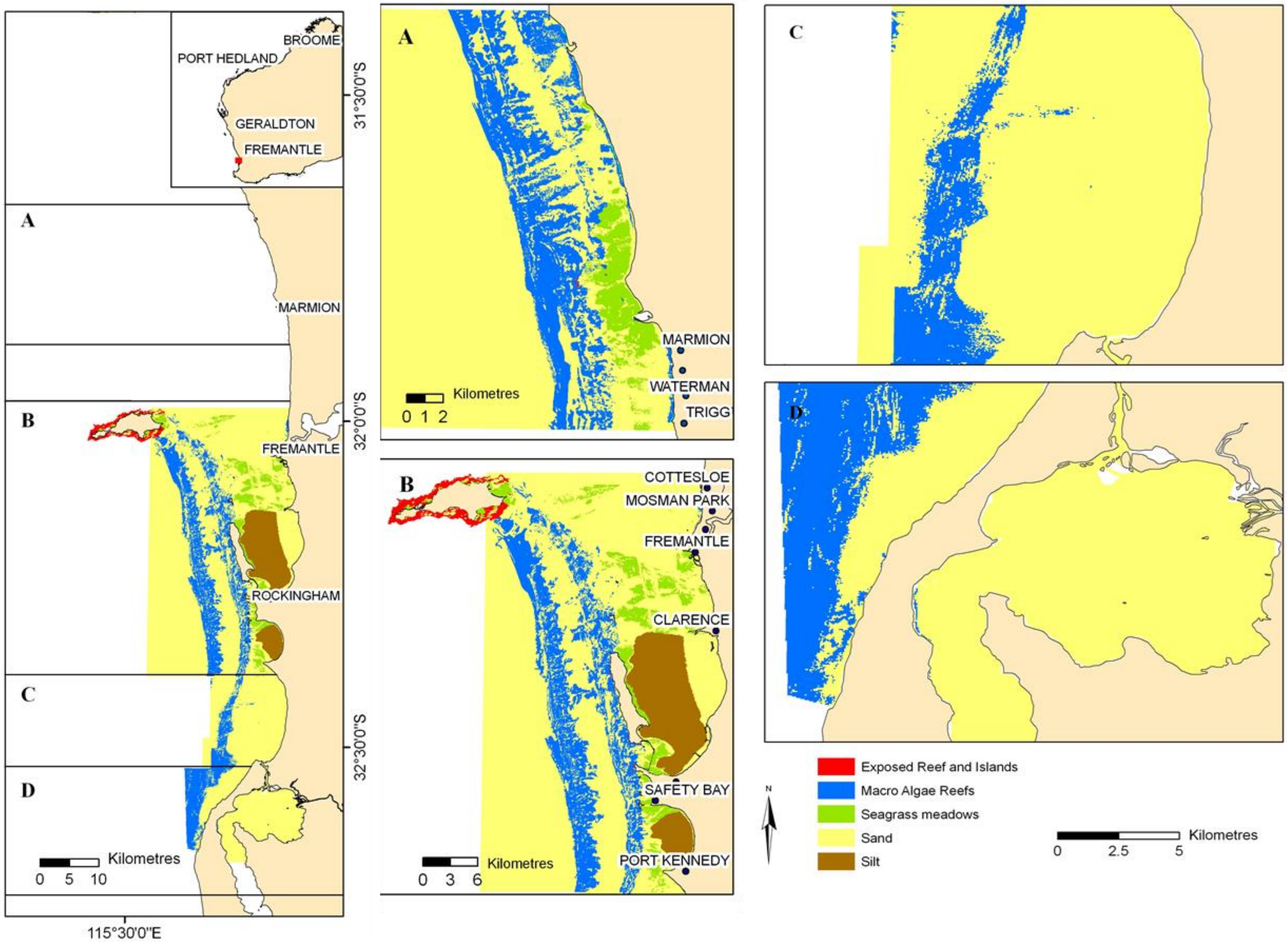

**Figure 14.5. Major benthic habitats of Perth metropolitan waters from Yanchep to Mandurah (Source: Department of Environmental Protection 1996)**

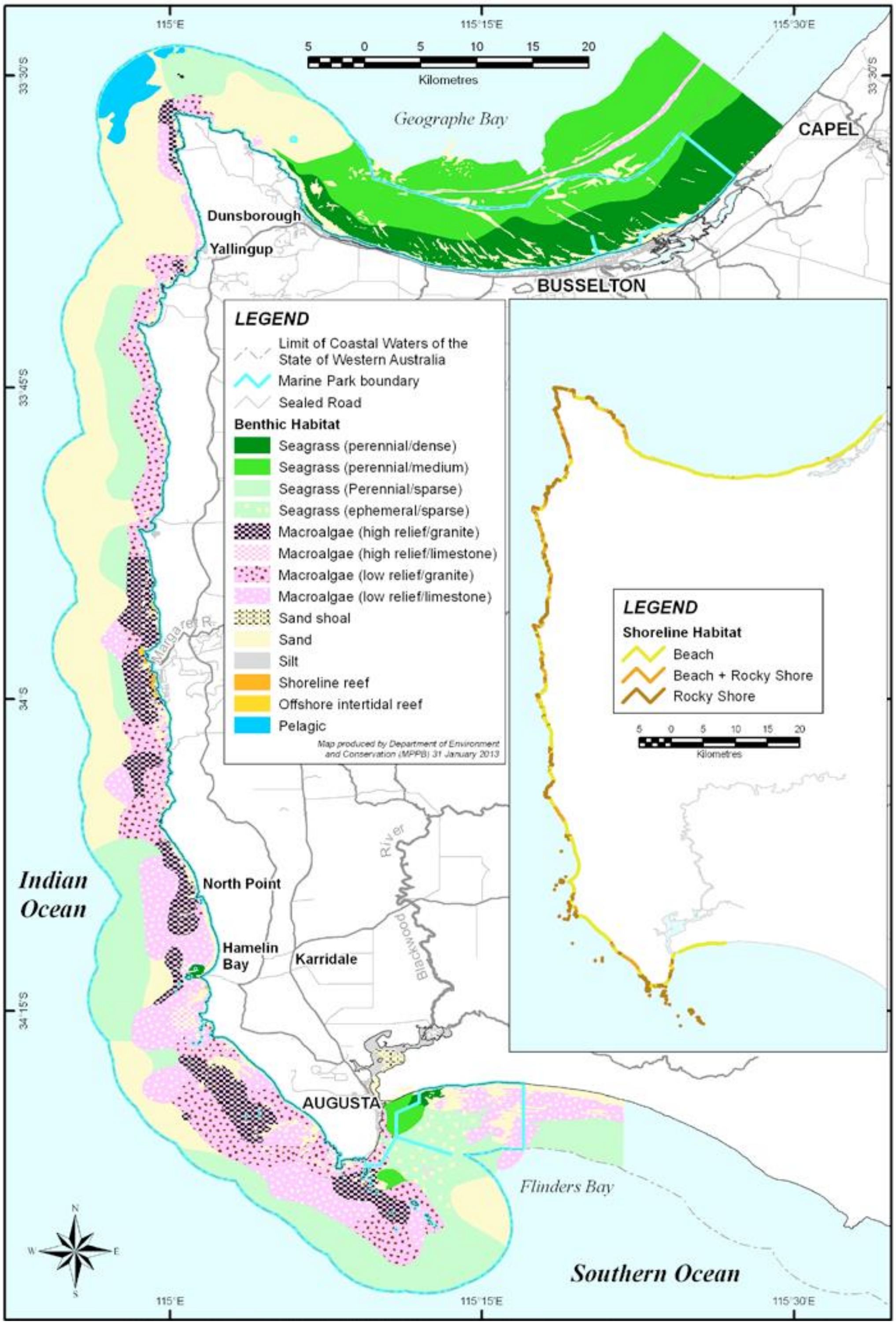

**Figure 14.6. Major benthic and shoreline habitats within and adjacent to the Ngari Capes Marine Park (Source: DEC 2013)**

#### 14.2.6.2 Fishery Impacts

*Octopus* aff. *tetricus* inhabit rocky reefs, seagrass meadows and sandy substrates in depths of 5 to 70 m (Edgar 1997; Norman and Reid 2000). Fishery-dependent and fishery-independent data indicate a negligible effect of depth on catch rates (abundance) of this species in the West Coast Bioregion (Hart et al. in press). Assuming that a cradle of trigger traps has an approximate 'fishing radius' of 50 m, logbook data suggest that the annual areal footprint of the fishery between 2010 and 2017 has varied from 1.5 to 2% of the estimated total harvestable area of 25,000 km$^2$ on the west coast of WA (Hart et al. in press). The areas fished by the OIMF do not vary markedly between years, however, not all areas along the coast have been fished every year.

Shelter pots and trigger traps are likely to have minimal impact on the marine benthos due to both types of gear being relatively small and lightweight. The main impact would likely occur during retrieval of fishing gear, with a small amount of drag occurring when traps are lifted from the seafloor. Trigger traps in the OIMF are primarily set on sandy areas around robust limestone reef habitats covered with coralline and macroalgae. This type of high-energy coastal habitat is regularly subjected to swell and winter storms and is therefore considered highly resilient to any damage from trap fishing activities. Within Cockburn Sound, shelter pots are set in sandy and seagrass areas. The frequency of potential disturbance to the benthos is minimised by the long soak times in the fishery, averaging 11 days in the OIMF and 25 days in the CSLPF. Anchoring is uncommon in the fishery due to most traps being set in lines, with the fishing vessel in constant movement.

The main impact of the OIMF and the CSLPF on the broader ecosystem in which they operate would be due to the removal of *O.* aff. *tetricus*, which makes up approximately 99.9% of the total retained catch in octopus traps. Only a relatively small amount of octopus of approximately 200 to 260 t is harvested annually in WA relative to a potentially large overall population (Hart et al. in press). Octopuses are highly fecund and have a relatively short life cycle, such that the biomass removed from fishing is effectively renewed annually. Thus, it is highly unlikely that the commercial take of octopus will significantly affect the trophic structure of the ecosystem.

## 14.3 Risk Assessment Methodology

Risk assessments have been extensively used as a mean to filter and prioritise the various identified fisheries management issues in Australia (Fletcher et al. 2002). The risk analysis methodology utilised for this risk assessment of the WA octopus fisheries is based on the global standard for risk assessment and risk management (AS/NZS ISO 31000), which has been adopted for use in a fisheries context (see Fletcher et al. 2002, Fletcher 2005; 2015). The broader risk assessment process is summarised in Figure 14.7.

The first stage establishes the context or scope of the risk assessment, including determining which activities and geographical extent will be covered, a timeframe for the assessment and the objectives to be delivered (Section 14.3.1). Secondly, risk identification involves the process of recognising and describing the relevant sources of risk (Section 14.3.1). Once these components have been identified, risk scores are determined by evaluating the potential consequences (impacts) associated with each issue, and the likelihood (probability) of a particular level of consequence actually occurring (Section 14.3.3).

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

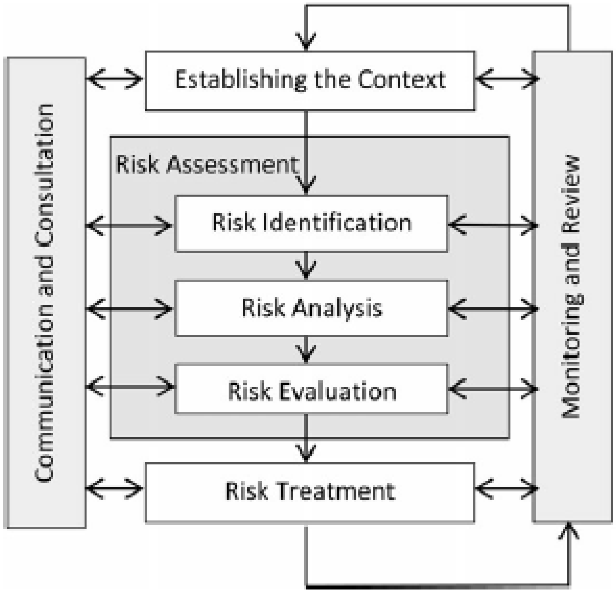

**Figure 14.7. Position of risk assessment within the risk management process.**

### 14.3.1 Scope

This risk assessment covers commercial trap fishing by the OIMF and the CSLPF within the management boundaries of these fisheries. It considers only the ecological impacts of fishing with unbaited octopus traps, including both shelter pots and trigger traps. The calculation of risk in the context of a fishery is usually determined within a specified period, which for this assessment is the next five years (i.e. until 2023).

For the purpose of this assessment, risk was defined as *the uncertainty associated with achieving a specific management objective or outcome* (adapted from Fletcher 2015). For the Department, ‘risk’ is the chance of something affecting the agency’s performance against the objectives laid out in their relevant legislation. In contrast, for the commercial fishing industry, the term ‘risk’ generally relates to the potential impacts on their long-term profitability. For the general community, ‘risk’ could relate to possible impact on their enjoyment of the marine environment. The aim for each of these groups is to ensure the ‘risk’ of an unacceptable impact is kept to an acceptable level.

An important part of the risk assessment and risk management process is communication and consultation with stakeholders. Ecological risk assessments undertaken by the Department typically engages all stakeholders of the fishery to participate in a workshop for collectively scoring risk issues. This allows the assessment to consider not only the ecological sustainability of the fishing activities but also how different external environmental, social and economic drivers may affect the performance of the fishery. As there have been two previous risk assessments undertaken for the octopus fisheries (Department of Fisheries 2005; 2010) and both incorporated key external (i.e. non-fisher) stakeholder groups in the risk evaluation, this current assessment considered only the ecological impacts of fishing (as required to inform the harvest strategy). To ensure sufficient consultation, drafts of this document were circulated to all relevant stakeholders to provide them the opportunity to comment prior to the assessment being finalised.

### 14.3.2 Risk Identification

The first step in the risk assessment process was to identify the issues relevant to the fishery being assessed. Issues were identified using a component tree approach (see Figure 14.8 for a generic example), where major risk components are deconstructed into smaller sub-components that are more specific to allow the development of operational objectives (Fletcher et al. 2002). The component trees are tailored to suit the individual circumstances of the fishery being examined by adding and expanding some components and collapsing or removing others.

The development of the component tree for evaluating the ecological sustainability of the WA octopus fisheries (see Section 14.4) was based on:

- Previous risk assessments undertaken for the fisheries to achieve approval for Wildlife Trade Operations (Department of Fisheries 2005, 2010);
- Identified gaps in the Marine Stewardship Council (MSC) performance indicators, as identified during a pre-assessment of the industry against the MSC Fisheries Standards in 2013;
- A gap analysis undertaken by Departmental research staff in April 2018; and
- Consultation with industry and external stakeholders following the first draft of this report.

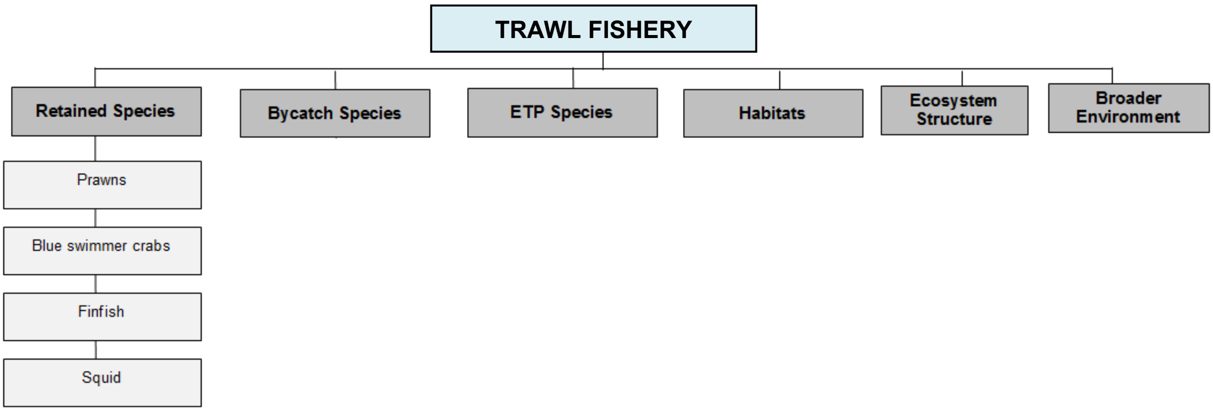

**Figure 14.8. An example of a component tree for ecological sustainability, identifying the main components (dark grey boxes) and sub-components for retained species in a trawl fishery.**

### 14.3.3 Risk Analysis, Evaluation and Treatment

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

Although consequence and likelihood analyses can range in complexity, this assessment utilised a 4×4 matrix (Figure 14.9). The consequence levels ranged from 1 (e.g. minor impact to fish stocks) to 4 (e.g. major impact to fish stocks) and likelihood levels ranged from 1 (Remote; i.e. < 5 % probability) to 4 (Likely; i.e. ≥ 50 % probability). Scoring involved an assessment of the likelihood that each level of consequence is occurring, or is likely to occur within the 5-year period specified for this assessment. If an issue is not considered to have any detectable impact, it can be considered to be a 0 consequence; however, it is preferable to score such components as there being a remote (1) likelihood of a minor (1) consequence.

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

1. Fish stocks (retained/bycatch species) – measured at a stock level;
2. ETP species – measured at a population or regional level;
3. Habitats – measured at a regional level; and
4. Ecosystem/Environment – measured at a regional level.

For each issue, the consequence and likelihood scores were evaluated to determine the highest risk score using the risk matrix (Figure 14.9). Each issue was thus assigned a risk level within one of five categories: Negligible, Low, Medium, High or Severe (Table 14.2).

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

**Figure 14.9. 4 × 4 Consequence – Likelihood Risk Matrix (based on AS 4360 / ISO 31000; adapted from Department of Fisheries 2015).**

**Table 14.2. Risk levels applied to evaluate each individual risk issue (modified from Fletcher 2005)**

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

The risk analysis of the WA octopus fisheries was initially conducted at by Departmental staff during a workshop held on April 26, 2018 at the WA Fisheries and Marine Research Laboratories' facilities. The rationale for classifying the risk levels of the various issues was documented at the workshop, forming the basis of the subsequent sections of this report. The outputs were then circulated to relevant stakeholders, including representatives from the OIMF and CSLPF, the Western Australian Fishing Industry Council (WAFIC), and Department of Biodiversity, Conservation and Attractions. Where discrepancies in risk scores occurred, all risk ratings are provided, along with the justification for any differences.

## 14.4 Risk Analysis

Six ecological components, comprising 29 sub-components, were identified as potentially impacted by the two WA octopus fisheries (Figure 14.10). The risk ratings for each of the risk issues are summarised in Table 14.3. Although each issue was scored separately for the two fisheries (OIMF and CSLPF), individual results are only provided if the scores were considered to differ (Table 14.3).

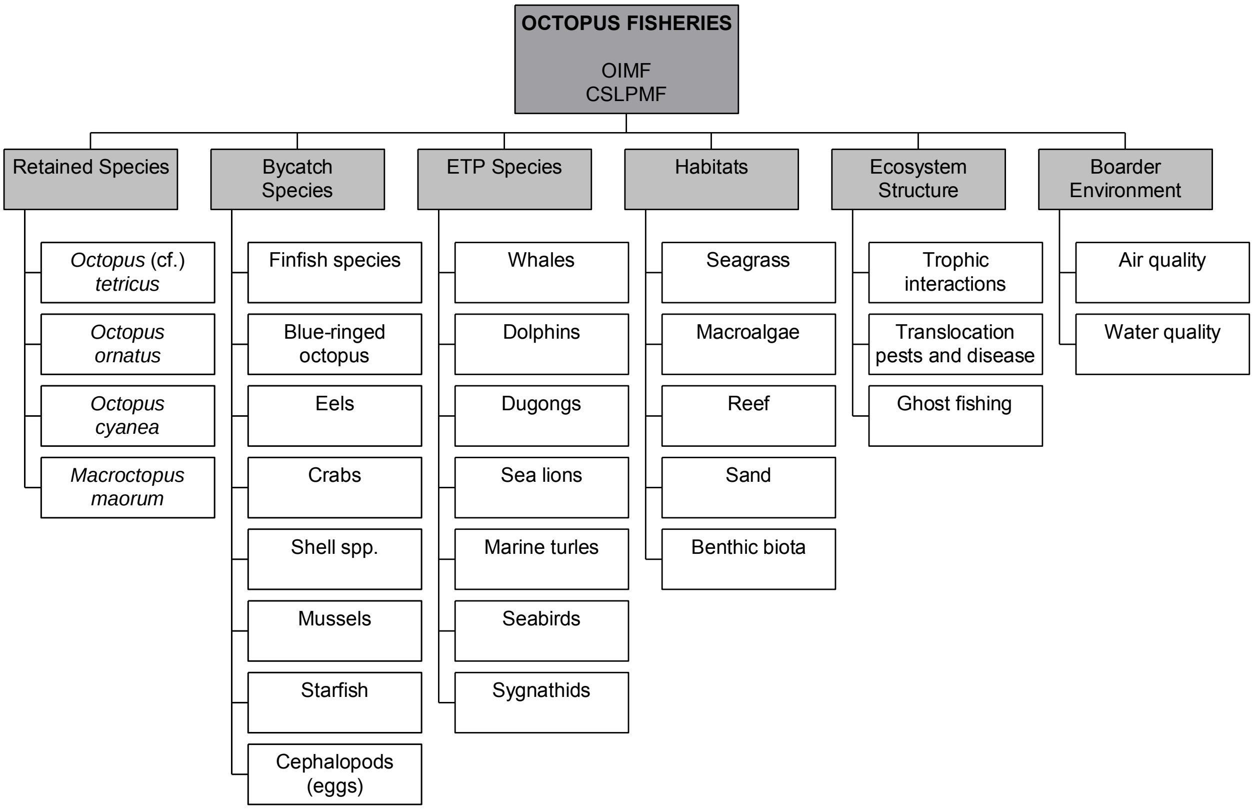

**Figure 14.10. Component tree for assessing the ecological sustainability aspects of the OIMF and CSLPF.**

**Table 14.3. Overview of the objectives, components, and risk scores and ratings considered in the 2018 ecological risk assessment of the WA octopus fisheries (OIMF and CSLPF).**

| Aspect | Fishery Objective | Component | Issues | Risk Scoring | Risk rating |
|---|---|---|---|---|---|
| Retained Species | To maintain spawning stock biomass of each retained species at a level where the main factor affecting recruitment is the environment | *Octopus* aff. *tetricus* | All fishing | C1, L4 or C2, L2 | LOW |
| | | Other octopus species | Trap fishing (OIMF) | C1, L4 | LOW |
| | | | Trap fishing (SCLPMF) | C1, L1 | NEGLIGIBLE |
| Bycatch Species | To ensure fishing impacts do not result in serious or irreversible harm to bycatch (non-retained) species populations | Finfish species | Capture by traps | C1, L1 | NEGLIGIBLE |
| | | Blue-ringed octopus | Capture by traps | C1, L1 | NEGLIGIBLE |
| | | Eels | Capture by traps | C1, L1 | NEGLIGIBLE |
| | | Crabs | Capture by traps (OIMF) | C1, L1 | NEGLIGIBLE |
| | | | Capture by traps (CSLPF) | C1, L3 | LOW |
| | | Shell species | Capture by traps | C1, L1 | NEGLIGIBLE |
| | | Mussels | Capture by traps | C1, L1 | NEGLIGIBLE |
| | | Starfish | Capture by traps | C1, L1 | NEGLIGIBLE |
| | | Cephalopods (eggs) | Capture by traps | C1, L1 | NEGLIGIBLE |
| ETP Species | To ensure fishing impacts do not result in serious or irreversible harm to ETP species' populations | Syngnathids | Capture by traps | C1, L4 | LOW |
| | | Whales | Entanglement | C1, L4 | LOW |
| | | Dolphins | Entanglement | C1, L2 | NEGLIGIBLE |
| | | Dugongs | Entanglement | C1, L1 | NEGLIGIBLE |
| | | Sea lions | Entanglement | C1, L1 | NEGLIGIBLE |
| | | Marine turtles | Entanglement | C1, L1 | NEGLIGIBLE |
| | | Seabirds | Entanglement | C1, L1 | NEGLIGIBLE |

| Aspect | Fishery Objective | Component | Issues | Risk Scoring | Risk Rating |
|---|---|---|---|---|---|
| Habitats | To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function | Seagrass | Damage by traps | C1, L3 | LOW |
| | | Macroalgae | Damage by traps | C1, L3 | LOW |
| | | Reef | Damage by traps | C1, L3 | LOW |
| | | Sand | Damage by traps | C1, L1 | NEGLIGIBLE |
| | | Benthic biota | Damage by traps | C1, L3 | LOW |
| Ecosystem Structure | To ensure the effects of fishing do not result in serious or irreversible harm to ecological processes | Trophic Interactions | Predator – prey interactions | C1, L3 | LOW |
| | | | Provisioning | C1, L3 | LOW |
| | | Translocation of pests and/or disease | Vessel hulls | C1, L3 | LOW |
| | | Ghost fishing | Lost fishing gear | C1, L1 | NEGLIGIBLE |
| Broader Environment | To ensure the effects of fishing do not result in serious or irreversible harm to the broader environment | Air Quality | Exhaust | C1, L3 | LOW |
| | | Water Quality | Debris/litter | C1, L3 | LOW |
| | | | Oil/fuel spills | C1, L3 | LOW |

### 14.4.1 Retained Species

#### 14.4.1.1 *Octopus* aff. *tetricus*

As the key target species in the OIMF and CSLPF, the *O.* aff. *tetricus* stock in WA may experience a significant impact from trap fishing.

**Risk Rating: Impact of trap fishing on the *O.* aff. *tetricus* stock in WA (C1×L4 = LOW)**

*Justification*

- With a short lifespan (18 months), fast growth (matures at 4-6 months of age) and high fecundity (female lays 100,000s eggs), *O.* aff. *tetricus* has a very high inherent productivity.
- *Octopus* aff. *tetricus* is year-round breeder, ensuring a constant supply of recruits.
- The retained commercial catch of *O.* aff. *tetricus* in WA has remained stable over the past five years, averaging around 240 t annually, with 76% and 16% of this catch landed by the OIMF and CSLPF, respectively.
- Trigger traps are selective for medium-sized octopus (750 – 4000 g) that are strong and flexible enough to trigger the trap door to close (Hart et al. 2016).
- Juvenile octopus that are not of a marketable size and brooding females with eggs are occasionally caught in traps but are generally alive and returned immediately to the water. The impact of such discarding is considered as part of the overall weight-of-evidence stock assessment for this species.
- The primary performance indicator for the stock (based on the standardised commercial catch rate in the two main areas of the OIMF; Zone 1 and Zone 2) has been fluctuating above the target reference level. This indicates that the stock has only experienced a minor level of depletion to date and is highly likely to be above 40% of unfished levels.
- Although a trial of baited traps could increase fishing efficiency, it is unlikely to change exploitation markedly over the next five years.

#### 14.4.1.2 Other species

Although caught only occasionally, the stocks of *O. cyanea*, *O. ornatus* and *M. maorum* have the potential to experience a significant impact from trap fishing if retained in larger numbers.

**Risk Rating: Impact of trap fishing by the OIMF on WA stocks of *O. cyanea, O. ornatus* and *M. maorum* (C1×L4 = LOW)**

**Risk Rating: Impact of trap fishing on by the CSLPF WA stocks of *O. cyanea, O. ornatus* and *M. maorum* (C1×L1 = NEGLIGIBLE)**

*Justification:*

- Like *O.* aff. *tetricus*, *O. cyanea*, *O. ornatus* and *M. maorum* have very high inherent productivity (i.e. short lifespan and high fecundity).
- *Octopus cyanea and O. ornatus* are primarily tropical species and would only be available for capture by traps in the northernmost extent of the OIMF.
- *Macroctopus maorum* lives in southern waters around Cape Leeuwin to Tasmania and would only be available for capture by traps in the southern parts of the OIMF.
- Commercial catch records suggest that <0.1% of the total octopus catch in WA comprises species other than *O.* aff. *tetricus*.
- Although both the OIMF and CSLPF are permitted to retain any octopus species caught in traps, it is believed that those other than *O.* aff. *tetricus* are commonly discarded due to a low commercial value of these species. Discarded individuals are expected to have a high post-release survival as they would be immediately returned to the water.
- Despite no formal assessments of the WA stocks of *O. cyanea*, *O. ornatus* and *M. maorum*, the very low catches relative to the target species suggest it is highly likely that these species are currently experiencing only a minor level of exploitation by the OIMF.
- Although a trial of baited traps could increase fishing efficiency, this is unlikely to change exploitation markedly over the next five years.
- There is considered only a remote chance of minor impacts on these stocks by the CSLPF due to the lack of overlap with the distribution of these species.

### 14.4.2 Bycatch Species

#### 14.4.2.1 Finfish species

There is potential for the octopus trap fisheries to catch and discard low numbers of finfish, including bastard red cod and cobbler.

**Risk Rating: Impact of trap fishing on finfish species (C1×L1 = NEGLIGIBLE)**

*Justification*

- Trigger traps are selective for medium-sized octopus that are strong and flexible enough to trigger the trap door to close (Hart et al. 2016).
- Fishery-independent monitoring using trigger traps indicates that bastard red cod and cobbler are caught only very rarely. All captures were in un-triggered traps.
- Although there is no available bycatch information for shelter traps, finfish could move freely in and out of the traps and thus very few individuals would be caught at the time of retrieval.

- Finfish that are incidentally captured are generally alive and returned to the water immediately.

#### 14.4.2.2 Blue-ringed octopus

There is potential for the octopus trap fisheries to catch and discard low numbers of blue-ringed octopus.

**Risk Rating: Impact of trap fishing on blue-ringed octopus (C1×L1 = NEGLIGIBLE)**

*Justification*

- Trigger traps are selective for medium-sized octopus that are strong and flexible enough to trigger the trap door to close (Hart et al. 2016).
- Fishery-independent monitoring using trigger traps indicates that blue-ringed octopus are caught only very rarely. All captures were in un-triggered traps.
- Although there is no available bycatch information for shelter traps, blue-ringed octopus could move freely in and out of the traps and thus very few individuals would be caught at the time of retrieval.
- Blue-ringed octopus that are incidentally captured are generally alive and returned to the water immediately.

#### 14.4.2.3 Eels

There is potential for the octopus trap fisheries to catch and discard low numbers of eels.

**Risk Rating: Impact of trap fishing on eels (C1×L1 = NEGLIGIBLE)**

*Justification*

- Trigger traps are selective for medium-sized octopus that are strong and flexible enough to trigger the trap door to close (Hart et al. 2016).
- Fishery-independent monitoring using trigger traps indicates that eels are caught only very rarely (in <1 % of traps). All captures were in un-triggered traps.
- Although there is no available bycatch information for shelter traps, eels could move freely in and out of the traps and thus very few individuals would be caught at the time of retrieval.
- Eels that are incidentally captured are generally alive and returned to the water immediately.

### 14.4.2.4 Crabs

There is potential for the octopus trap fisheries to catch and discard low numbers of crabs.

**Risk Rating: Impact of trap fishing by the OIMF on crabs (C1×L1 = NEGLIGIBLE)**

**Risk Rating: Impact of trap fishing by the CSLPF on crabs (C1×L3 = LOW)**

*Justification*

- Trigger traps are selective for medium-sized octopus that are strong and flexible enough to trigger the trap door to close (Hart et al. 2016).
- Previous risk assessments indicate that crabs (including blue swimmer crabs, sand crabs and spider crabs) are occasionally caught in octopus traps but are alive and immediately returned to the water (some may have minor loss of limbs).
- The blue swimmer crab is a commercially and recreationally targeted species, however, the fishery in Cockburn Sound currently closed to fishing due to low stock levels.
- It is possible that the incidental capture of blue swimmer crabs in octopus traps by the CSLPF could have some, but minor impact on the recovery of the Cockburn Sound stock.

### 14.4.2.5 Shell species

There is potential for the octopus trap fisheries to catch and discard low numbers of shell species.

**Risk Rating: Impact of trap fishing on shell species (C1×L1 = NEGLIGIBLE)**

*Justification*

- Previous risk assessments indicate that shell species (including specimen shells, pip and razor shells) have the potential to be caught in octopus traps, most likely swept into traps on retrieval of the fishing gear.
- Shells that are incidentally captured are generally alive and returned to the water immediately.

### 14.4.2.6 Mussels

There is potential for the octopus trap fisheries to catch and discard low numbers of mussels.

**Risk Rating: Impact of trap fishing on mussels (C1×L1 = NEGLIGIBLE)**

*Justification*

- Previous risk assessments indicate that mussels have the potential to be caught in octopus traps, most likely swept into traps on retrieval of the fishing gear.

- Mussels that are incidentally captured are generally alive and returned to the water immediately.

#### 14.4.2.7 Starfish

There is potential for the octopus trap fisheries to catch and discard low numbers of starfish.

**Risk Rating: Impact of trap fishing on starfish (C1×L1 = NEGLIGIBLE)**

*Justification*

- Previous risk assessments indicate that starfish have the potential to be caught in octopus traps, most likely swept into traps on retrieval of the fishing gear.
- Starfish that are incidentally captured are generally alive and returned to the water immediately.

#### 14.4.2.8 Cephalopods (eggs)

There is potential for octopus trap fisheries to catch and discard eggs of cephalopods such as cuttlefish and squid if laid inside traps.

**Risk Rating: Impact of trap fishing on cephalopods (eggs) (C1×L1 = NEGLIGIBLE)**

*Justification*

- Previous risk assessments indicate that cephalopods such as cuttlefish and squid could potentially lay eggs inside octopus traps.
- If incidentally captured, these eggs would be immediately returned to the water immediately.

### 14.4.3 Endangered, Threatened and Protected (ETP) Species

#### 14.4.3.1 Syngnathids

There is potential for interactions of the octopus fisheries with syngnathids such as sea horses and pipefish through capture by fishing gear.

**Risk Rating: Impact on syngnathids of capture by octopus fishing gear (C1×L4 = LOW)**

*Justification:*

- There have been no reported interactions of the octopus fisheries with syngnathids.
- Syngnathids have occasionally been observed attaching to a rope or the outside of the trap and are returned to the water immediately.

#### 14.4.3.2 Whales

There is potential for interactions of the octopus fisheries with whales, including humpback whales and southern right whales, through entanglement in fishing gear.

**Risk Rating: Impact on whales of entanglement in octopus fishing gear (C1×L4 = LOW)**

*Justification:*

- There have only been 12 reports of whales entangled in octopus fishing gear since 1994, including 1 southern right whale and 11 humpback whales.
- Nine of the whales were either successfully disentangled or freed themselves from the fishing gear, and there have been no directly observed mortalities of the three that evaded rescue.
- The OIMF has recently adopted a number of mitigation measures to reduce the chance of entanglements, with only one entanglement reported since.
- Although the likelihood of entanglements is increasing with increasing numbers of whales, impacts would only be minor.

#### 14.4.3.3 Dolphins

There is potential for interactions of the octopus fisheries with dolphins through entanglement in fishing gear.

**Risk Rating: Impact on dolphins of entanglement in octopus fishing gear (C1×L2 = NEGLIGIBLE)**

*Justification:*

- There have been no reported interactions of the octopus fisheries with dolphins, suggesting that the chance of entanglement is unlikely.
- The fishery has recently adopted a number of mitigation measures to reduce the chance of entanglements.

#### 14.4.3.4 Dugongs

There is potential for interactions of the octopus fisheries with dugongs through entanglement in fishing gear.

**Risk Rating: Impact on dugongs of entanglement in octopus fishing gear (C1×L1 = NEGLIGIBLE)**

*Justification:*

- There have been no reported interactions of the octopus fisheries with dugongs.
- There is only a remote chance that dugongs could become entangled in octopus fishing gear as their distribution does is not considered to overlap with the areas in which the fisheries currently operate.
- The fishery has recently adopted a number of mitigation measures to reduce the chance of entanglements.

#### 14.4.3.5 Sea lions

There is potential for interactions of the octopus fisheries with sea lions through entanglement in fishing gear.

**Risk Rating: Impact on sea lions of entanglement in octopus fishing gear (C1×L1 = NEGLIGIBLE)**

*Justification:*

- There have been no reported interactions of the octopus fisheries with sea lions, suggesting that the chance of entanglement is remote.
- The fishery has recently adopted a number of mitigation measures to reduce the chance of entanglements.

#### 14.4.3.6 Marine turtles

There is potential for interactions of the octopus fisheries with marine turtles through entanglement in fishing gear.

**Risk Rating: Impact on marine turtles of entanglement in octopus fishing gear (C1×L1 = NEGLIGIBLE)**

*Justification:*

- There have been no reported interactions of the octopus fisheries with marine turtles, suggesting that entanglements are unlikely.
- The fishery has recently adopted a number of mitigation measures to reduce the chance of entanglements.

#### 14.4.3.7 Seabirds

There is potential for interactions of the octopus fisheries with seabirds through entanglement in fishing gear.

**Risk Rating: Impact on seabirds of entanglement in octopus fishing gear (C1×L1 = NEGLIGIBLE)**

*Justification:*

- There have been no reported interactions of the octopus fisheries with marine turtles, suggesting that the chance of entanglement is remote.
- The fishery has recently adopted a number of mitigation measures to reduce the chance of entanglements.

### 14.4.4 Habitats

#### 14.4.4.1 Seagrasses, macroalgae and reef

There is a potential for seagrasses, macroalgal and reef habitats to be damaged by octopus traps when fishing.

**Risk Rating: Impact of octopus fishing on seagrass, macroalgal and reef habitats (C1×L3 = LOW)**

*Justification:*

- Octopus traps are primarily set on sandy areas around robust limestone reef habitats covered with coralline and macroalgae.
- Octopus traps are sometimes set on or near seagrass meadows and previous risk assessments report that dead fronds are occasionally brought to the surface when fishing gear is retrieved.
- As both shelter pots and trigger traps are relatively small and lightweight, they would only have minor impact on habitats.
- Potential fishery impacts on habitats are most likely to occur during gear retrieval, however, this is minimised due to the relatively long soak time of traps.
- Fishery-independent data from depletion experiments suggest that the fisheries currently target less than 10% of potential octopus habitat.
- The areas fished do not vary markedly between years, however, not all areas along the coast have been fished every year and this would allow for recovery of habitats.

#### 14.4.4.2 Sand

Small amounts of sand often enter octopus traps when fishing.

**Risk Rating: Impact of octopus fishing on sand habitats (C1×L1 = NEGLIGIBLE)**

*Justification:*

- Octopus traps are primarily set on sandy areas around limestone reef habitats or seagrass meadows and thus sand is commonly brought up to the surface by octopus traps as the fishing gear is retrieved.
- Potential fishery impacts on habitats are most likely to occur during gear retrieval, however, this is minimised due to the relatively long soak time of traps.
- As both shelter pots and trigger traps are relatively small and lightweight, there is only a remote chance that they would have any measurable impact on sand habitats.
- Fishery-independent data from depletion experiments suggest that the fisheries currently target less than 10% of potential octopus habitat.

- The areas fished do not vary markedly between years, however, not all areas along the coast have been fished every year and this would allow for recovery of habitats.

#### 14.4.4.3 Benthic biota

Small amounts of attached epibenthos such as ascidians may be damaged or removed by octopus traps.

**Risk Rating: Impact of octopus fishing on marine benthos (C1×L3 = 3, LOW)**

*Justification:*

- It is possible that epifauna such as ascidians and sponges that attach to seagrasses, algae or reef habitat are damaged by octopus traps.
- As both shelter pots and trigger traps are relatively small and lightweight, there is only a remote chance that they would have any measurable impact on marine benthos.
- Potential fishery impacts on habitats are most likely to occur during gear retrieval, however, this is minimised due to the relatively long soak time of traps.
- Fishery-independent data from depletion experiments suggest that the fisheries currently target less than 10% of potential octopus habitat.
- The areas fished do not vary markedly between years, however, not all areas along the coast have been fished every year and this would allow for recovery of habitats.

### 14.4.5 Ecosystem Structure

#### 14.4.5.1 Trophic Interactions

##### 14.4.5.1.1 Predator – Prey Interactions

The removal of octopus from the environment may alter the key elements of the local ecosystem including predator – prey interactions.

**Risk Justification: Impact on trophic interactions of removing octopus from the ecosystem (C1×L3 = LOW)**

*Justification:*

- The OIMF and CSLPF currently land more than 90% of the total *O.* aff. *tetricus* catch in WA, which has averaged around 240 t over the past five years.
- The target species is highly productive, with a short life-span and high fecundity. It is year-round breeder, thus ensuring a constant supply of recruits.
- Fishery-dependent catch rate information used as a proxy/index for abundance indicates that the exploited stock is above 40% of unfished levels.
- Fishery-independent data from depletion experiments suggest that the fisheries currently target less than 10% of potential octopus habitat, thus exploiting only a small proportion of available biomass.

- There are no species known to be dependent on *O.* aff. *tetricus* as a primary food source.
- Any potential effects of octopus fishing on trophic interactions within the ecosystem are expected to be minor.

#### 14.4.5.1.2 Provisioning

The discarding of bycatch can provide a source of food that would not normally be available to other organisms.

**Risk Rating: Impact on trophic interactions from discarding of bycatch into the ecosystem (C1× L3 = LOW)**

*Justification:*

- The quantity of bycatch returned to the water is very low and the majority is likely to be alive when returned to the water.
- Some of the bycatch, including cobbler and blue-ringed octopus are venomous and thus predators tend to avoid these species.

### 14.4.5.2 Introduction of Diseases, Pests, Pathogens or Non-Native Species

Vessels in the OIMF and SCLPMF can move between different areas for fishing, which has the potential to introduce or translocate marine pests and/or disease.

**Risk Rating: Impact of introducing/translocating diseases, pests, pathogens or non-native species from vessels and fishing gear on the ecosystem (C1×L3 = LOW)**

*Justification:*

- Vessels do not travel large distances to fishing grounds, limiting the potential spread of organisms attached to hulls.
- The Department maintains an active surveillance program in the Fremantle Port for marine pests and diseases. There is also a passive surveillance program throughout WA, actively investigating any reports of abnormal mortalities, which are backed up by emergency response capability in the areas of both aquatic pests and diseases.
- A Departmental incident response manual has been developed, which details protocol associated with emergency biosecurity response. The Department is equipped with state-of-the-art diagnostic laboratories and capability. It participates in nationally-coordinated proficiency testing programs and is accredited to ISO17025 for both pest identification and pathogen identification.

### 14.4.5.3 Ghost fishing

Traps are occasionally lost whilst fishing, which could result in a cycle of continued captures and baiting of the traps.

**Risk Rating: Impact on lost octopus traps and ghost fishing on the ecosystem (C1×L1 = NEGLIGIBLE)**

*Justification:*

- The number of octopus traps lost at sea is likely to be low.
- As shelter traps are open-ended, animals can move freely in and out of the traps and the potential for lost traps to continue catching and baiting traps is remote.
- Once triggered, the closed door of trigger traps would inhibit other animals of entering the trap, thus limiting the likelihood of ghost fishing.

### 14.4.6 Broader Environment

#### 14.4.6.1 Air quality

Boats which operate in the OIMF and CSLPF utilise fuel and emit exhaust fumes.

**Risk Rating: Impact of fuel use and/or exhaust from fishing vessels on regional air quality (C1×L3 = LOW)**

*Justification:*

- There are currently around 15 active vessels in the OIMF, which operate over a large area from north of Kalbarri to Geographe Bay.
- The operations of CSLPF are restricted to Cockburn Sound, however, only four vessels are currently fishing for octopus using traps.
- Fishing operations are relatively infrequent due to the long soak time of the octopus fishing gear; around 11 days for trigger traps and 25 days for shelter pots that are predominantly used in the CSLPF.
- Overall, the low number of vessels and long soak time of fishing gear results in the generation of minimal exhaust across a relatively large spatial scale.

#### 14.4.6.2 Water quality

##### 14.4.6.2.1 Debris/Litter

The operation of fishing vessels in the OIMF and CSLPF may reduce water quality through rubbish and debris, including lost fishing gear.

**Risk Rating: Impact of rubbish/litter from fishing vessels on regional water quality (C1×L3 = LOW)**

*Justification:*

- Fishers are aware of the public sensitivities to waste disposal and are careful to store any personal litter on vessels until it can be disposed of in waste disposal bins.

- The fisheries currently operate with unbaited traps and do not generate litter from bait boxes. Although a baited trap trial in the OIMF may occur in the next five years, this is not within the scope of this current risk assessment
- As fishing effort is unlikely to increase markedly over the next five years, there is considered to be a low risk of lost gear and other debris from the fishery effecting water quality.

#### 14.4.6.2.2 Oil/Fuel Discharge

Vessels operating in the OIMF and CSLPF have the potential to reduce water quality through oil and fuel spills.

**Risk Rating: Impact of oil and/or fuel discharge from fishing vessels on regional water quality (C1×L3 = LOW)**

*Justification:*

- It is possible that accidental oil or fuel spills from fishing vessels can occur, however, the impact of such discharge on regional water quality would only be minor.

## 14.5 Risk Evaluation & Treatment

This risk assessment has assisted in the identification and evaluation of the different types of ecological risks associated with the WA octopus fisheries. Different levels of risk have different levels of acceptability, with different requirements for monitoring and reporting, and management actions (see Table 14.2 for a summary). Risks identified as negligible or low are considered acceptable, requiring either no or periodic monitoring, and no specific management actions. Issued identified as medium risk are considered acceptable providing there is specific monitoring, reporting, and management measures are implemented. Risks identified as high are considered 'not desirable', requiring strong management actions or new control measures to be introduced in the near future. Severe risks are considered 'unacceptable' with major changes to management required in the immediate future (Fletcher et al. 2002).

Thirty-one issues associated with the ecological sustainability of the OIMF and CSLPF were scored for risk (Table 14.4). All issues considered in this risk assessment were evaluated as low or negligible risks, which do not require any specific control measures (as per Fletcher et al. 2002; Table 14.2). It is recommended that the risks be reviewed in 5 years, or prior to the review of the current (2018-2023) harvest strategy, where the risk scores are used as the performance indicator for the non-target ecological assets. Monitoring and assessment of the *O.* aff. *tetricus* resource will be ongoing, with the commercial catch rates updated on an annual basis.

**Table 14.4. Summary of scores across each risk issue considered in the 2018 risk rating of the WA octopus fisheries**

| | **Component** | **Risk Score** | | | | | **Total** |
|---|---|---|---|---|---|---|---|
| | | **Negligible** | **Low** | **Medium** | **High** | **Severe** | |
| **Ecological Sustainability** | Retained Species | 1 | 2 | - | - | - | **3** |
| | Bycatch Species | 8 | 1 | - | - | - | **9** |
| | ETP species | 5 | 2 | - | - | - | **7** |
| | Habitats | 1 | 4 | - | - | - | **5** |
| | Ecosystem Structure | 1 | 3 | - | - | - | **4** |
| | Broader Environment | - | 3 | - | - | - | **3** |
| **Total** | | **16** | **15** | **-** | **-** | **-** | **31** |

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## 14.7 Appendix A

### Risk ratings in previous risk assessments for the WA octopus fisheries

| Component and Sub/component | 2005 | 2010 |
|---|---|---|
| Retained species | | |
| Common Perth octopus (*O. tetricus*) | LOW | MODERATE |
| White-striped octopus (*O. ornatus*) | LOW | MODERATE |
| Maori octopus (*O. maorum*) | LOW | MODERATE |
| Bycatch | | |
| Blue-ringed octopus (*Hapalochlaena* sp.) | NEGLIGIBLE | NEGLIGIBLE |
| Baby octopus | NEGLIGIBLE | NEGLIGIBLE |
| Eels | NEGLIGIBLE | NEGLIGIBLE |
| Shells | NEGLIGIBLE | NEGLIGIBLE |
| Mussels | NEGLIGIBLE | NEGLIGIBLE |
| Crabs | NEGLIGIBLE | MINOR |
| Eggs (Octopus, cuttlefish and squid) | LOW | MINOR |
| Seagrass | NEGLIGIBLE | NEGLIGIBLE |
| Algae | NEGLIGIBLE | NEGLIGIBLE |
| Starfish | Not assessed | NEGLIGIBLE |
| ETP Species | | |
| Syngnathids | NEGLIGIBLE | MINOR |
| Turtles | NEGLIGIBLE | MODERATE |
| Whales | NEGLIGIBLE | MINOR |
| Dolphins | NEGLIGIBLE | MINOR |
| Dugongs | NEGLIGIBLE | NEGLIGIBLE |
| Sea lions | NEGLIGIBLE | NEGLIGIBLE |
| Seabirds (incl. penguins) | NEGLIGIBLE | NEGLIGIBLE |
| Benthic biota | | |
| Sand | LOW | NEGLIGIBLE |
| Seagrass | LOW | NEGLIGIBLE |
| Reef | LOW | NEGLIGIBLE |
| Ecosystem | | |
| Provisioning | NEGLIGIBLE | MINOR |
| Trophic fishing level | LOW | MODERATE |
| Ghost fishing | LOW | NEGLIGIBLE |
| Broader environment | | |
| Loss of octopus fishing gear (rubbish) | LOW | MINOR |
| Debris | NEGLIGIBLE | MINOR |
| Fuel and oil spills | NEGLIGIBLE | MINOR |

## 14.8 Appendix B

## LIKELIHOOD LEVELS

1. Remote – Never heard of in these circumstances but not impossible within the timeframe (<5% probability)
2. Unlikely – Not expected to occur in the timeframe but it has been known to occur elsewhere under special circumstances (5- <20% probability)
3. Possible – Clear evidence to suggest this is possible in some circumstances within the timeframe (20- <50% probability)
4. Likely – Expected to occur in the timeframe (≥50% probability)

## CONSEQUENCE LEVELS

**FISH STOCKS (retained / non-retained species) – measured at a stock level**

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

**ETP SPECIES – measured at a population or regional level**

1. Few individuals directly impacted in most years, level of capture/interaction is well below that which will generate public concern
2. Level of capture is the maximum that will not impact on recovery or cause unacceptable public concern
3. Recovery may be being affected and/or some clear, but short-term public concern will be generated
4. Recovery times are clearly being impacted and/or public concern is widespread

**HABITATS – measured at a regional level**

1. Measurable impacts to habitats but still not considered to impact on habitat dynamics or system
2. Maximum acceptable level of impact to habitat with no long-term impacts on region-wide habitat dynamics
3. Above acceptable level of loss/impact with region-wide dynamics or related systems may begin to be impacted
4. Level of habitat loss clearly generating region-wide effects on dynamics and related systems

**ECOSYSTEM / ENVIRONMENT – measured at a regional level**

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