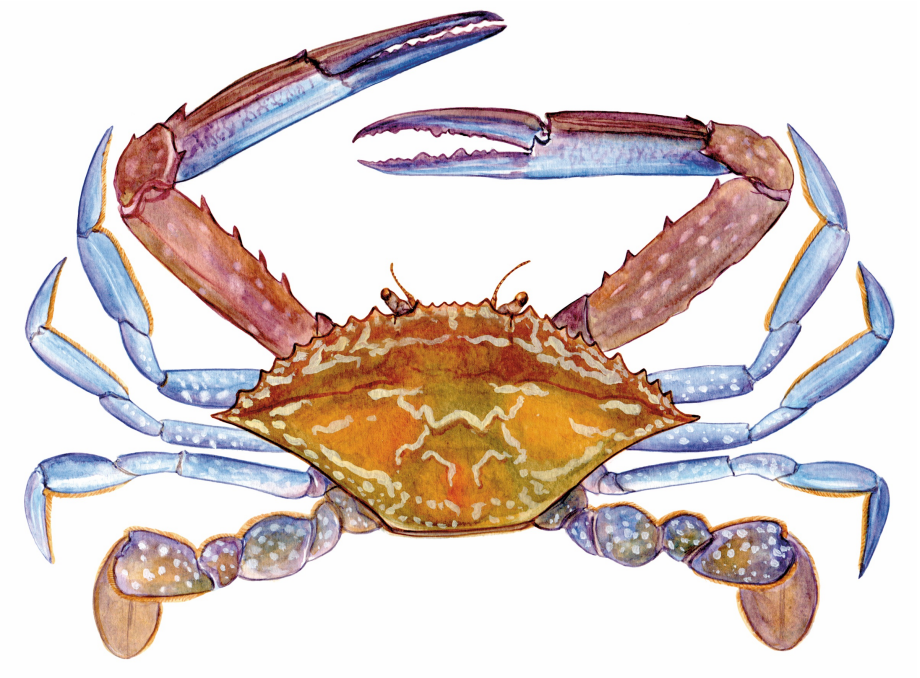
Monterey Bay Aquarium
Seafood Watch

Environmental sustainability assessment of wild-caught Blue swimmer crab from Australia caught using pots and bottom trawls



Species:	Blue swimmer crab *(Portunus armatus)*
Location:	Australia: Queensland, New South Wales, Cockburn Sound, Gulf of St. Vincent, Peel-Harvey Estuary, Shark Bay, Spencer Gulf
Gear:	Pots, Bottom trawls
Type:	Wild Caught
Author:	Seafood Watch
Published:	April 3, 2023
Report ID:	27978

Assessed using Seafood Watch Fisheries Standard v4

Table of Contents

About Seafood Watch

Monterey Bay Aquarium's Seafood Watch program evaluates the environmental sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Seafood Watch's science-based ratings are available at www.SeafoodWatch.org. Each rating is supported by a Seafood Watch assessment, in which the fishery or aquaculture operation is evaluated using the Seafood Watch standard.

Seafood Watch standards are built on our guiding principles, which outline the necessary environmental sustainability elements for fisheries and aquaculture operations. The guiding principles differ across standards, reflecting the different impacts of fisheries and aquaculture.

- Seafood rated Best Choice comes from sources that operate in a manner that's consistent with our guiding principles. The seafood is caught or farmed in ways that cause little or no harm to other wildlife or the environment.

- Seafood rated Good Alternative comes from sources that align with most of our guiding principles. However, one issue needs substantial improvement, or there's significant uncertainty about the impacts on wildlife or the environment.

- Seafood rated Avoid comes from sources that don't align with our guiding principles. The seafood is caught or farmed in ways that have a high risk of causing harm to wildlife or the environment. There's a critical conservation concern or many issues need substantial improvement.

Each assessment follows an eight-step process, which prioritizes rigor, impartiality, transparency and accessibility. They are conducted by Seafood Watch scientists, in collaboration with scientific, government, industry and conservation experts and are open for public comment prior to publication. Conditions in wild capture fisheries and aquaculture operations can change over time; as such assessments and ratings are updated regularly to reflect current practice.

More information on Seafood Watch guiding principles, standards, assessments and ratings are available at www.SeafoodWatch.org.

Guiding Principles

Seafood Watch defines sustainable seafood as originating from sources, whether fished[1] or farmed, that can maintain or increase production in the long term without jeopardizing the structure or function of affected ecosystems.

The following guiding principles illustrate the qualities that fisheries must possess to be considered sustainable by the Seafood Watch program (these are explained further in the Seafood Watch Standard for Fisheries):

- Follow the principles of ecosystem-based fisheries management.
- Ensure all affected stocks are healthy and abundant.
- Fish all affected stocks at sustainable levels.
- Minimize bycatch.
- Have no more than a negligible impact on any threatened, endangered, or protected species.
- Managed to sustain the long-term productivity of all affected species.
- Avoid negative impacts on the structure, function, or associated biota of aquatic habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.

These guiding principles are operationalized in the four criteria in this standard.Each criterion includes:

- Factors to evaluate and score
- Guidelines for integrating these factors to produce a numerical score and rating

Once a rating has been assigned to each criterion, Seafood Watch develops an overall recommendation. Criteria ratings and the overall recommendation are color coded to correspond to the categories on the Seafood Watch pocket guides and online guide:

Best Choice/Green: Buy first; they're well managed and caught or farmed responsibly.

Good Alternative/Yellow: Buy, but be aware there are concerns with how they're caught, farmed or managed.

Avoid/Red: Take a pass on these for now; they're caught or farmed in ways that harm other marine life or the environment.

[1] "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates

Summary

Blue swimmer crab is a tropical species found in estuaries and inshore marine waters throughout the Indo-Pacific region. This report evaluates the blue swimmer crab (*Portunus armatus*) fisheries in four states of Australia: New South Wales, Queensland, South Australia, and Western Australia. In Australia, blue swimmer crabs are primarily caught using pots but are also caught in the Shark Bay prawn trawl fishery in Western Australia.

Along the east coast of Australia, in New South Wales and Queensland, there is believed to be a single overlapping and semicontinuous blue swimmer crab population. Recent stock assessments conducted in both New South Wales and Queensland indicate that the blue swimmer crab stock is sustainable. In South Australia, three separate biological populations of blue swimmer crab have been identified: Spencer Gulf, Gulf of St. Vincent, and West Coast. Nearly all (99%) blue swimmer crab fishing occurs in the Spencer Gulf and Gulf of St. Vincent. Both the Spencer Gulf and Gulf of St. Vincent populations are being sustained at an appropriate level. In Western Australia, the stock delineation of blue swimmer crabs is uncertain, but there is some evidence of distinct separation between the Peel-Harvey Estuary and Shark Bay. The blue swimmer crab abundances in both the Peel-Harvey Estuary and Shark Bay are believed to be healthy. The Shark Bay stock was declared as fully recovered in 2019.

The pot fisheries in all regions solely target blue swimmer crab, and nontarget catch or bycatch is typically low. But, there may be some concerns regarding bycatch of endangered, threatened, and protected (ETP) species in some regions. For instance, in the Queensland pot fishery, there are concerns about incidental catches of vulnerable sea turtles, other ETP species, and ghost fishing. In the Western Australia Shark Bay prawn trawl fishery that catches blue swimmer crab, bycatch of ETP species such as sea snakes and syngnathids is cause for concern.

The Australian blue swimmer crab fisheries are generally well-managed, and recovery efforts have been successful in Shark Bay. But, data collection and analysis could be improved. In the Queensland pot fishery and the Shark Bay prawn trawl fishery, further management measures are needed to reduce impacts on vulnerable bycatch species.

The crab pots used to catch blue swimmer crab cause low damage to the physical and biological structures of the seafloor, while bottom trawls can cause high damage. Managers have established several spatial closures to limit fishing impacts on bottom habitats and the ecosystem as a whole.

Overall, the blue swimmer crab pot fisheries in the Spencer Gulf and the Gulf of St. Vincent (South Australia), and in the Peel-Harvey Estuary (Western Australia) are rated "Green" because of low impacts on blue swimmer crab, other species, and the environment. The blue swimmer crab pot fisheries in Shark Bay (Western Australia) and New South Wales are rated "Yellow" for possible concerns about bycatch in these areas. The Queensland blue swimmer crab pot fishery is rated "Red" as a result of concerns about the fishery's impact on vulnerable sea turtles, other bycatch species, and ghost fishing, as well as the lack of a bycatch strategy to address these issues. The Shark Bay prawn trawl fishery is rated "Yellow" because of the high impact on bycatch species and on the habitat in general.

Final Seafood Recommendations

SPECIES | FISHERY	C 1 TARGET SPECIES	C 2 OTHER SPECIES	C 3 MANAGEMENT	C 4 HABITAT	OVERALL	VOLUME (MT) YEAR
Blue swimmer crab | Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia	4.284	1.000	3.000	2.449	**Good Alternative (2.369)**	Unknown
Blue swimmer crab | Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia	4.284	3.413	4.000	3.464	**Best Choice (3.773)**	Unknown
Blue swimmer crab | Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia	4.284	3.318	4.000	3.464	**Best Choice (3.746)**	Unknown
Blue swimmer crab | Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia	4.284	1.000	4.000	3.464	**Good Alternative (2.776)**	Unknown
Blue swimmer crab | Southwest Pacific | Pots | Australia | New South Wales	3.413	1.000	3.000	3.742	**Good Alternative (2.488)**	Unknown
Blue swimmer crab | Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia	4.284	3.413	4.000	3.464	**Best Choice (3.773)**	Unknown
Blue swimmer crab | Western Central Pacific | Pots | Australia | Queensland	3.413	1.000	1.000	3.240	**Avoid (1.824)**	Unknown

Production volumes for the Gulf of St Vincent and Spencer Gulf were taken in 2018/19 from (Beckmann et al. 2020). The production volume for Peel-Harvey Estuary (PHE) was taken in 2019 from (Johnston et al. 2020); note that the production volume of PHE was calculated as 90% of the total commercial catch from the West Coast Bioregion (ibid). In Shark Bay, the total TACC in 2019/20 for both the pot and bottom trawl commercial fisheries was set to 589.67 MT {Johnston et al. 2020b}. The production volume from New South Wales was in the 2018/19 season from (Johnson 2020). The production volume from Queensland was taken in the season 2018/19 from (Lovett et al. 2020).

Summary

Overall, the blue swimmer crab pot fisheries in the Spencer Gulf and the Gulf of St. Vincent (South Australia), and in the Peel-Harvey Estuary (Western Australia) are rated "Green" because of low impacts on blue swimmer crab, other species, and the environment. The blue swimmer crab pot fisheries in Shark Bay (Western Australia) and New South Wales are rated "Yellow" for possible concerns about bycatch in these areas.

The Queensland blue swimmer crab pot fishery is rated "Red" as a result of concerns about the fishery's impact on vulnerable sea turtles, other bycatch species, and ghost fishing, as well as the lack of a bycatch strategy to address these issues. The Shark Bay prawn trawl fishery is rated "Yellow" because of the high impact on bycatch species and on the habitat in general.

Scoring Guide

Scores range from zero to five where zero indicates very poor performance and five indicates the fishing operations have no significant impact.

Final Score = geometric mean of the four Scores (Criterion 1, Criterion 2, Criterion 3, Criterion 4).

Best Choice/Green = Final Score >3.2, and no Red Criteria, and no Critical scores

Good Alternative/Yellow = Final score >2.2-3.2, and neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern2, and no more than one Red Criterion, and no Critical scores

Avoid/Red = Final Score ≤2.2, or either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern or two or more Red Criteria, or one or more Critical scores.

[2] Because effective management is an essential component of sustainable fisheries, Seafood Watch issues an Avoid recommendation for any fishery scored as a Very High Concern for either factor under Management (Criterion 3).

Introduction

Scope of the analysis and ensuing recommendation

This report evaluates blue swimmer crab, *Portunus armatus* (formerly *Portunus pelagicus*), caught with pots in New South Wales, Queensland, South Australia, and Western Australia, as well as blue swimmer crab caught in the Western Australia Shark Bay prawn trawl fishery. Small amounts of blue swimmer crab are also caught in other trawl fisheries and in mesh or hoop net fisheries but are not evaluated in this report.

Species Overview

Blue swimmer crab is a large crab in the Portunidae family that can live 3 to 4 years, reaches a carapace width of 20–25 cm, and has a claw span up to 80 cm (Department of Fisheries WA 2011){Johnston et al. 2020b}. It has flat, disc-shaped hind legs that are used like paddles for swimming (Department of Fisheries WA 2011). It is a tropical species found in estuaries and inshore marine waters from the intertidal zone to depths around 50 m, in algal and seagrass habitats and in both sandy and muddy substrata (PIRSA 2020). It is found throughout the Indo-Pacific region and in all six Australian states except Tasmania. Blue swimmer crab is adapted to warmer waters, so in the temperate parts of Australia, the life cycle has evolved to increase growth and reproduction during the warmer times of the year, when water temperatures are elevated (PIRSA 2020). The species reaches sexual maturity at 6–14 months, when it reaches a carapace width of 8.6–11.0 cm {Johnston et al. 2020b}. Spawning generally is protracted and year-round, with peak spawning either in the fall/winter or in the summer, depending on the region and on environmental conditions {Johnston et al. 2020b}(PIRSA 2020).

In Australia, blue swimmer crab is an important species for both the recreational and commercial fisheries. Blue swimmer crab is managed differently in each state. In South Australia, blue swimmer crab is managed by Primary Industries and Regions South Australia. In Western Australia, it is managed by the Government of Western Australia's Department of Primary Industries and Regional Development (DPIRD). In New South Wales, the Department of Primary Industries Fishing and Aquaculture is responsible for fisheries management, and in Queensland, the Department of Agriculture and Fisheries is the management body. The Queensland crab fishery is known as the C1 fishery and comprises both blue swimmer crab and mud crab.

Production Statistics

The global production of blue swimmer crab reached a high of 302,826 tonnes (live weight) in 2017, and then declined somewhat to 251,915 tonnes in 2020 (Figure 1) (FAO 2022).

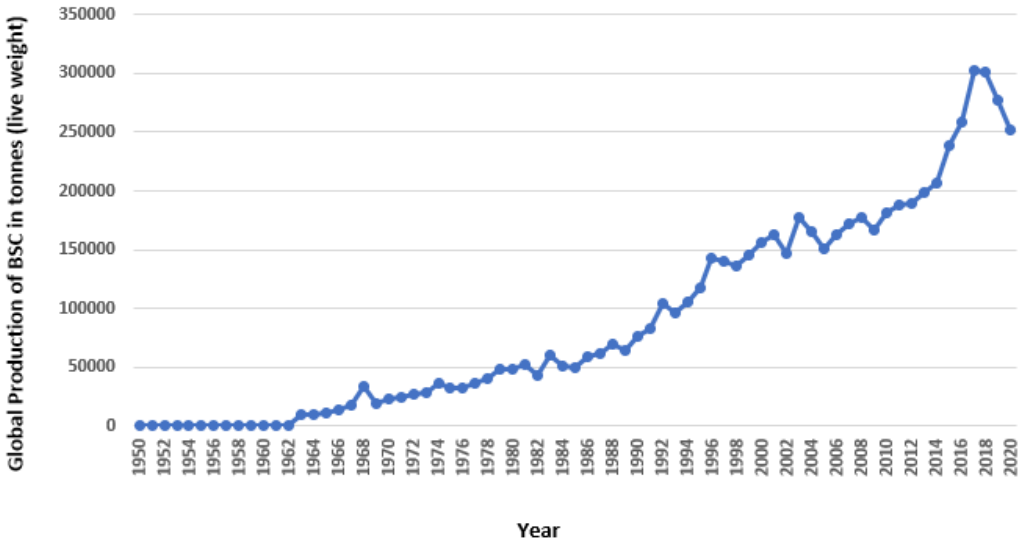


Figure 1: Global production of blue swimmer crab in tonnes (live weight). Taken from (FAO 2022).

In Australia, the total commercial catch was approximately 1,029 t in 2019 {Johnston et al. 2020b}. Historically, the commercial fisheries in Western Australia and Queensland have been the largest, but in both states, catches have declined in recent years (Figure 2) {Johnston et al. 2020b}. In 2018 and 2019, the Shark Bay in Western Australia had the highest blue swimmer crab catch, where the species is caught with both pots and trawls (DPIRD 2020). In all other areas, pots are the predominant gear used to catch blue swimmer crab. There are also significant recreational catches of blue swimmer crab in most areas.

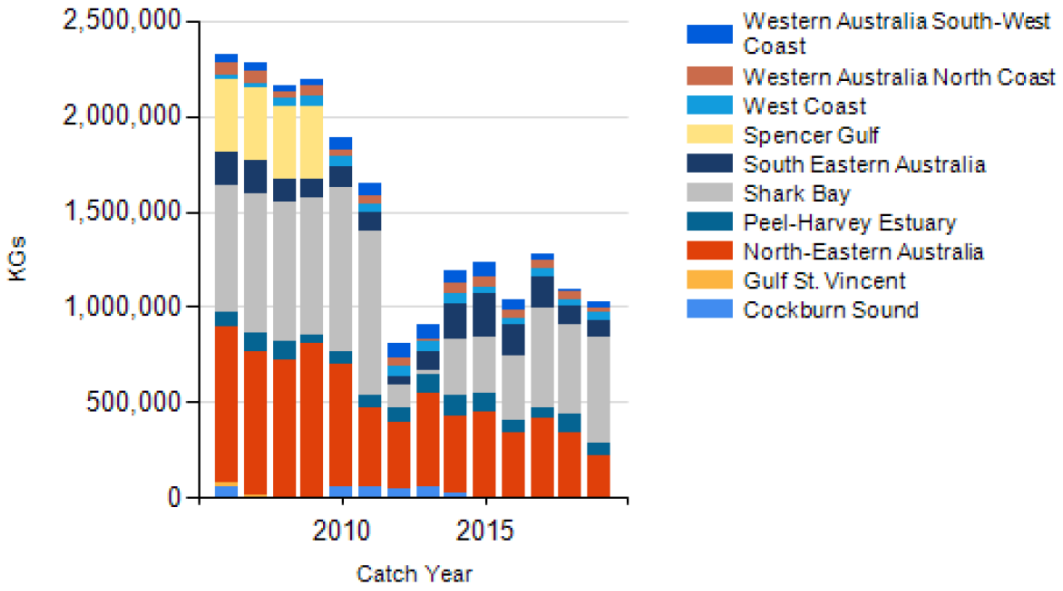


Figure 2: Commercial catch of blue swimmer crab (in kg, excluding confidential catch) from 2006 to 2019. Taken from (Johnston et al. 2020).

Importance to the US/North American market.

Generally, all species of crab imported to the United States from Australia are lumped together. The volume of crab imports to the United States from Australia is small, and in 2021, it was only 3,991 kg. It is unclear if any of this is blue swimming crab (NMFS 2022b).

Currently, most blue swimmer crab imported to the United States comes from Indonesia, the Philippines, China, Vietnam, and India (NMFS 2022); all these blue swimmer crab fisheries are rated "Red"/"Avoid."

Common and market names.

Other common names include blue crab, blue manna, or blueys (Department of Fisheries WA 2013b).

Primary product forms

The primary product forms are pasteurized lump meat, special meat, and claw meat, which can be canned, in pouches, or frozen, as well as raw and cooked whole crab.

Assessment

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Standard for Fisheries, available at www.seafoodwatch.org. The specific standard used is referenced on the title page of all Seafood Watch assessments.

Criterion 1: Impacts on the species under assessment

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. When abundance is unknown, abundance is scored based on the species' inherent vulnerability, which is calculated using a Productivity-Susceptibility Analysis. The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

Rating is Critical if Factor 1.3 (Fishing Mortality) is Critical.

Guiding principles

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level*

Criterion 1 Summary

BLUE SWIMMER CRAB			
REGION / METHOD	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Southwest Pacific | Pots | Australia | New South Wales	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Western Central Pacific | Pots | Australia | Queensland	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

The stock structure of blue swimmer crab on the east coast of Australia is likely overlapping or

semicontinuous. Because of the geographic separation between major fishing grounds for blue swimmer crab in New South Wales and Queensland, they are managed and assessed as separate biological stocks.

In South Australia, three separate biological populations of blue swimmer crab have been identified: Spencer Gulf, Gulf of St. Vincent, and West Coast. Nearly all (99%) blue swimmer crab fishing occurs in the Spencer Gulf and Gulf of St. Vincent. Both the Spencer Gulf and Gulf of St. Vincent populations are being sustained at an appropriate level.

In Western Australia, blue swimmer crab is fished in numerous fisheries across five regions. The stock delineation between these regions is unknown. This report focuses on the major blue swimmer crab fisheries in Western Australia, which occur across two management units: the Peel-Harvey Estuary and Shark Bay.

Criterion 1 Assessments

SCORING GUIDELINES

Factor 1.1 - Abundance
Goal: Stock abundance and size structure of native species is maintained at a level that does not impair recruitment or productivity.

- *5 (Very Low Concern) — Strong evidence exists that the population is above an appropriate target abundance level (given the species' ecological role), or near virgin biomass.*
- *3.67 (Low Concern) — Population may be below target abundance level, but is at least 75% of the target level, OR data-limited assessments suggest population is healthy and species is not highly vulnerable.*
- *2.33 (Moderate Concern) — Population is not overfished but may be below 75% of the target abundance level, OR abundance is unknown and the species is not highly vulnerable.*
- *1 (High Concern) — Population is considered overfished/depleted, a species of concern, threatened or endangered, OR abundance is unknown and species is highly vulnerable.*

Factor 1.2 - Fishing Mortality
Goal: Fishing mortality is appropriate for current state of the stock.

- *5 (Low Concern) — Probable (>50%) that fishing mortality from all sources is at or below a sustainable level, given the species ecological role, OR fishery does not target species and fishing mortality is low enough to not adversely affect its population.*
- *3 (Moderate Concern) — Fishing mortality is fluctuating around sustainable levels, OR fishing mortality relative to a sustainable level is uncertain.*
- *1 (High Concern) — Probable that fishing mortality from all source is above a sustainable level.*

Blue swimmer crab

Factor 1.1 - Abundance

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia

Low Concern

According to the most recent data-limited stock assessment summary from 2019, annual commercial catch per unit effort (CPUE) has increased since 2014–15 (Figure 3) (Beckmann et al. 2020). Fishery independent survey data show that the CPUE of legal-sized crabs has been above the trigger reference point since 2015 (Beckmann et al. 2020). The 2018–19 legal-size CPUE was 4.8 (±0.1 SE) kg/potlift, which was above both the trigger reference point of 1.7 kg/potlift and the target reference point of 2.5 kg/potlift (Beckmann et al. 2020). Although reference points have not been specified for pre-recruit CPUE, the value in March–April of 2018 was the second highest and was comparable to levels in March–April of 2017, when pre-recruits were the highest ever recorded (Beckmann et al. 2020). The primary performance indicator, which is legal-size CPUE, is well above the target reference point, and a quantitative stock assessment is lacking, but data-limited indicators demonstrate that the stock is healthy; hence, abundance has been scored a low concern.

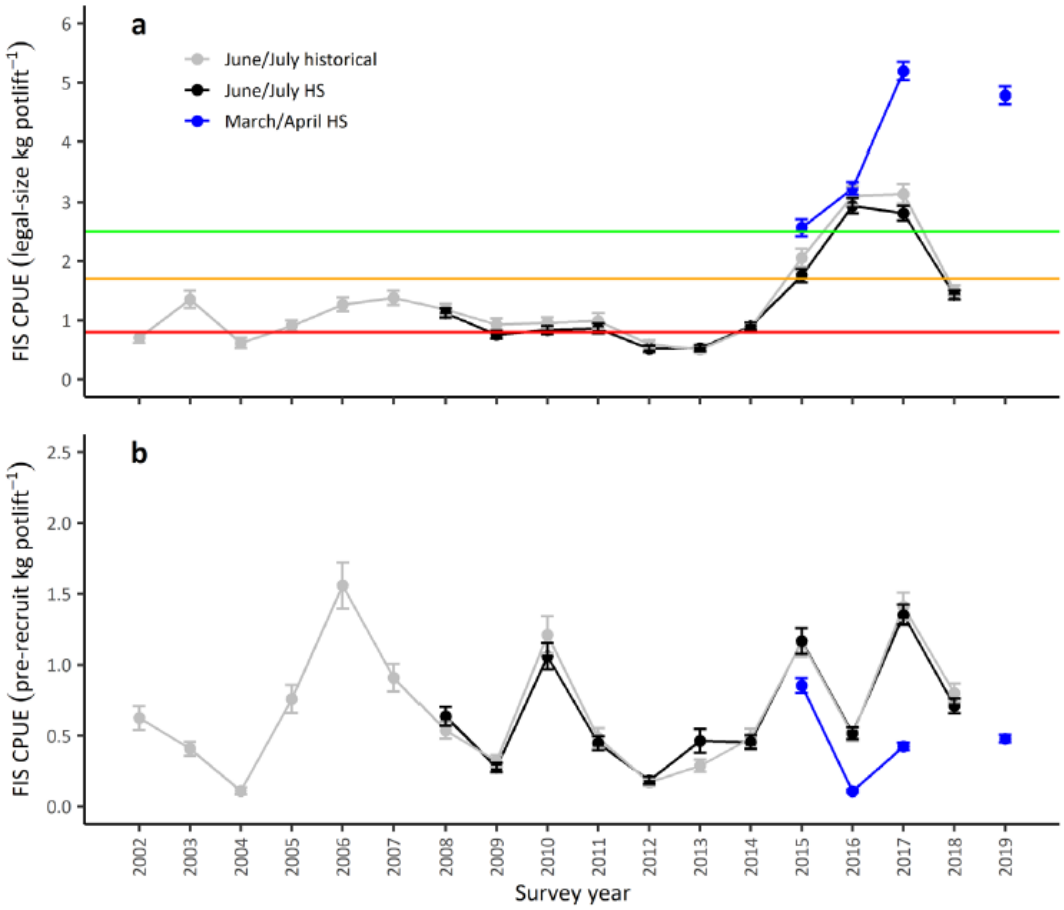


Figure 3: Key fishery independent outputs used to assess the stock status of the blue swimmer crab fishery in the Gulf of St. Vincent. The figure shows fishery-independent catch per unit effort (CPUE) by weight of (a) legal-size crabs (kg/potlift) and (b) pre-recruit crabs (kg/potlift). Green, yellow, and red lines represent the target, trigger, and limit reference points, respectively, for March–April. Error bars indicate standard error. Taken from (Beckmann et al. 2020).

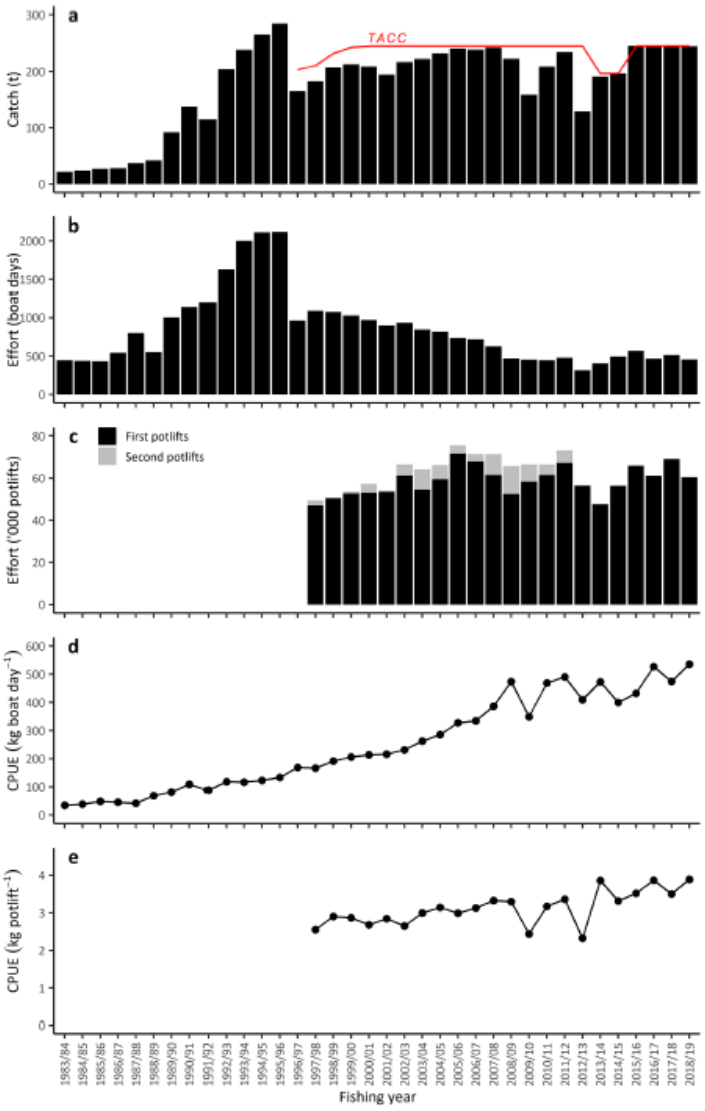


Figure 4: Fishery-dependent outputs of the blue swimmer crab fishery in the Gulf of St. Vincent, showing: (a) trends in total catch in t; (b) targeted effort (boat days); (c) total effort from first and second potlifts by the blue swimmer crab fishery ('000 potlifts); (d) catch per unit effort by day (CPUE/kg boat day); and (e) CPUE by potlift (kg/potlift). Taken from (Beckmann et al. 2020).

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern

According to the latest data-limited stock assessment, conducted in 2018–19, the commercial season catch was 66.5 t from 59,472 traplifts (Johnston et al. 2020). Standardized commercial catch rates have remained constant over time, and range from 0.73 to 1.42 kg/traplift (Figure 5) (Johnston et al. 2020). The 2018–19 season catch rate was 0.92 kg/traplift, which is above the limit reference point of 0.51 kg/traplift and the threshold of 0.73 kg/traplift, and falls within the target

reference range (Johnston et al. 2020). This target reference range extends between maximum and minimum values of the reference period, where the latter represents the threshold level, or the stock level at maximum sustainable yield (MSY) (Johnston et al. 2020). The current catch rate is above the threshold level and within the target range, and a quantitative stock assessment is lacking, but data-limited indicators demonstrate that the stock is healthy; therefore, a score of low concern has been awarded for abundance.

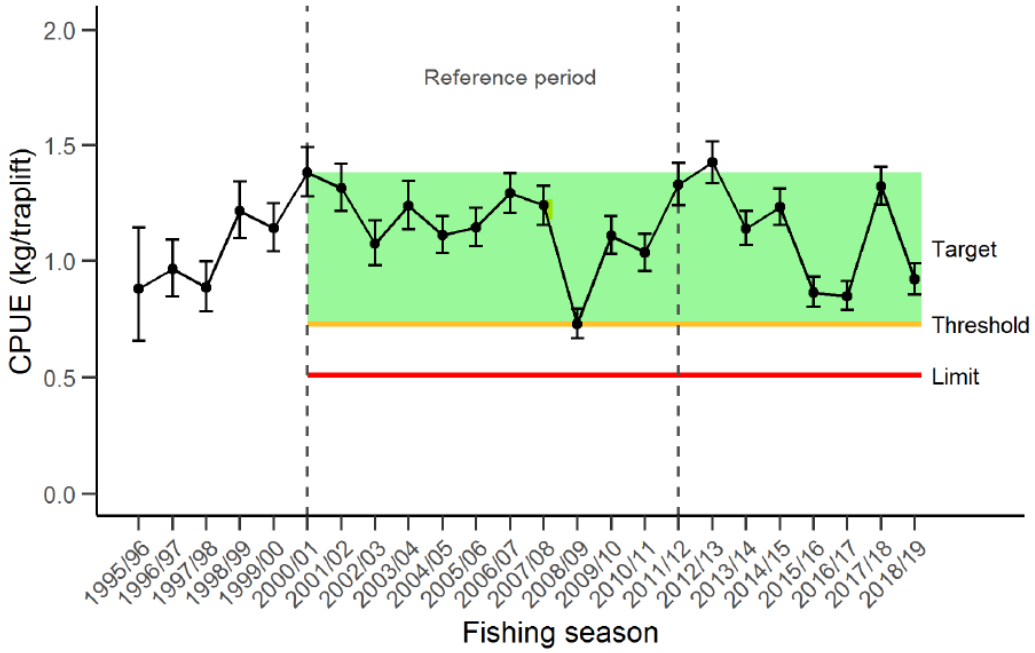


Figure 5: Primary performance indicator: annual standardized commercial catch rate (kg/traplift) of blue swimmer crab in the Peel-Harvey Estuary crab fishery. Taken from (Johnston et al. 2020).

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern

The blue swimmer crab fishery in Shark Bay expanded from 2000 to 2010, with peak landings of 828 t in 2010, caught in a targeted commercial fishery with crab traps, and as a by-product in the prawn and scallop commercial trawl fishing sectors {Johnston et al. 2020b}. But, during the summer of 2010–11, because of an extreme marine heat wave, two flooding events, and high fishing pressure in previous years, the 2011 crab stock abundance reached record low levels {Johnston et al. 2020b}(Chandrapavan et al. 2019). Thereafter, in 2012, commercial fishing for blue swimmer crab was closed {Johnston et al. 2020b}(Chandrapavan et al. 2019). In 2013, indices of spawning stock increased to 1,789 kg/nm^2 (well above the limit reference of 300 kg/nm^2), and recruitment levels improved to 2,197 kg/nm^2 (where the limit reference level was 700 kg/nm^2) {Johnston et al. 2020b}. The most recent data-limited stock assessment estimates from 2017 and 2018 show that the legal CPUE was within the target reference range of >350 kg/nm^2 (Figure 6c),

the juvenile CPUE was above the limit reference point of 991 kg/nm^2 (Figure 6d), the spawning CPUE was above the limit reference point of 200 kg/nm^2 (Figure 6b), and the annual standardized trap CPUE was greater than or equal to the target reference point of 1.4 kg/traplift (Figure 7) (Chandrapavan et al. 2019)(DPIRD 2020e). Since 2013, there has been a steady stock recovery, and in 2019, the stock was declared as fully recovered {Johnston et al. 2020b}. In April 2020, there was a significantly large recruitment event, with spawning and recruitment levels well above the limit, and legal biomass and commercial catch rates well above target reference levels and the historical range {Johnston et al. 2020b}. The Shark Bay blue swimmer crab stock has been deemed as fully recovered, with multiple abundance indicators showing record high levels, and a quantitative stock assessment is lacking, but data-limited indicators demonstrate that the stock is healthy. Hence, a score of low concern has been awarded for abundance.

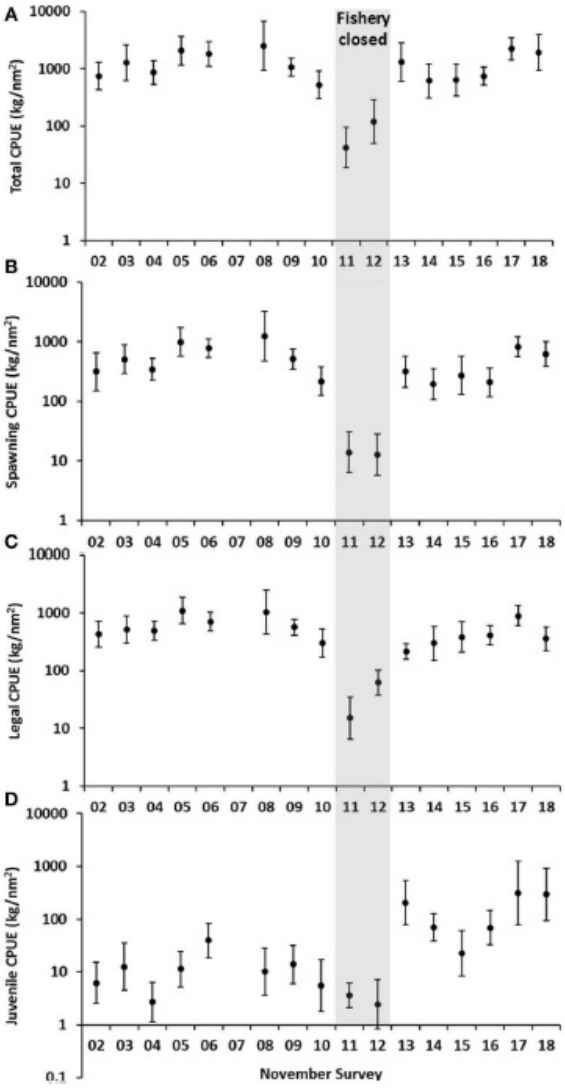


Figure 6: Annual November fishery-independent survey catch rates (standardized mean ±95% CI) from 2002 to 2018 presented on a log scale: (a) total (all crabs) biomass levels; (b) spawning (all females ≥110 mm carapace width [CW]); (c) legal (all crabs ≥135 mm CW); and (d) juvenile (females <110 mm CW, males <100 mm CW). Taken from (Chandrapavan et al. 2019).

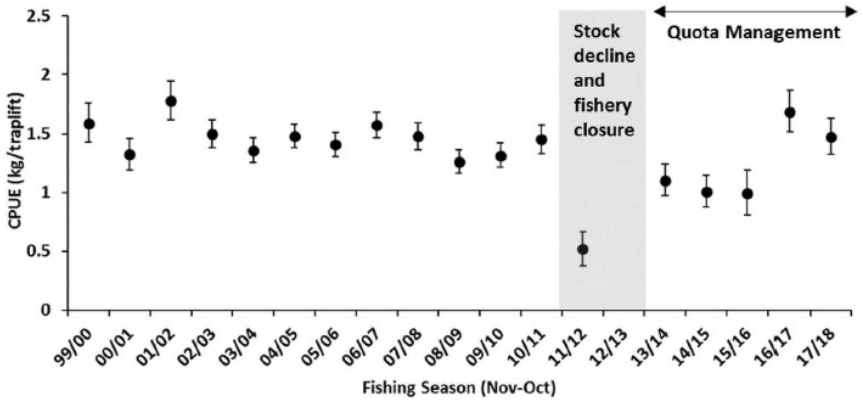


Figure 7: Standardized commercial crab trap legal-size catch rate (mean ±95% CI) (kg/traplift) for the Shark Bay Crab Managed Fishery from 1999 to 2018. Taken from (Chandrapavan et al. 2019).

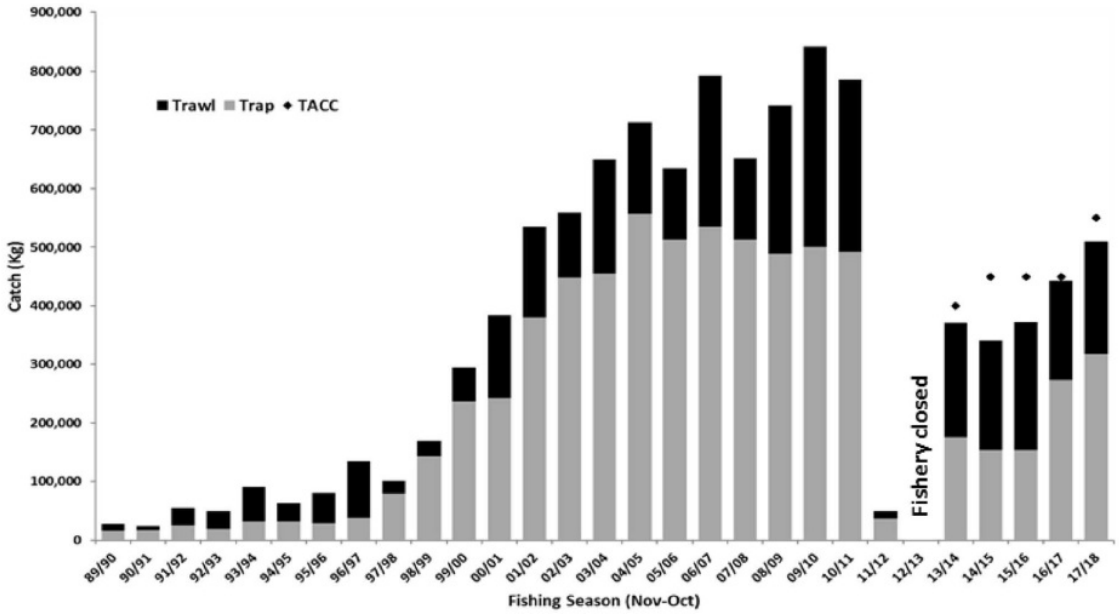


Figure 8: Catch history of the Shark Bay Crab Managed Fishery (by trap and trawl sectors) between 1989 and 2018. Taken from (Chandrapavan et al. 2019).

Southwest Pacific | Pots | Australia | New South Wales

Moderate Concern

The most recent stock assessment conducted using modified Catch-MSY modeling indicates that the biomass of blue swimmer crab in 2018–19 was depleted to 32% relative to unfished levels, with a 95% confidence interval of 6% to 57%, and lies between the limit reference point of $0.2B_0$ and the target reference point of $0.48B_0$ {Johnston et al. 2020b}(Johnson 2020). Thus, the biomass of this stock is unlikely to be fully depleted and recruitment is unlikely to be impaired; however, the Catch-MSY model outputs do include some trajectories that deplete the biomass to less than 20% of the unfished levels within five years {Johnston et al. 2020b}(Johnson 2020). Because the current

predicted mean biomass is less than 75% of the target reference point, a score of moderate concern has been awarded for abundance.

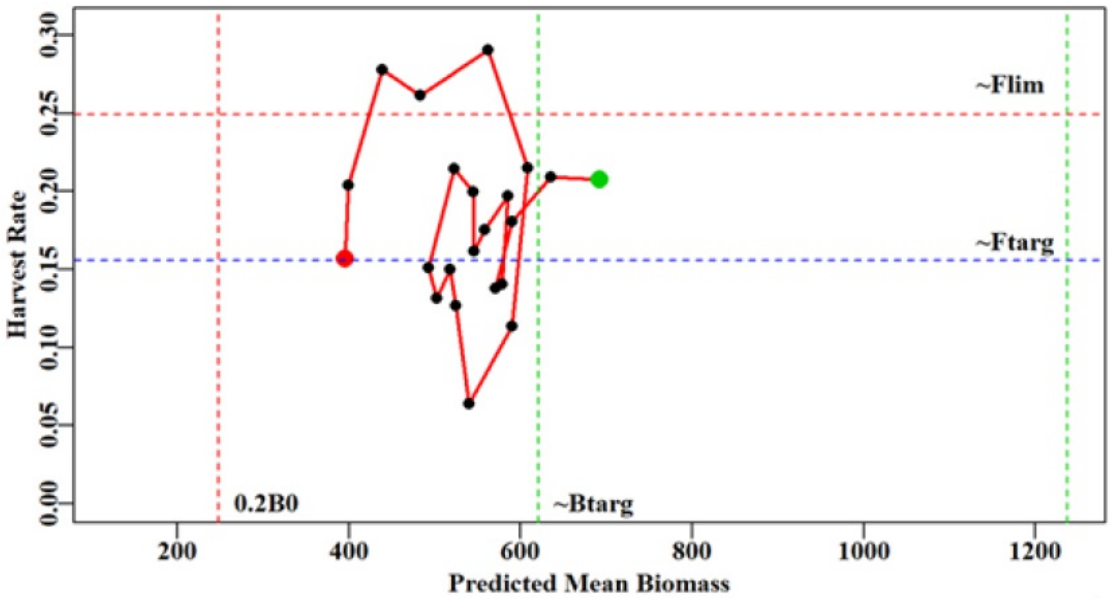


Figure 9: BSC stock status trajectory from 1997–98 to 2018–19, showing annual stock status in estimated biomass (t) and harvest rate. The start of the trajectory in 1997–98 is indicated by a green point and final year 2018–19 by a red point. Taken from (Johnson 2020).

Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Low Concern

According to the most recent data-limited stock assessment from 2019, annual commercial CPUE has been stable over the past ten seasons (Beckmann et al. 2020). Fishery independent survey data show that the CPUE of legal-sized crab has been above the trigger reference point since 2016 (Figure 10) (Beckmann et al. 2020). The 2018–19 legal-size CPUE was 5.3 (±0.1 SE) kg/potlift, which was above both the trigger reference point of 2.4 kg/potlift and the target reference point of 3.7 kg/potlift (Beckmann et al. 2020). Although reference points have not been specified for pre-recruit CPUE, the value in 2019 was above the historically low levels observed in June–July of 2002–06. Because the primary performance indicator, which is legal-size CPUE, is well above the target reference point, and a quantitative stock assessment is lacking but data-limited indicators demonstrate that the stock is healthy, abundance has been scored a low concern.

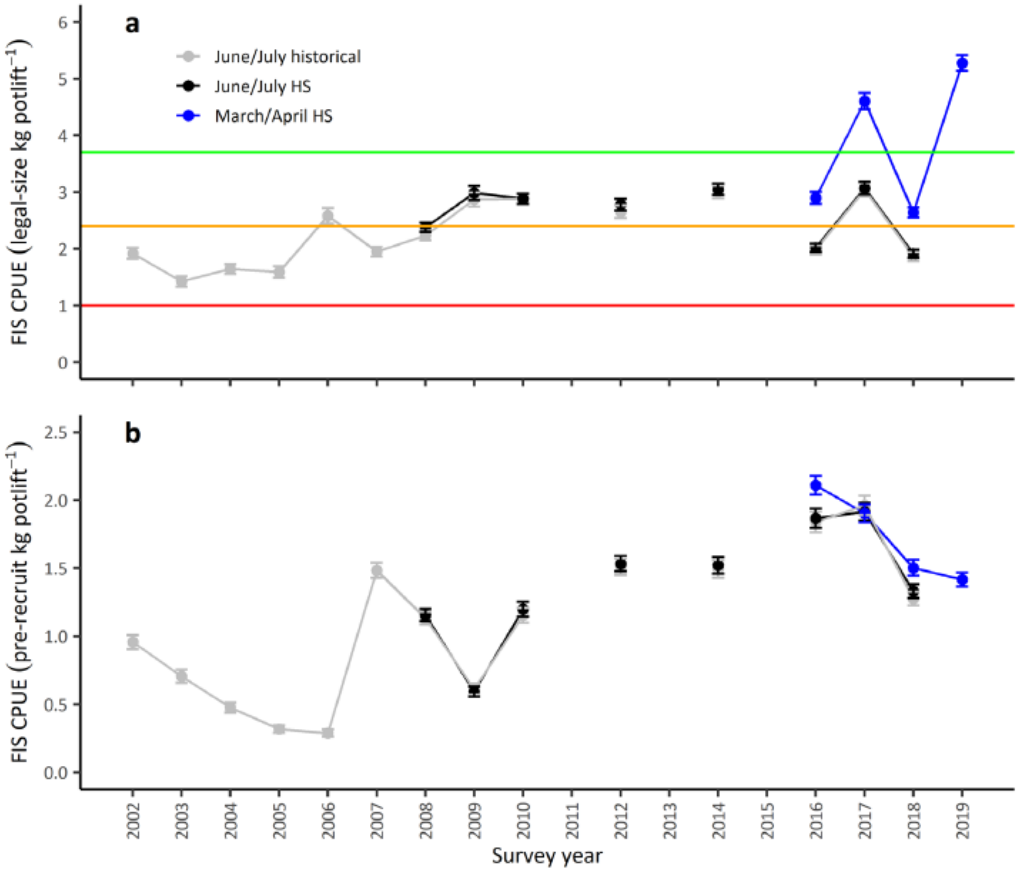


Figure 10: Key fishery independent outputs used to assess the stock status of the blue swimmer crab fishery in the Spencer Gulf. The figure shows fishery-independent catch per unit effort (CPUE) by weight of (a) legal-size crab (kg/potlift), and (b) pre-recruit crab (kg/potlift). The green, yellow, and red lines represent the target, trigger, and limit reference points, respectively, for March–April. Error bars are standard error. Taken from (Beckmann et al. 2020).

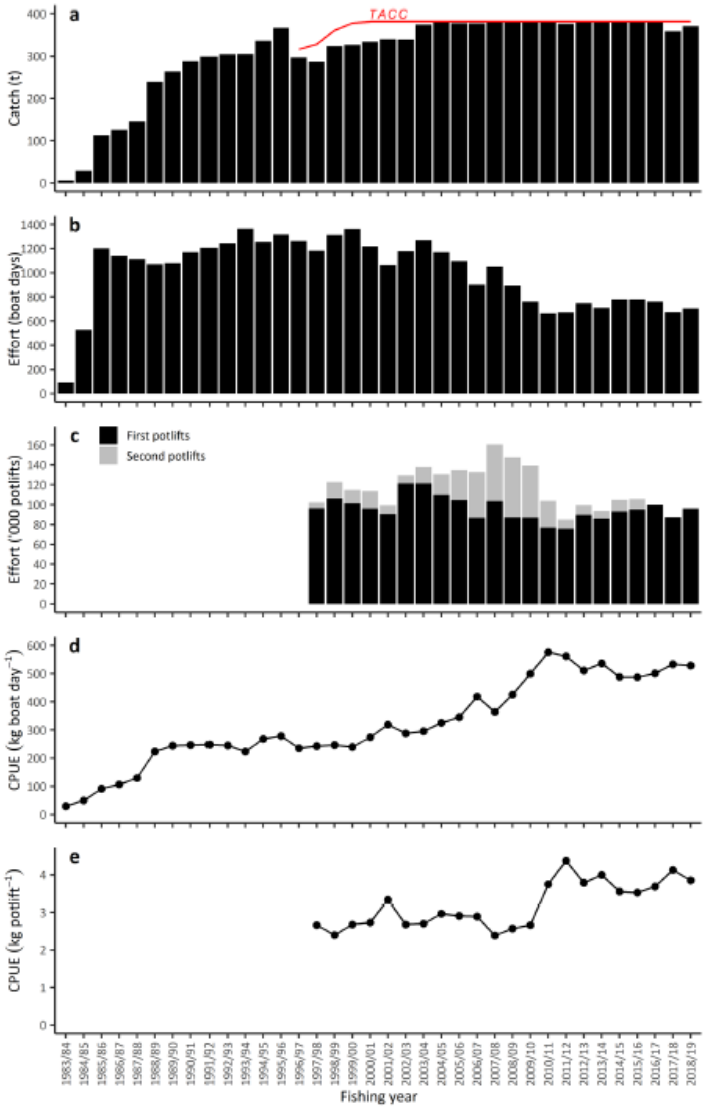


Figure 11: Fishery-dependent outputs of the blue swimmer crab fishery in the Spencer Gulf, showing: (a) trends in total catch in t; (b) targeted effort (boat days); (c) total effort from first and second potlifts by the blue swimmer crab fishery ('000 potlifts); (d) catch per unit effort by day (CPUE/kg boat day); and (e) CPUE by potlift (kg/potlift). Taken from (Beckmann et al. 2020).

Western Central Pacific | Pots | Australia | Queensland

Moderate Concern

According to the most recent stock assessment of blue swimmer crab in Queensland, the exploitable biomass fell to around 33% of the unfished biomass in 2018–19 (Lovett et al. 2020). The maximum sustainable yield (MSY) is estimated at approximately 631–843 t per year, and the yield required to maintain a biomass ratio of 60% was estimated at 415–557 t (Lovett et al. 2020). Because the exploitable biomass ratio in 2018–19 was approximately 0.34, which was above the limit reference point but less than 75% of the target reference point, a score of moderate concern has been awarded for abundance.

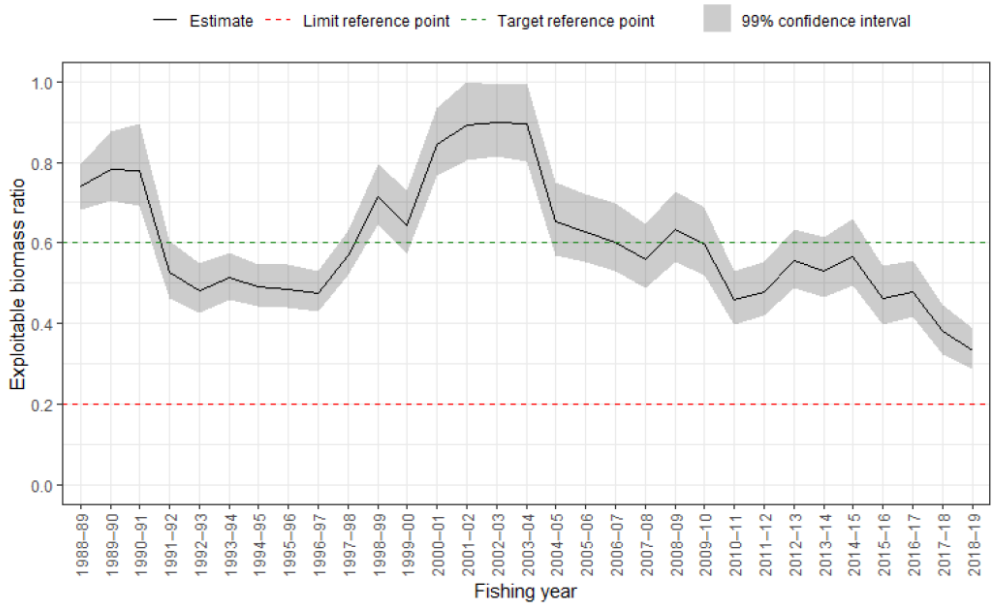


Figure 12: Annual exploitable biomass relative to virgin biomass for Queensland east coast blue swimmer crab. Taken from (Lovett et al. 2020).

Factor 1.2 - Fishing Mortality

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia

Low Concern

In the Gulf of St. Vincent, the annual total allowable commercial catch (TACC) was fully harvested from 2014–15 to 2018–19 (Beckmann et al. 2020). From 2015 to 2016, the annual TACC was increased to 245 t, because the TACC setting is linked to the legal-sized CPUE (PIRSA 2020), and abundance since 2015–16 has been above the trigger reference point/goal and in 2018–19 was above the target reference point/goal (Beckmann et al. 2020). This suggests that fishing levels on this population are likely sustainable. Thus, a score of low concern has been awarded for fishing mortality.

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern

Commercial catches of blue swimmer crab in the Peel-Harvey Estuary have remained relatively stable after the mid-1990s, ranging from 50 t to 100 t (Figure 13) (Johnston et al. 2020). An annual TACC is set, with a catch/effort tolerance level (DPIRD 2020c). The catch/effort tolerance range is set to ensure that catch/effort remains within specific limits. Therefore, if the catch does not breach the specified tolerance level, it may be inferred that overfishing is not occurring. In November 2018, the predicted commercial catch for 2018–19 was 80 t; the actual catch was 66.5 t, which was within the predictive range (Johnston et al. 2020). In addition, the mean annual standardized size of crabs caught in the commercial fishing industry from 2006 to 2019 has ranged from 127 to 136 mm;

thus, the size of fished crabs has remained at or above the minimum legal size of 127 mm (Figure 14) (Johnston et al. 2020). The population is thought to be well protected because the minimum size limit for both the commercial and recreational fisheries (i.e., 127 mm CW) is well above the size at which crabs sexually mature (i.e., 86–98 mm CW), ensuring that the crabs can reproduce at least once before they are caught {Johnston et al. 2020b}. Because the most recent catch estimates did not breach the tolerance range, and the mean carapace width of crabs is above the minimum size limit, this factor has been scored a low concern.

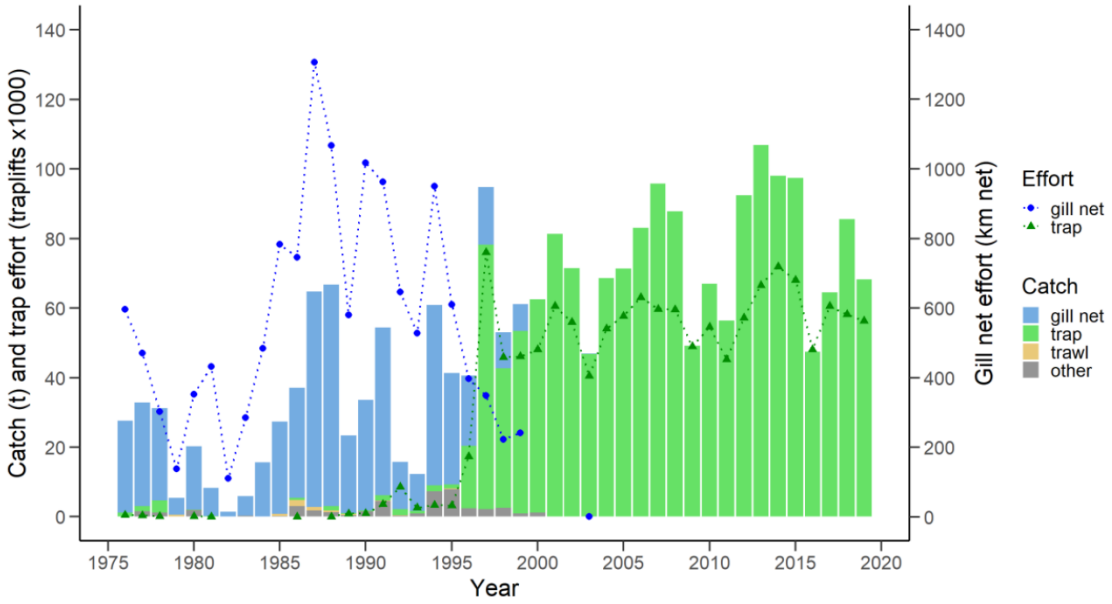


Figure 13: Annual commercial catch (tonnes) and effort for each fishing method in the Peel-Harvey Estuary from 1976 to 2019. Taken from (Johnston et al. 2020).

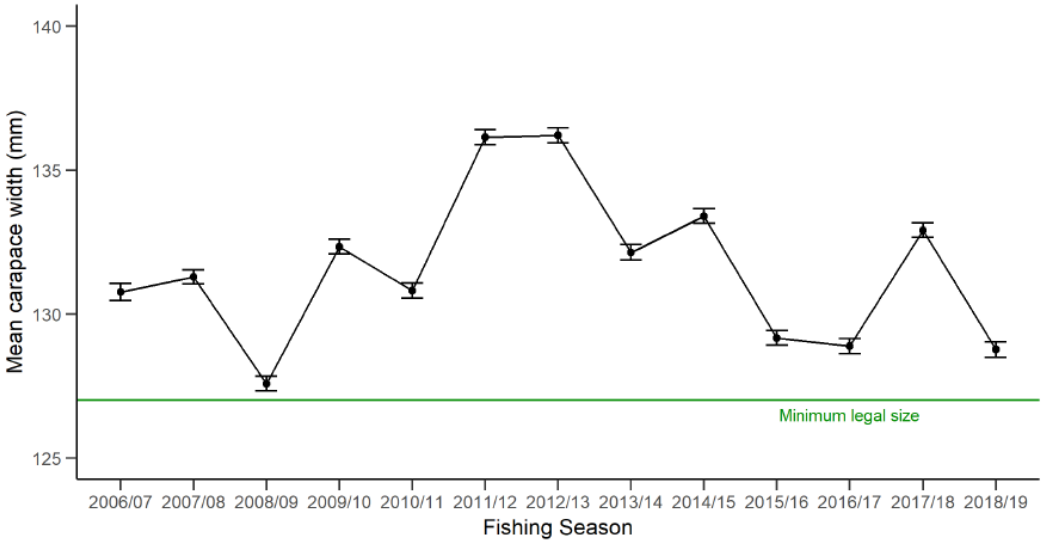


Figure 14: Mean standardized annual size (CW, mm; ±95% confidence intervals) of blue swimmer crab measured during commercial monitoring surveys in the Peel-Harvey Estuary each fishing season from 2006–07 to 2018–19. Taken from (Johnston et al. 2020).

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern

There is a TACC in place to ensure that fishing pressure on the Shark Bay blue swimmer crab population is controlled {Johnston et al. 2020b}. Further, in 2020, as a consequence of record-high abundance levels, the TACC was increased from 550 t to 650 t, which is the maximum quota set for this fishery {Johnston et al. 2020b}. A catch tolerance range for the Shark Bay Crab Managed Fishery has been defined as achieving at least 90% of the annual TACC; if the catch/effort remains within the tolerance range, the fishery is considered to be operating acceptably (DPIRD 2020e). These facts collectively indicate that fishing pressure on the Shark Bay blue swimmer crab stock is likely at a sustainable level. Hence, fishing mortality has been rated a low concern.

Southwest Pacific | Pots | Australia | New South Wales

Low Concern

According to the most recent stock assessment, in 2018–19, under revised management strategies, the estimated harvest rate of blue swimmer crab in New South Wales (which is used as the fishing mortality proxy) declined and remained at 0.15, which was at the target reference point of F_{TARG} (F_{MSY}) (Johnson 2020) (see Figure 9). As a result, fishing mortality is scored a low concern.

Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Low Concern

In the Spencer Gulf, the total allowable catch limit has remained constant since the early 2000s. The annual TACC was nearly fully harvested (up to ≈98%) from 2003–04 to 2016–17, and was harvested up to 94% in 2017–18 (Beckmann et al. 2020). In 2018–19, 97% of the TACC was

harvested, which was equivalent to a 10 t under-catch (Beckmann et al. 2020). During this time, the population has remained above the limit abundance reference point/goal and is currently above the target reference point/goal (Beckmann et al. 2020). Because the TACC setting is linked to the legal-sized CPUE (PIRSA 2020), this suggests that fishing levels on this population are likely sustainable. Thus, a score of low concern has been awarded for fishing mortality.

Western Central Pacific | Pots | Australia | Queensland

Low Concern

Per the updated stock assessment, fishing pressure on the blue swimmer crab stock in Queensland in 2018–19 was approximately 0.48, which was below the target reference point of F_{60} = 0.55 (Figure 15) (Lovett et al. 2020). Hence, fishing mortality has been awarded a score of low concern.

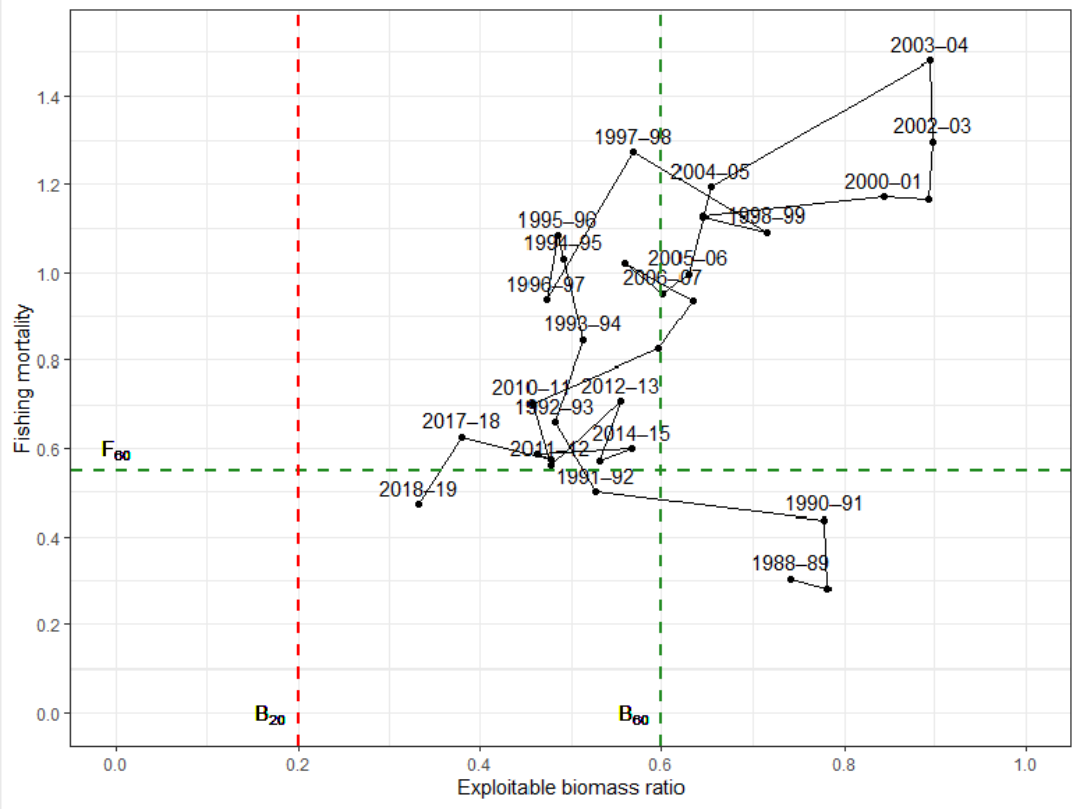


Figure 15: Phase plot of fishing pressure over time relative to the predicted exploitable biomass trajectory. Taken from (Lovett et al. 2020).

Criterion 2: Impacts on Other Species

All main retained and bycatch species in the fishery are evaluated under Criterion 2. Seafood Watch defines bycatch as all fisheries-related mortality or injury to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing. Species are evaluated using the same guidelines as in Criterion 1. When information on other species caught in the fishery is unavailable, the fishery's potential impacts on other species is scored according to the Unknown Bycatch Matrices, which are based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type. The fishery is also scored for the amount of non-retained catch (discards) and bait use relative to the retained catch. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard/bait score. The Criterion 2 rating is determined as follows:

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

Rating is Critical if Factor 2.3 (Fishing Mortality) is Crtitical

Guiding principles

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level.*
- *Minimize bycatch.*

Criterion 2 Summary

Criterion 2 score(s) overview

This table(s) provides an overview of the Criterion 2 subscore, discards+bait modifier, and final Criterion 2 score for each fishery. A separate table is provided for each species/stock that we want an overall rating for.

BLUE SWIMMER CRAB			
REGION / METHOD	**SUB SCORE**	**DISCARD RATE/LANDINGS**	**SCORE**
Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia	1.000	1.000: < 100%	Red (1.000)
Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia	3.413	1.000: < 100%	Green (3.413)
Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia	3.318	1.000: < 100%	Green (3.318)
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia	1.000	1.000: < 100%	Red (1.000)
Southwest Pacific | Pots | Australia | New South Wales	1.000	1.000: < 100%	Red (1.000)
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia	3.413	1.000: < 100%	Green (3.413)
Western Central Pacific | Pots | Australia | Queensland	1.000	1.000: < 100%	Red (1.000)

Criterion 2 main assessed species/stocks table(s)

This table(s) provides a list of all species/stocks included in this assessment for each 'fishery' (as defined by a region/method combination). The text following this table(s) provides an explanation of the reasons the listed species were selected for inclusion in the assessment.

GULF OF ST. VINCENT | INDIAN OCEAN, EASTERN | POTS | AUSTRALIA | SOUTH AUSTRALIA			
SUB SCORE: 3.413	DISCARD RATE: 1.000	**SCORE: 3.413**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Degen's leatherjacket	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Rough rock crab	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Spider crab	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Blue swimmer crab	3.670: Low Concern	5.000: Low Concern	Green (4.284)

PEEL-HARVEY ESTUARY | INDIAN OCEAN, EASTERN | POTS | AUSTRALIA | WESTERN AUSTRALIA			
SUB SCORE: 3.318	DISCARD RATE: 1.000	**SCORE: 3.318**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Striped mullet	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)
Blue swimmer crab	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Yellow-eye mullet	3.670: Low Concern	5.000: Low Concern	Green (4.284)

SHARK BAY | INDIAN OCEAN, EASTERN | BOTTOM TRAWLS | AUSTRALIA | WESTERN AUSTRALIA			
SUB SCORE: 1.000	DISCARD RATE: 1.000	**SCORE: 1.000**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Sawfish species	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea snakes (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Finfish	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Goatfish	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Saucer scallop	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Sea turtles	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Syngnathidae species	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Benthic inverts	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Brushtooth lizardfish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Western king prawn	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)
Blue swimmer crab	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Brown Tiger Prawn	3.670: Low Concern	5.000: Low Concern	Green (4.284)

SHARK BAY | INDIAN OCEAN, EASTERN | POTS | AUSTRALIA | WESTERN AUSTRALIA			
SUB SCORE: 1.000	DISCARD RATE: 1.000	**SCORE: 1.000**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Dugong	1.000: High Concern	1.000: High Concern	Red (1.000)
Marine mammals	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea snakes (unspecified)	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Sawfish species	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Sea turtles	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Syngnathidae species	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Benthic inverts	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Finfish	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Blue swimmer crab	3.670: Low Concern	5.000: Low Concern	Green (4.284)

SOUTHWEST PACIFIC | POTS | AUSTRALIA | NEW SOUTH WALES			
SUB SCORE: 1.000	DISCARD RATE: 1.000	**SCORE: 1.000**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Marine mammals	1.000: High Concern	1.000: High Concern	Red (1.000)
Blue swimmer crab	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

SPENCER GULF | INDIAN OCEAN, EASTERN | POTS | AUSTRALIA | SOUTH AUSTRALIA			
SUB SCORE: 3.413	DISCARD RATE: 1.000	**SCORE: 3.413**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Degen's leatherjacket	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Rough rock crab	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Spider crab	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Blue swimmer crab	3.670: Low Concern	5.000: Low Concern	Green (4.284)

WESTERN CENTRAL PACIFIC | POTS | AUSTRALIA | QUEENSLAND			
SUB SCORE: 1.000	DISCARD RATE: 1.000	**SCORE: 1.000**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Marine mammals	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea turtles	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea snakes (unspecified)	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
False Water Rat	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Grouper (unspecified)	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Saltwater crocodile	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Sawfish species	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Seabirds	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Speartooth Shark	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Benthic inverts	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Blue swimmer crab	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Finfish	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Serrated swimming crab	3.670: Low Concern	5.000: Low Concern	Green (4.284)

The blue swimmer crab pot fisheries in Australia generally catch low amounts of nontarget species. In New South Wales, bycatch of nontarget species was low (Barnes et al. 2022b). But, because the Seafood Watch (SFW) Unknown Bycatch Matrix (UBM) indicates that marine mammals are susceptible to pots and traps in the Southwest Pacific, and because these species are known to occur along the coast of New South Wales, particularly in regions such as Wallis Lake where blue swimmer crab is fished, marine mammals were included as a main species. In the New South Wales pot fishery, marine mammals limit the score per the UBM.

In the South Australia pot fishery, the primary bycatch species are rough rock crab (approximately 81% of the total bycatch), spider crab, and Degen's leatherjacket (Hooper 2018). All other species accounted for <5% of the bycatch. The impact of the South Australia blue swimmer crab pot fishery on these other crab species is low. In the South Australia pot fisheries, both in the Spencer Gulf and Gulf of St. Vincent, no species limit the score.

In the Queensland crab pot fishery, mud crab is also targeted by operators in the Criterion 1 fishery, so it has been included as a main species (DAF 2019). Unknown species of finfish and benthic invertebrates are caught as bycatch, so they have been added as main species (DAF 2019). Other species of crabs, including coral swimmer crab (*Charybdis feriatus*), three spot crab (*Portunus saguinolentus*), and hairyback crab (*Charybdis natator*), are also caught as nontarget species but generally compose <10 t of the catch and make up <5% of the catch, so they have been excluded as main species (DAF 2019). "Species of Conservation Concern" that are listed as vulnerable, threatened, or endangered under the Nature Conservation Act 1992 and the Environmental Protection and Biodiversity Conservation Act 1999 and/or protected under the Fisheries Regulation 2008 that have been either reported to interact with crab pots

through fisher logbooks and/or identified as high-risk species in this fishery through a Level 1 Ecological Risk Assessment have been included as main species (DAF 2019){Walton and Jacobsen 2019}. These include: marine mammals, marine turtles, saltwater crocodile, sea snakes, seabirds, grouper, sawfishes, and false water rats (DAF 2019). In the Queensland crab pot fishery, marine mammals limit the score following the SFW standard and the UBM, and sea turtles limit the score because of their protected status and the ecological risk assessment conducted.

In the Peel-Harvey Estuary in Western Australia, catch composition data and an Ecological Risk Assessment indicate that there are no significant bycatch species caught in crab pots (Fisher et al. 2020). But, discards of bait species (striped mullet and yelloweye mullet) have been included as main species. In the Peel-Harvey Estuary crab pot fishery, no species limit the score.

In Shark Bay, Western Australia, few species are caught as bycatch in blue swimmer crab pots (DPIRD 2020). Low numbers of coral crab (*Charybdis cruciata*), sand crab (*Ovalipes australiensis*), octopus, toadfish (*Lagocephalus sceleratus*), and spangled emperor (*Lethrinus nebulosus*) may end up as bycatch but have been excluded due to these low numbers (DPIRD 2020). Unknown species of finfish and benthic invertebrates may end up as bycatch and have been included as main species (DPIRD 2020). Although there have been no reported interactions between crab pots and protected species, DPIRD 2020 mentions that there is a potential for the fishery to interact with species such as sawfish, cetaceans, dugong, sea snakes, sea turtles, and syngnathids (DPIRD 2020); hence, they have been included as main species. In the Shark Bay crab pot fishery, dugong and marine mammals limit the score because of their protected status and the SFW UBM.

In Western Australia, blue swimmer crab is also caught in the Shark Bay prawn trawl fishery, so this fishery was assessed in this report. The western king prawn and the Australian tiger prawn account for most of the retained catch in this fishery and have been included as main species. Bycatch and discards in this fishery are high (DPIRD 2020). From fishery-independent trawl survey catch composition data, species that made up >5% of the catch (such as western king prawn, saucer scallop, goatfish, and brushtooth lizardfish) were included as main species. Brown tiger prawn was added as a main species, because it is typically caught in large volumes in the Shark Bay prawn trawl fishery. Further, many smaller volumes of unknown benthic invertebrates and finfish are typically caught in the prawn trawl fishery, so they were also added as main species. Because syngnathids and sea snakes are caught in prawn trawl nets in Shark Bay, they were included as main species (DPIRD 2020). Low numbers of sawfish are caught in prawn trawl nets and were included as a main species because it is of conservation concern. Turtles are also caught in prawn trawl nets, so they were included as main species. In the Shark Bay prawn trawl fishery in Western Australia, sawfish limit the score due to its protected status and the SFW UBM, and sea snakes limit the score because of their protected status and their susceptibility to trawls. Since 2004, turtle excluder devices (TED) and other secondary bycatch reduction devices have been fully implemented in trawls in Shark Bay (DPIRD 2020), and reduce bycatch volumes.

Criterion 2 Assessment

SCORING GUIDELINES

Factor 2.1 - Abundance
(same as Factor 1.1 above)

Factor 2.2 - Fishing Mortality
(same as Factor 1.2 above)

Factor 2.3 - Modifying Factor: Discards and Bait Use
Goal: Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For fisheries that use bait, bait is used efficiently.

Scoring Guidelines: The discard rate is the sum of all dead discards (i.e. non-retained catch) plus bait use divided by the total retained catch.

Ratio of bait + discards/landings	Factor 2.3 score
<100%	1
>=100	0.75

Benthic inverts

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Moderate Concern

The striated locust lobster (*Eduarctus martensii*), a benthic invertebrate found in Shark Bay, is categorized as "Least Concern" by the International Union for the Conservation of Nature (IUCN) (Chan, T.Y. 2013), so benthic invertebrates have been assigned a score of moderate concern for abundance.

Justification:

Trawl surveys revealed that several benthic invertebrates are found in Shark Bay (Kangas and Morrison 2013), including, but not limited to: *Penaeus latisulcatus*, *Annachlamys flabellata*, *Portunus rubromarginatus*, *Portunus tenuipes*, *Metapenaeopsis crassissima*, *Herdmania pallida*, *Metapenaeus dalli*, *Metapenaeus endeavouri*, *Colochirus quadrangularis*, *Eduarctus martensii*, *Thalamita sima*, *Colochirus crassus*, and *Portunus hastatoides*. Of these species, none were listed by the IUCN or on the Australian species profile and threats database, and no stock stock assessments of these species have been conducted, except for the striated locust lobster (*E. martensii*), which has been listed by the IUCN.

Western Central Pacific | Pots | Australia | Queensland

Moderate Concern

According the SFW standard, unknown benthic invertebrates including crustaceans and other invertebrates that are caught as bycatch are rated a moderate concern for abundance.

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Moderate Concern

Because the fishing mortality of benthic invertebrates found in trawl nets in Shark Bay is unknown, a score of moderate concern has been awarded for this factor.

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia
Western Central Pacific | Pots | Australia | Queensland

Low Concern

According to the SFW Unknown Bycatch Matrix, benthic invertebrates caught as bycatch in pots are scored 3.5 out of 5, so fishing mortality is considered a low concern.

Brown Tiger Prawn

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Low Concern

The brown tiger prawn stock is assessed following a weight of evidence, data-limited approach (Newman et al. 2021). The spawning stock biomass in the northern Carnarvon Peron Line area between June and July was 27.4 kg/hr, and in the southern Carnarvon Peron Line area was 71.3 kg/hr, 16.7 kg/hr, and 18.7 kg/hr in June, August, and September, respectively (Newman et al. 2021). The combined spawning stock biomass in these two areas was above the target reference point of 25 kg/hr (Newman et al. 2021). Because the stock appears to be healthy, abundance of brown tiger prawn has been scored a low concern.

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Low Concern

The brown tiger prawn catch prediction was 435 to 650 t, with an annual catch tolerance range set at 400 to 700 t (Newman et al. 2021). The catch/effort tolerance range is set to ensure that catch/effort remains within specific limits. Therefore, if the catch does not breach the specified tolerance level, it may be inferred that overfishing is not occurring. In 2020, the total catch was 680 t, which was above the upper end of the predicted catch but within the catch tolerance range (Newman et al. 2021). Further, fishing effort since 2007 (when all boats adopted quad gear) has been between 33,000 and 41,000 trawl hours (standardized to twin nets); in 2020, fishing effort was the lowest recorded for the fishery, at 29,000 trawl hours, and was reduced as a precautionary measure (Newman et al. 2021). Taken together, fishing mortality appears to be controlled, so it is scored a low concern.

Brushtooth lizardfish

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Moderate Concern

There has been no stock assessment of brushtooth lizardfish (*Saurida undosquamis*) from Shark Bay, so a productivity-susceptibility analysis (PSA) was conducted to determine the vulnerability score of the species. The PSA generated a score of 2.97, indicating that brushtooth lizardfish has medium vulnerability. For this reason, abundance has been rated a moderate concern.

Justification:

Productivity Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	All individuals over 1 year are sexually mature.	1
Von Bertalanffy (Brody) Growth Coefficient (K)	K = 0.500 from Australia (FishBase 2022)	1

Fecundity	19,856 to 79,282 (Kadarsha et al. 2013); up to 38,388 (FishBase 2022b)	1
Average maximum size	Max length = 50 cm SL (FishBase 2022c)	1
Average size at maturity	Lm = 15 cm for males and 15.5 cm for females	1
Reproductive strategy	Lizardfish are generally broadcast spawners {Grabowski et al. 2014}	1
Productivity score		1

Susceptibility Attribute	**Relevant information**	**Score (1 = low risk, 2 = medium risk, 3 = high risk)**
Areal overlap (Considers all fisheries)	Unknown, default score used	3
Vertical overlap (Considers all fisheries)	Unknown, default score used	3
Seasonal Availability (Considers all fisheries; score using the most conservative option)	Unknown, default score used	3
Selectivity of fishery (Specific to fishery under assessment)	Default score used; conditions of "high risk" do not apply	2
Post-capture mortality (Specific to fishery under assessment)	Unknown, but species likely retained	3
Susceptibility score		2.8

Vulnerability = $\sqrt{(P^2 + S^2)}$

$V = \sqrt{(1^2 + 2.8^2)}$

$V = 2.97$

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Moderate Concern

There has been no stock assessment conducted on brushtooth lizardfish from Shark Bay, so fishing mortality is unknown. For this reason, this factor has been rated a moderate concern.

Degen's leatherjacket

Factor 2.1 - Abundance

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Moderate Concern

There has been no stock assessment of Degen's leatherjacket (*Thamnaconus degeni*) from South Australia, so a productivity-susceptibility analysis (PSA) was conducted to determine the vulnerability score of the species.

The PSA generated a score of 2.97, indicating that Degen's leatherjacket has medium vulnerability. As a result, abundance has been rated a moderate concern.

Justification:

Productivity Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	1.6 to 2.6 yrs (FishBase 2022d)	1
Von Bertalanffy (Brody) Growth Coefficient (K)	K = 0.36/yr (FishBase 2022d)	1
Fecundity	28,250 to 218,000 eggs in reticulated leatherjacket (Zouari-Ktari and Bradai 2011)	1
Average maximum size	Max length = 28 cm TL (FishBase 2022e)	1
Average size at maturity	Lm = 17.4 cm TL (FishBase 2022d)	1
Reproductive strategy	Leatherjackets are generally broadcast spawners {Miller and Stewart 2012}	1
Productivity score		1

Susceptibility Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	Unknown, default score used	3
Vertical overlap (Considers all fisheries)	Unknown, default score used	3
Seasonal Availability (Considers all fisheries; score using the most conservative option)	Unknown, default score used	3
Selectivity of fishery (Specific to fishery under assessment)	Default score used; conditions of "high risk" do not apply	2
Post-capture mortality (Specific to fishery under assessment)	Unknown, but species likely retained	3
Susceptibility score		2.8

Vulnerability = $\sqrt{(P^2 + S^2)}$

V = $\sqrt{(1^2 + 2.8^2)}$

V = 2.97

Factor 2.2 - Fishing Mortality

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Low Concern

In comparison to other fisheries, bycatch in the South Australian blue swimmer crab fishery is considered to have a low impact, partly because of the recent increases in mesh size and escape gaps, which have resulted in decreased bycatch abundances overall (Hooper 2018). Hence, this factor has been scored a low concern.

Dugong

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

High Concern

Dugong is listed globally as "Vulnerable" by the IUCN (Marsh and Sobtzick 2019). At the federal level in Australia, dugong is protected under the Environment Protection and Biodiversity Act (EPBC Act) of 1999 (Department of the Environment 2021). Further, in the state of Western Australia, dugong is listed as "Other Protected Fauna" under the Biodiversity Conservation Act of 2016 (Department of the Environment 2022). For all these reasons, dugong has been rated a high concern for abundance.

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

High Concern

According to the SFW Unknown Bycatch Matrix, marine mammals such as dugong that are entangled in pots/traps in the Southwest Pacific are scored 2 out of 5. Hence, fishing mortality is awarded a score of high concern.

False Water Rat

Factor 2.1 - Abundance

Western Central Pacific | Pots | Australia | Queensland

High Concern

The false water rat or water mouse (*Xeromys myoides*) is listed as "Vulnerable" by the IUCN (Woinarski and Burbidge 2016). The species also has a "Vulnerable" status under the Australian EPBC Act 1999, and in the state of Queensland under the Nature Conservation (Animals) Regulation 2020 (Department of the Environment 2022o). Therefore, this species has been rated a high concern.

Factor 2.2 - Fishing Mortality

Western Central Pacific | Pots | Australia | Queensland

Low Concern

Although there are known interactions between the false water rat and the blue swimmer crab pot fishery (DAF 2019), the likelihood of interactions are minimal due to spatial and temporal separation (pers. comm., Meder, A.). Thus, fishing mortality has been assigned a score of low concern.

Finfish

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Western Central Pacific | Pots | Australia | Queensland

Moderate Concern
According the SFW standard, unknown fish species that are caught as bycatch are rated a moderate concern for abundance.

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Moderate Concern
Unknown fish species that are caught in crab pots in Shark Bay include leatherjacket and boxfish (DPIRD 2020). According to the SFW standard, unknown fish species that are caught as bycatch are rated a moderate concern for abundance.

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

High Concern
Per the SFW Unknown Bycatch Matrix, finfish caught as bycatch in bottom trawls score a 2 out of 5. Thus, a fishing mortality score of high concern has been awarded.

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia
Western Central Pacific | Pots | Australia | Queensland

Low Concern
According to the SFW Unknown Bycatch Matrix, finfish caught as bycatch in pots are scored a 3.5 out of 5. Hence, fishing mortality is scored a low concern.

Goatfish

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Moderate Concern
According to the SFW standard, unknown fish species such as *Upeneus* spp. are rated a moderate concern for abundance.

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

High Concern

According to the SFW Unknown Bycatch Matrix, finfish caught as bycatch in bottom otter trawls are scored 2 out of 5. Hence, fishing mortality is considered a high concern.

Grouper (unspecified)

Factor 2.1 - Abundance

Western Central Pacific | Pots | Australia | Queensland

High Concern

According to the SFW standard, unknown fish species such as grouper are rated a high concern for abundance.

Factor 2.2 - Fishing Mortality

Western Central Pacific | Pots | Australia | Queensland

Low Concern

According to the SFW Unknown Bycatch Matrix, finfish caught as bycatch in crab pots are scored 3.5 out of 5. Thus, fishing mortality is considered a low concern.

Marine mammals

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

High Concern

Globally, Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) is listed as "Near Threatened" by the IUCN (Braulik et al. 2019). Under the Australian EPBC Act 1999, all cetaceans are protected in Australian waters (Department of the Environment 2021b). Further, humpback whale (*Megaptera novaeangliae*) in particular is considered "Vulnerable" under the EPBC Act (Department of the Environment 2021b). Because both of these species are found in Shark Bay, abundance of marine mammals such as cetaceans has been rated a high concern.

Southwest Pacific | Pots | Australia | New South Wales

High Concern

According to the SFW standard, marine mammals that interact with crab pots are highly vulnerable, so they are scored a high concern for abundance.

Western Central Pacific | Pots | Australia | Queensland

High Concern

According to the SFW standard, marine mammals such as whales that interact with crab pots are highly vulnerable, so they are scored a high concern for abundance.

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia
Southwest Pacific | Pots | Australia | New South Wales

High Concern
According to the SFW Unknown Bycatch Matrix, marine mammals such as cetaceans that are entangled in pots/traps in the Southwest Pacific are scored a 2 out of 5. Hence, fishing mortality is scored a high concern.

Western Central Pacific | Pots | Australia | Queensland

High Concern
Per the SFW Unknown Bycatch Matrix, marine mammals such as whales that are caught as bycatch in crab pots in the Southwest Pacific are scored a 2 out of 5 for fishing mortality. Thus, fishing mortality of marine mammals is scored a high concern.

Rough rock crab

Factor 2.1 - Abundance

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Moderate Concern
Little information on the rough rock crab (*Nectocarcinus integrifrons*) is available, and its abundance is unknown. Therefore, a productivity-susceptibility analysis (PSA) was conducted to determine the vulnerability score of the species, using attributes of similar species. The PSA generated a score of 3.10, indicating that rough rock crab has a medium vulnerability; life history characteristics for rough rock crab and other *Nectocarcinus* spp. are unavailable; therefore, *Portunus* spp. were used in the PSA conducted. For this reason, abundance has been rated a moderate concern.

Justification:

Productivity Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	Mean age of adult *Portunus armatus* crabs is 1.5 years {Marks, R. et al. 2019}	1
Average maximum age	3 yrs *P. pelagicus*/*P. armatus* (Kangas 2000)	1
Von Bertalanffy (Brody) Growth Coefficient (K)	K = 1.4 for *P. pelagicus* (SealifeBase 2022)	1
Fecundity	830,000 to 990,000 eggs in *P. armatus* (Johnston and Yeoh 2021)	1
Reproductive strategy	*Nectocarcinus antarcticus* are external brooders (SealifeBase 2022b)	2
Density dependence	No depensatory or compensatory dynamics known	2
Productivity score		1.333

Susceptibility Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	Unknown, default score used	3
Vertical overlap (Considers all fisheries)	Unknown, default score used	3
Seasonal Availability (Considers all fisheries; score using the most conservative option)	Unknown, default score used	3
Selectivity of fishery (Specific to fishery under assessment)	Default score used; conditions of "high risk" do not apply	2
Post-capture mortality (Specific to fishery under assessment)	Unknown, but species likely retained	3
Susceptibility score		2.8

Vulnerability = $\sqrt{(P^2 + S^2)}$

$V = \sqrt{(1.333^2 + 2.8^2)}$

V = 3.10

Factor 2.2 - Fishing Mortality

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Low Concern

There is no directed fishery for rough rock crab in Southern Australia. According to fishery-independent surveys, rough rock crab is the most abundant bycatch species in the Southern Australia blue swimmer crab pot fishery (Hooper 2018). It is legal for blue swimmer crab license holders to retain rough rock crab; however, it is not retained because it has little to no market value (Hooper 2018). Most rough rock crabs are likely returned to the water alive and unharmed. The blue crab fishery is considered to have a low but not negligible impact on rough rock crab populations, partly because of the recent increases in mesh size and escape gaps, which have resulted in decreased bycatch abundances overall (Hooper 2018). Hence, this factor has been scored a low concern.

Saltwater crocodile

Factor 2.1 - Abundance

Western Central Pacific | Pots | Australia | Queensland

High Concern

Although the population of saltwater crocodile (*Crocodylus porosus*) in Queensland is increasing (Queensland Government 2021c), it is listed as a marine species under the Australian EPBC Act 1999, and as "Vulnerable" in Queensland per the Nature Conservation (Animals) Regulation 2020 (Department of the Environment 2022m). Therefore, abundance has been scored a high concern.

Factor 2.2 - Fishing Mortality

Western Central Pacific | Pots | Australia | Queensland

Low Concern

Although there is no information on the susceptibility of crocodiles to crab pots in Queensland, saltwater crocodile is found mostly in north and far north Queensland (Queensland Government 2021c), and there is a low proportion of overlap between the crocodile populations and blue swimmer crab commercial effort. Therefore, fishing mortality of crocodiles in pots in the region has been scored a low concern.

Saucer scallop

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

High Concern

A lines of evidence, data-limited approach was used to assess the scallop stock in Shark Bay, using both fishery-dependent and fishery-independent data (Kangas et al. 2019), as follows:

1. Commercial annual catch (% of quota): The landed weight of scallops from northern Shark Bay in 2018–19 was 61.5 t, which was only 35% of the TACC set for that region (Kangas et al. 2019). In November of 2018, survey data showed quite low stock abundance in northern Shark Bay, with high mortality of residual individuals and low recruitment (Kangas et al. 2019). A subsequent survey in 2019 overall confirmed these low abundance levels (Kangas et al. 2019). In contrast, the landed weight of scallops in 2018–19 from Denham Sound was 178 t, which reflected annual landings expectations (Kangas et al. 2019).
2. Annual fishery-dependent catch rate: In 2017–18 and 2018–19, the annual commercial catch rate, which primarily focused on catches from Denham Sound, showed that catch rates were within the higher end of the historical range (Kangas et al. 2019).
3. Fishery-independent spawning stock indices: The spawning stock in the northern Shark Bay in November 2018 was below the limit level (Kangas et al. 2019). In contrast, the spawning stock in Denham Sound in 2018 was above the threshold level (Kangas et al. 2019).
4. Fishery-independent recruitment indices: In northern Shark Bay, in November 2018, quite low levels of recruitment were observed (Kangas et al. 2019). Subsequently, in February 2019, only two sites within the northern Shark Bay region showed high recruit abundance (Kangas et al. 2019). In contrast, in Denham Sound, the November 2018 survey confirmed a moderate level of recruitment, and the subsequent February 2019 survey indicated a high level of recruitment (Kangas et al. 2019).
5. Stock recruitment analysis: A stock recruitment relationship (SRR) exists in both the northern

Shark Bay and Denham Sound (Kangas et al. 2019). In 2018, the SRR from northern Shark Bay was below the limit reference level set, whereas the SRR from Denham Sound was above threshold levels (Kangas et al. 2019). Taken together, the evidence indicates that stock abundance in northern Shark Bay is below the limit level and is likely to affect stock recovery, whereas the stock abundance in Denham Sound is above threshold levels, with no recruitment impairment (Kangas et al. 2019).

Because abundance in the northern stock area is depleted, an abundance score of high concern has been awarded for this factor for Shark Bay.

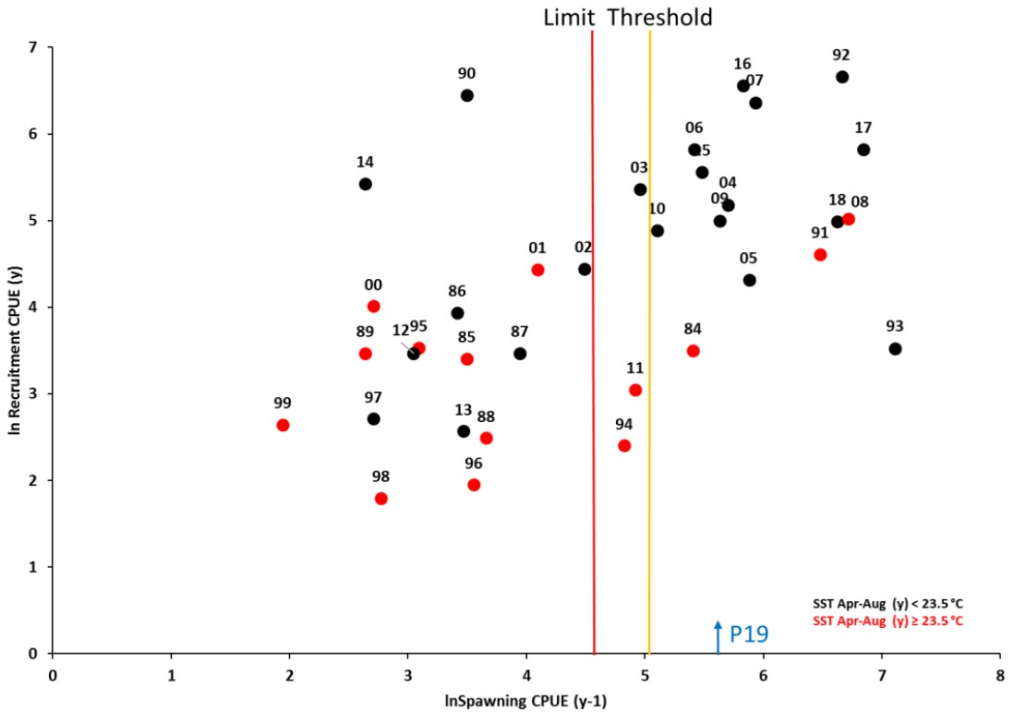


Figure 16: Relationship (log transformed) between the scallop survey index (November year y) with the estimated spawning stock (year y) based on the total scallop abundance (in November year y-1) for Denham Sound. Taken from (Kangas et al. 2019).

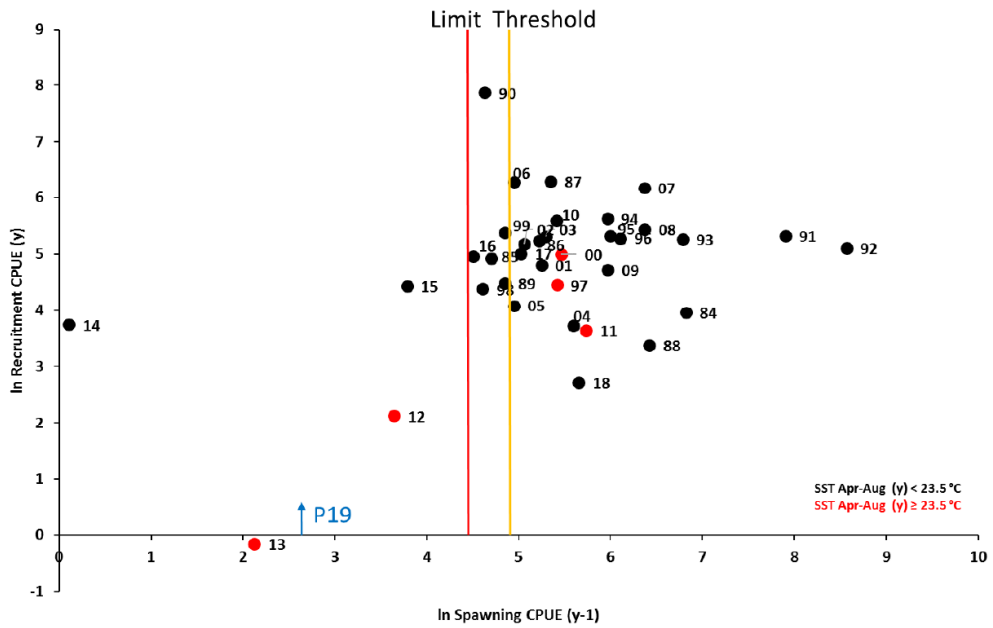


Figure 17: Relationship (log transformed) between the scallop survey recruitment index (November year y) with the estimated spawning stock (year y) based on the total scallop abundance (in November year y-1) for northern Shark Bay. Taken from (Kangas et al. 2019).

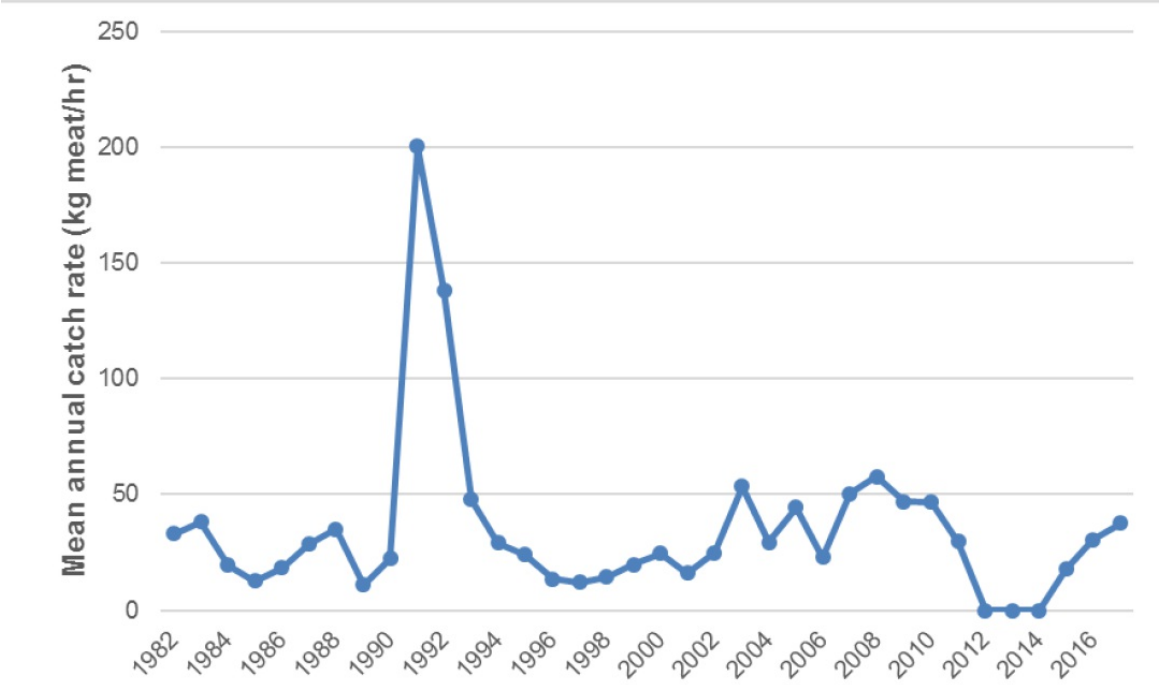


Figure 18: Annual scallop fleet mean catch rates (kg meat/h). Taken from (Kangas et al. 2019).

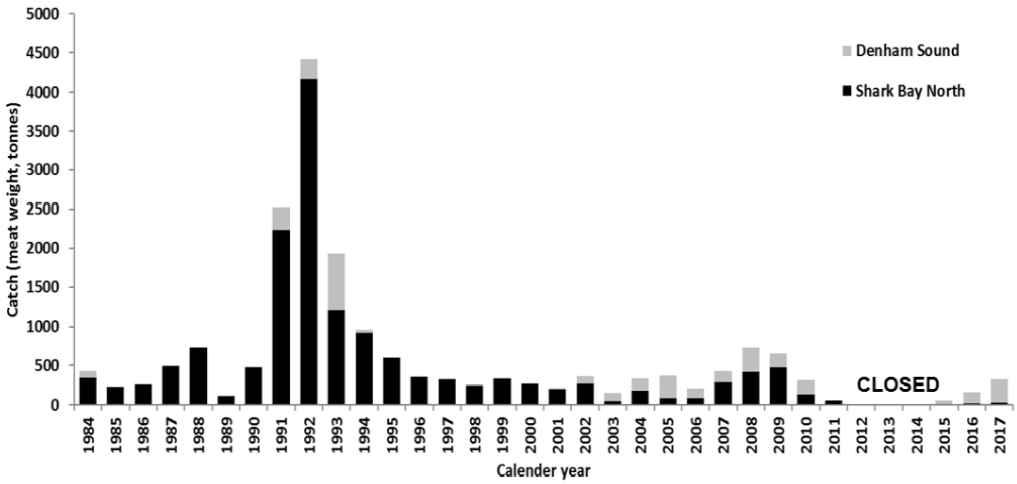


Figure 19: Annual total catch of saucer scallop (tonnes) in northern Shark Bay and Denham Sound. Taken from (Kangas et al. 2019).

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Moderate Concern

A TACC of 263 t was set for the scallop fishery in Shark Bay in 2018 (Kangas et al. 2019). Nevertheless, it is unknown if this level of fishing mortality is sustainable for all the regions in Shark Bay, because catches were not realized in northern Shark Bay in 2018, whereas catches from Denham Sound were per the catch prediction. Hence, a fishing mortality score of moderate concern has been awarded.

Sawfish species

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

High Concern

Sawfish species such as the green sawfish (*Pristis zijsron*) are known to be present in Shark Bay (DPIRD 2020). This species is listed globally as "Critically Endangered" by the IUCN (Simpfendorfer 2013), as a threatened species by the Australian EPBC Act 1999 (Department of the Environment 2022c), and as "Vulnerable" in the state of Western Australia under the Biodiversity Conservation Act of 2016 (Department of the Environment 2022c). Hence, abundance of sawfish has been scored a high concern.

Western Central Pacific | Pots | Australia | Queensland

High Concern

Sawfish species such as green sawfish (*Pristis zijsron*), largetooth sawfish (*Pristis pristis*), and narrow sawfish (*Anoxypristis cuspidata*) are known to occur in Queensland waters, but their populations have contracted along the Queensland coast through time {Walton and Jacobsen 2019}. All these species are listed under the IUCN Red List, and under the Australian EPBC Act 1999 (Table 1 in Justification). All species of sawfish are listed as "no take" species under the Fisheries Regulation 2008 (Queensland) {Walton and Jacobsen 2019}. Hence, sawfish have been scored a "high concern" for abundance.

Justification:

Table 1. Sawfish species listings under the IUCN and EPBC

Species name	IUCN status	Listing under the Australian EPBC Act
Green sawfish (*P. zijsron*)	Critically Endangered {Simpdenforfer, C. 2013}	Vulnerable (Department of the Environment 2022c)
Largetooth sawfish (*P. pristis*)	Critically Endangered (Kyne et al. 2013)	Vulnerable (Department of the Environment 2022r)
Narrow sawfish (*A. cuspidata*)	Endangered (D'Anastasi et al. 2013)	under threatened listing assessment, due 10/30/22 (Department of the Environment 2022q)

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

High Concern

According to the SFW Unknown Bycatch Matrix, sharks such as sawfish caught as bycatch in bottom trawls in the Southwest Pacific are scored a 2 out of 5. Thus, fishing mortality is considered a high concern.

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia
Western Central Pacific | Pots | Australia | Queensland

Low Concern

According to the SFW Unknown Bycatch Matrix, sharks such as sawfish caught as bycatch in crab pots in the Southwest Pacific are scored a 5 out of 5. Hence, fishing mortality is considered a low concern.

Sea snakes (unspecified)

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

High Concern

The leaf-scaled sea snake (*Aipysurus foliosquama*), which makes up 30% of all sea snake interactions with the trawl fishery in Shark Bay, is listed as "Critically Endangered" under the Australian EPBC Act of 1999 and per the Biodiversity Conservation Act 2016 of Western Australia (Department of the Environment 2022f). Hence, abundance of sea snakes has been rated a high concern.

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

High Concern

The leaf-scaled seasnake (*Aipysurus foliosquama*), which is found in Shark Bay, is listed as "Critically Endangered" under the Australian EPBC Act of 1999 and per the Biodiversity Conservation Act 2016 of Western Australia (Department of the Environment 2022f). Hence, abundance of sea snakes has been rated a high concern.

Western Central Pacific | Pots | Australia | Queensland

High Concern

All sea snakes in Australia are considered a listed marine species under the EPBC Act 1999, and are protected under the Nature Conservation Act 1992. As a result, abundance of sea snakes has been scored a high concern.

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

High Concern

Sea snakes are caught in large numbers in the Shark Bay prawn trawl fishery (DPIRD 2020). Because sea snakes are highly susceptible to trawling (Milton et al. 2009), and trawling likely affects coastal populations of sea snakes such as those in Shark Bay in Western Australia (D'Anastasi et al. 2016), a fishing mortality score of high concern has been awarded.

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Moderate Concern

Because there is no information on the susceptibility of sea snakes to pots in Western Australia, and the fishing mortality of sea snakes in pots in Shark Bay is unknown, a score of moderate concern has been assigned for this factor.

Western Central Pacific | Pots | Australia | Queensland

Moderate Concern

Because there is no information on the susceptibility of sea snakes to pots in Queensland, and the fishing mortality of sea snakes in pots in the region is unknown, a score of moderate concern has been assigned for this factor.

Sea turtles

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

High Concern

Both the green sea turtle (*Chelonia mydas*) and loggerhead turtle (*Caretta caretta*) are found in Shark Bay.

Green sea turtle is listed globally as "Endangered" by the IUCN (Seminoff 2004), as "Vulnerable" on the Australian EPBC Act of 1999 (Department of the Environment 2022e), and as "Vulnerable" per the Biodiversity Conservation Act 2016 of Western Australia (Seminoff 2004).

Loggerhead turtle is listed globally as "Vulnerable" by the IUCN (Casale and Tucker 2017), as "Endangered" on the Australian EPBC Act of 1999 (Department of the Environment 2022g), and as "Endangered" per the Biodiversity Conservation Act 2016 of Western Australia (Seminoff 2004). As a result, a score of high concern has been awarded for abundance of sea turtles.

Western Central Pacific | Pots | Australia | Queensland

High Concern

All six species of sea turtle found in Queensland—flatback turtle (*Natator depressus*), green sea turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*), leatherback turtle (*Dermochelys coriacea*), and olive ridley turtle (*Lepidochelys olivacea*)—are protected under the Australian Government's Environmental Protection and Biodiversity Conservation Act 1999, and under Queensland's Nature Conservation (Animal) Regulation (2020) (Table 2)(Department of the Environment 2022e)(Department of the Environment 2022g) (Department of the Environment 2022h)(Department of the Environment 2022i)(Department of the Environment 2022j)(Department of the Environment 2022k). All these species, except flatback turtle, are also globally listed on the IUCN Red List (Seminoff 2004)(Casale and Tucker 2017) {Wallace et al. 2013}(Abreu-Grobois and Plotkin 2008)(Mortimer and Donnelly 2008). Therefore, sea turtles have been rated a high concern for abundance.

Justification:

Table 2. Statuses of all six species of sea turtle along the east coast of Australia under the IUCN, EPBC, and the Queensland Nature Conservation (Animal) Regulation

Species	Status per the IUCN Red List	Status per the EPBC Act 1999	Status per the Queensland Nature Conservation (Animal) Regulation 2020
Flatback turtle (*Natator depressus*)	Data Deficient (Red List Standards and Petitions Subcommittee. 1996)	Vulnerable (Department of the Environment 2022k)	Vulnerable (Department of the Environment 2022k)
Green sea turtle (*Chelonia mydas*)	Endangered (Seminoff 2004)	Vulnerable (Department of the Environment 2022e)	Vulnerable (Department of the Environment 2022e)
Hawksbill turtle (*Eretmochelys imbricata*)	Critically Endangered (Mortimer and Donnelly 2008)	Vulnerable (Department of the Environment 2022j)	Endangered (Department of the Environment 2022j)
Loggerhead turtle (*Caretta caretta*)	Vulnerable (Casale and Tucker 2017)	Endangered (Department of the Environment 2022g)	Endangered (Department of the Environment 2022g)
Leatherback turtle (*Dermochelys coriacea*)	Vulnerable {Wallace et al. 2013}	Endangered (Department of the Environment 2022i)	Endangered (Department of the Environment 2022i)
Olive ridley turtle (*Lepidochelys olivacea*)	Vulnerable (Abreu-Grobois and Plotkin 2008)	Endangered (Department of the Environment 2022h)	Endangered (Department of the Environment 2022h)

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Low Concern

Turtle excluder devices (TED) are fully implemented in trawls in Shark Bay, and reported interactions with turtles indicate that, from 2014 to 2018, only one turtle was reported to have died in a trawl net (DPIRD 2020). Therefore, fishing mortality has been assigned a score of low concern.

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern

According to the SFW Unknown Bycatch Matrix, sea turtles caught as bycatch in pots in the Southwest Pacific are scored a 5 out of 5, so fishing mortality is scored a low concern.

Western Central Pacific | Pots | Australia | Queensland

High Concern

Although marine turtles are known to get caught in crab pots in Queensland and pots may be equipped with turtle excluder devices, the use of bycatch reduction devices is not mandatory in the region (DoAF 2019). Logbook data from fishers indicate that 33 interactions with turtles were reported by crab trap fishers from 2002 to 2017 (DoAF 2019). Hawksbill turtle had the highest interaction rate (45%), followed by green sea turtle (24%), loggerhead turtle (21%), and unspecified turtles (9%) {Walton and Jacobsen 2019}. Most logbooks indicate that the animals were released alive; however, this information could not be confirmed {Walton and Jacobsen 2019}. For instance, some of these animals may later die due to injuries sustained from the gear, or because of extended periods of submersion when caught in the gear {Walton and Jacobsen 2019}. An Ecological Risk Assessment that was conducted indicated that turtles were considered a "high risk" because of interactions with the blue swimming crab pot fishery in Queensland {Walton and Jacobsen 2019}. According to the Marine Wildlife and Stranding Mortality Database, since 2000, at least 291 turtles have died as a result of crab pot or float line interactions in Queensland {Walton and Jacobsen 2019}, and the number of marine turtle interactions with fishing activities were highest due to crab pots and float lines, compared to other gear (Figure 21) {Walton and Jacobsen 2019}. For these reasons, fishing mortality is scored a high concern.

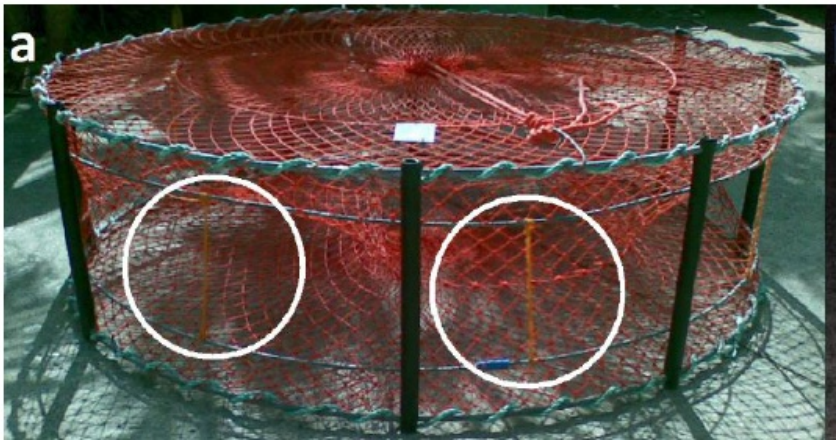


Figure 20: Turtle excluder devices for crab pots in Queensland. Taken from (DoAF 2019).

Year	Marine Turtles				
	Boat strike	Crab pot/float line	Ghost nets	Netting	Fishing line or rope
2000	78	14	0	0	10
2001	83	18	0	0	11
2002	65	29	0	0	23
2003	60	18	3	3	4
2004	75	25	21	5	7
2005	63	22	53	15	6
2006	67	26	6	4	11
2007	70	31	12	2	12
2008	92	47	22	4	16
2009	68	55	1	1	11
2010	63	44	15	0	14
2011[6]	126	37	5	32	24

[5] *This data includes reports from commercial fishers who are legally required to report turtle and dugong deaths to the Department of Environment and Heritage and through the SOCI logbook. This data will also include turtles that have interacted with recreational fishing sector and ghost pots.*

[6] *Data beyond 2011 is yet to be published and is not available to the public, hence why it is excluded from this assessment.*

Figure 21: Marine Wildlife Stranding and Mortality Database showing marine turtle interactions with various fishing gear, 2000 to 2011. Taken from {Walton and Jacobsen 2019}.

Seabirds

Factor 2.1 - Abundance

Western Central Pacific | Pots | Australia | Queensland

High Concern

According to the SFW standard, seabirds are known to be of high inherent vulnerability, so they are scored a high concern for abundance.

Factor 2.2 - Fishing Mortality

Western Central Pacific | Pots | Australia | Queensland

Low Concern

Per the SFW Unknown Bycatch Matrix, fishing mortality of seabirds caught as bycatch in crab pots in the Southwest Pacific is scored a 4 out of 5. Hence, this factor is scored a low concern.

Serrated swimming crab

Factor 2.1 - Abundance

Western Central Pacific | Pots | Australia | Queensland

Low Concern

Queensland has two stocks of mud crab (serrated swimming crab) that are assessed separately: one along the east coast and the other in the Gulf of Carpentaria. Both stocks are assessed using data-limited approaches. Along the east coast, the commercial catch in 2019 was 32% below the average catch for the previous 10 years (Saunders et al. 2020). In 2019, the nominal catch rate was 23 kg per fishing day, which was 15% below the 10-year average of 27 kg per fishing day (range 23–33 kg per fishing day) (Saunders et al. 2020). A recent stock assessment that was conducted using a modified catch-MSY model showed that, by the year 2017–18, the mean biomass ratio was 59%, with a median of 62%; 57% of the trajectories were above the 60% biomass target reference point, and none were below the 20% limit reference point (Northrop et al. 2019). In the Gulf of Carpentaria, the catch in 2018 (157 t) was the highest in five years, and the catch rate was 39 kg per fishing day, which was 23% greater than the 10-year average of 30 kg per fishing day (Saunders et al. 2020). In 2019, the catch rate was 34 kg per fishing day, which was also higher than the 10-year average of 30 kg per fishing day (Saunders et al. 2020). The stock assessment that was conducted using a modified catch-MSY model showed that, by 2017–18, the estimated mean biomass was 58%, and the estimated median biomass was 61%; 53% of trajectories were above the 60% biomass target reference point, and none were below the 20% limit reference point (Northrop et al. 2019). As a result, abundance of both mud crab stocks has been scored a low concern.

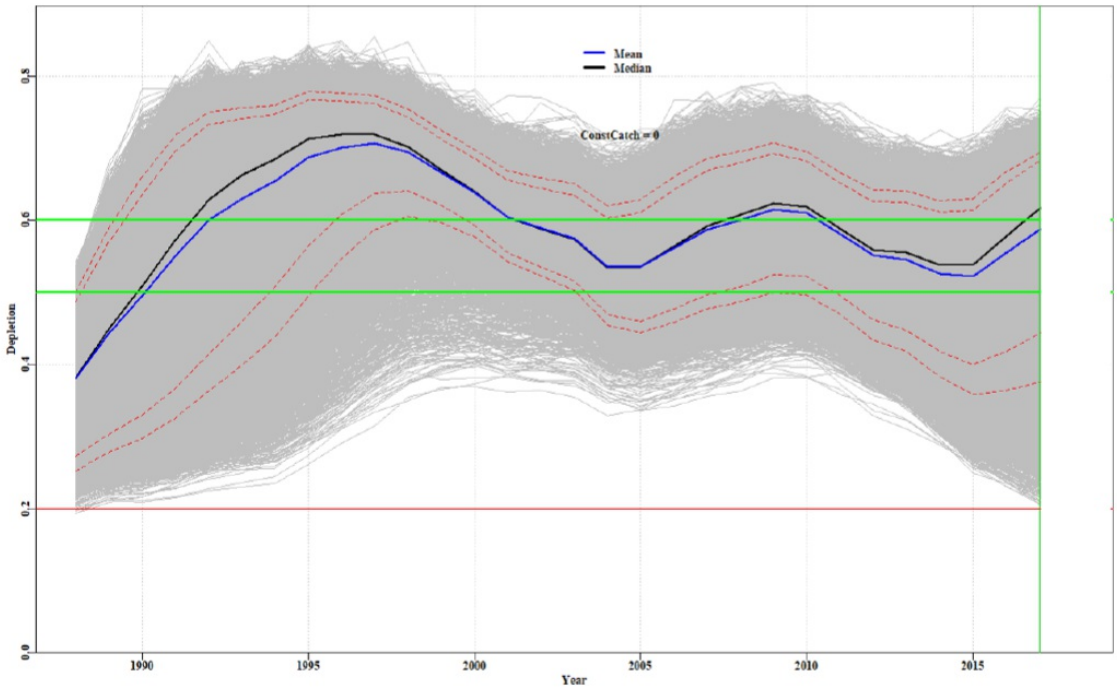


Figure 22: Mud crab biomass trajectories for east coast waters of Queensland. Trajectories show biomass ratios, labeled as depletion. The blue line equals the mean of the trajectories; the black line equals the median; the red dashed line equals the 80th and 90th percentile bounds; the two green lines equal the 50% depletion/biomass levels (where MSY is obtained) and the 60% target biomass ratio; and the red line equals the 20% biomass limit reference level. Taken from (Northrop et al. 2019).

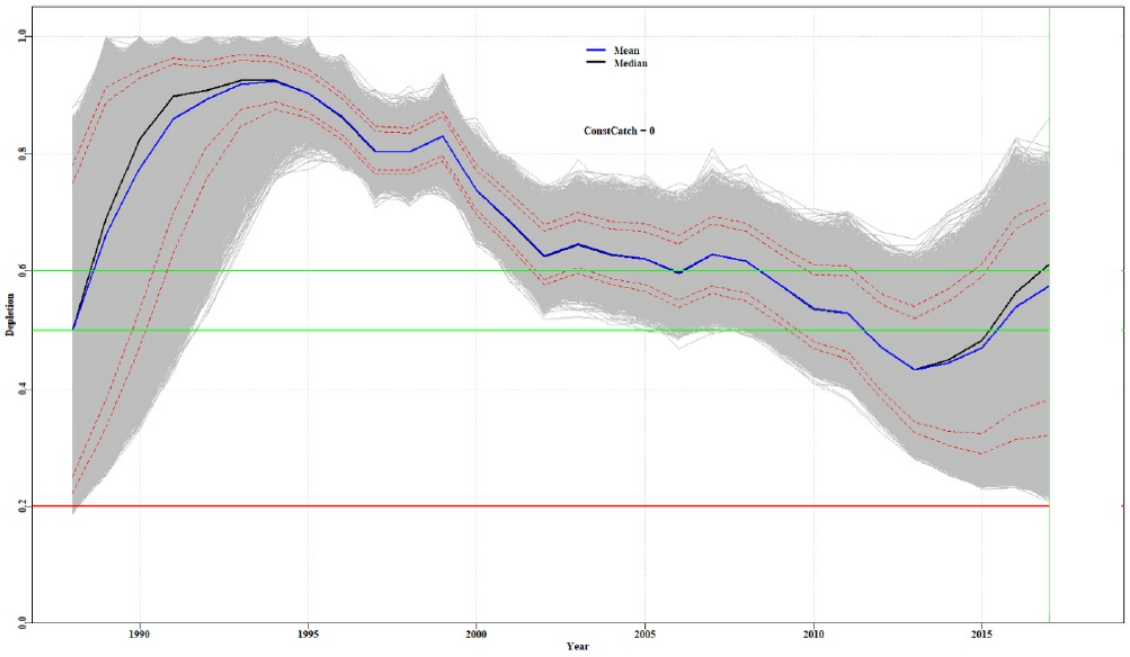


Figure 23: Mud crab biomass trajectories for the Gulf of Carpentaria. Trajectories show biomass ratios, labelled as "Depletion." The blue line equals the mean of the trajectories; the black line equals the median; the red dashed line equals the 80th and 90th percentile bounds; the two green lines equal the 50% depletion/biomass levels (where MSY is obtained) and the 60% target biomass ratio; and the red line equals the 20% biomass limit reference level. Taken from (Northrop et al. 2019).

Factor 2.2 - Fishing Mortality

Western Central Pacific | Pots | Australia | Queensland

Low Concern

There are no recent estimates for fishing mortality of mud crab (Saunders et al. 2020). But, for both the east coast and the Gulf of Carpentaria, a range of TACC limits were simulated to check their impact on future biomass ratios (Northrop et al. 2019), and TACC recommendations were made based on these simulations (Northrop et al. 2019)). To obtain a mean/median of at least 60% exploitable biomass by the 2026–27 fiscal year, with a low probability of biomass values below the limit reference point, catch limits of less than 1,100 t for the east coast and less than 120 t for the Gulf of Carpentaria have been recommended (Northrop et al. 2019). Based on these recommendations, TACCs of 730 t for the east coast and 97 t for the Gulf of Carpentaria were set (Northrop et al. 2019). Therefore, this factor has been rated a low concern.

Speartooth Shark

Factor 2.1 - Abundance

Western Central Pacific | Pots | Australia | Queensland

High Concern

The speartooth shark (*Glyphis glyphis*) is listed as "Vulnerable" by the IUCN (Kyne et al. 2021).

The species is listed as "Critically Endangered" under the Australian EPBC Act 1999 (Department of the Environment 2022p). Therefore, abundance of this species has been scored a high concern.

Factor 2.2 - Fishing Mortality

Western Central Pacific | Pots | Australia | Queensland

Low Concern

According to the SFW Unknown Bycatch Matrix, shark species such as speartooth shark caught as bycatch in crab pots in the Southwest Pacific are scored a 5 out of 5. Hence, fishing mortality is considered a low concern.

Spider crab

Factor 2.1 - Abundance

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Moderate Concern

According to the SFW standard, unknown invertebrate species, such as *Leptomithrax* spp., including the spider crab, are rated a moderate concern for abundance.

Factor 2.2 - Fishing Mortality

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Low Concern

Compared to that in other fisheries, bycatch in the South Australian blue crab fishery is considered to have a low impact on *Leptomithrax* spp., partly because of the recent increases in mesh size and escape gaps, which have resulted in decreased bycatch abundances overall (Hooper 2018). Hence, this factor has been scored a low concern.

Striped mullet

Factor 2.1 - Abundance

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern

The data-limited stock assessment of sea mullet (or striped mullet) (*Mugil cephalus*) conducted in 2015 for the Peel-Harvey Estuary indicated that the standardized catch rate of this species was 6.2 kg/100 m netting hour, which was well above the target range of 2.2 to 4.6 kg/100 m netting hour

{Johnston et al. 2015}. The catch of sea mullet in 2013 was 68 t, which was within the target range of 46 to 70 t {Johnston et al. 2015}. The sea mullet abundance indicators are above or within the target range, but a data-limited assessment has been used to assess the stock; therefore, a score of low concern has been assigned to this factor.

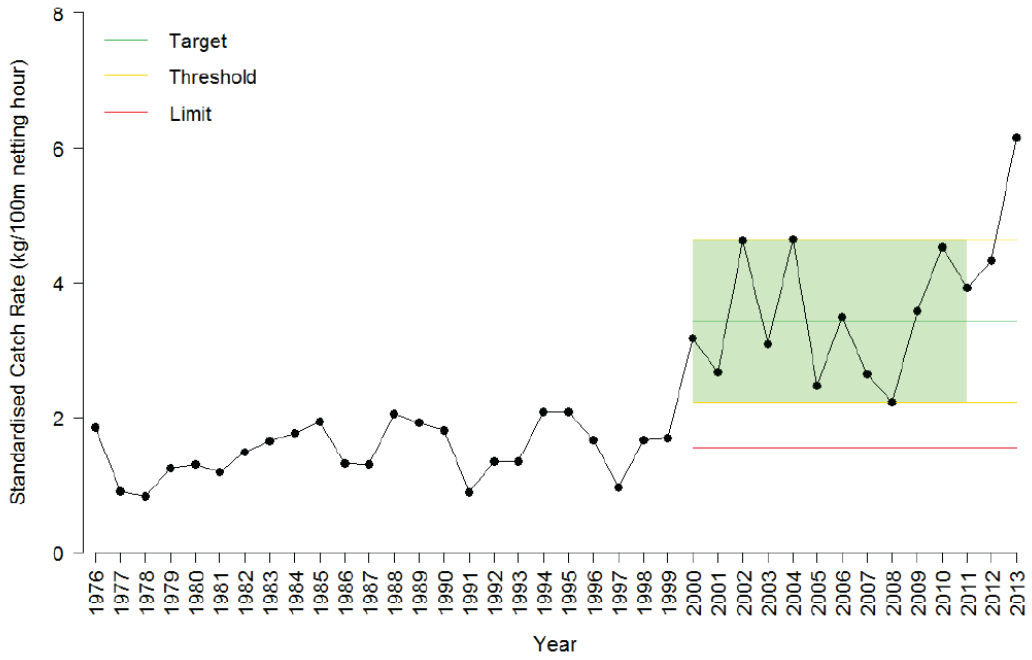


Figure 24: Annual standardized commercial catch rate (kg/100 m netting hour) of sea mullet in the Peel-Harvey Estuary relative to the associated reference points, 1976–2013. The shaded green area reflects the reference period (2000–11), from which reference points have been calculated. Taken from {Johnston et al. 2015}.

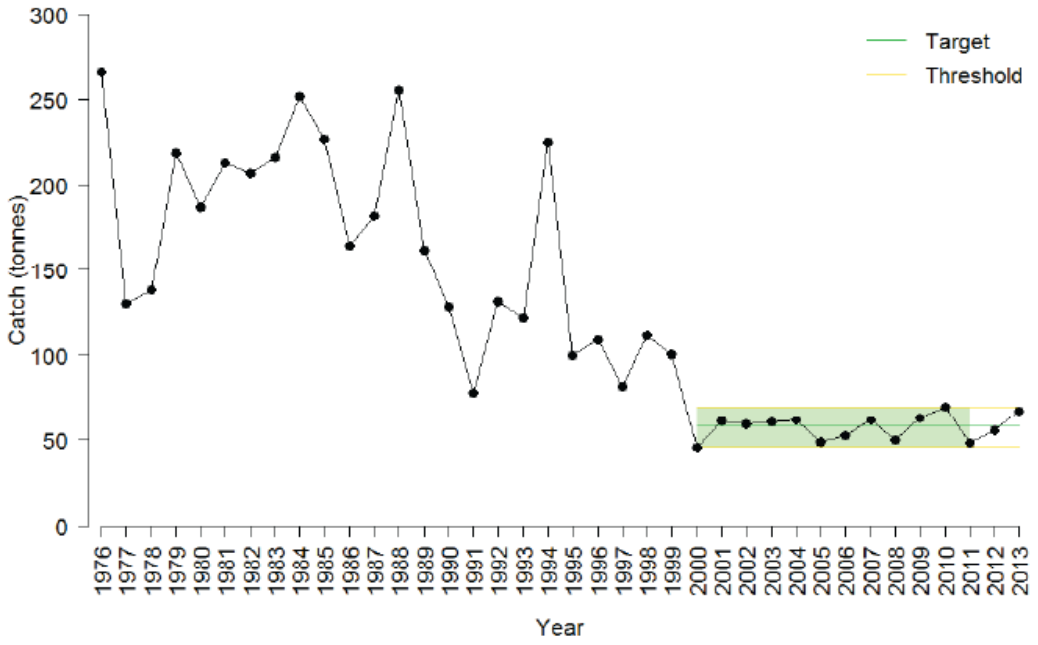


Figure 25: Annual commercial catch (tonnes) of sea mullet in the Peel-Harvey Estuary relative to the associated reference points, 1976–2013. The shaded green area reflects the reference period (2000–11), from which reference points have been calculated. Taken from {Johnston et al. 2015}.

Factor 2.2 - Fishing Mortality

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Moderate Concern

Although it is known that a majority of the sea mullet catch from the west coast bioregion is landed in the Peel-Harvey Estuary (DPIRD 2020b), fishing mortality is unknown. Hence, a score of moderate concern has been awarded for fishing mortality.

Syngnathidae species

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

High Concern

The three-spot seahorse (*Hippocampus trimaculatus*), which is found in Shark Bay, is listed as globally "Vulnerable" by the IUCN (Wiswedel 2015). The species is also listed on the Australian EPBC Act 1999 (Department of the Environment 2022d). Hence, syngnathids have been scored a high concern for abundance.

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern
According to the SFW Unknown Bycatch Matrix, finfish caught as bycatch in pots are scored a 3.5 out of 5. Hence, a score of low concern for fishing mortality has been awarded.

Western king prawn

Factor 2.1 - Abundance

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Low Concern
The data-limited stock assessment assumes a weight-of-evidence approach, and considers all information about the stock; the assessment is based on fishery-independent survey indices of recruitment from March to April and spawning stock levels from June to August (Noell et al. 2020). In 2019, a fishery-independent recruitment survey showed a mean catch rate of 92.1 kg/hr, which is well above the target level of 25 kg/hr (Noell et al. 2020). The mean spawning stock survey catch rate in 2019 was 61.2 kg/hr, which again was well above the target spawning stock catch rate of 25 kg/hr set for the Shark Bay region (Noell et al. 2020). Nevertheless, the total commercial catch rate for this stock in 2019 was 878 t, which was below the target range of 950–1,350 t (Noell et al. 2020). Two out of three indicators were well above the target reference points, the Department of Primary Industries and Regional Development considers the stock to be sustainable and not overfished, and a data-limited approach was used to assess the stock, so a score of low concern has been awarded for abundance.

Factor 2.2 - Fishing Mortality

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Moderate Concern
Although a reduction in overall effort was implemented in 2020 as part of precautionary management, fishing mortality is unknown. Hence, a score of moderate concern has been assigned.

Yellow-eye mullet

Factor 2.1 - Abundance

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern
In Western Australia, the stock assessment of yellow-eye mullet is based on a data-limited catch-MSY model, and is compared periodically to reference levels related to estimates of MSY (Earl et al. 2020). B_{MSY} is considered as the threshold level, and 50% B_{MSY} is set as the limit reference level

(Earl et al. 2020). Any stock level above B_{MSY} is considered the target level (Earl et al. 2020). In 2019, the relative stock biomass was high, at 0.9 of the unfished level (95% CL = 0.8–1.0) (Earl et al. 2020). Because biomass is considered to be well within the target level, abundance has been rated a low concern.

Factor 2.2 - Fishing Mortality

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern

The fishing mortality in 2019 on this stock was too low to be estimated, and is below the level of F_{MSY}, 0.15/year (Earl et al. 2020). Hence, fishing mortality has been scored a low concern.

Factor 2.3 - Discard Rate/Landings

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia
Southwest Pacific | Pots | Australia | New South Wales
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia
Western Central Pacific | Pots | Australia | Queensland

< 100%

Typically, in blue swimmer crab trap fisheries in Australia, bycatch of other species (that are retained or discarded) is minimal (Fisher et al. 2020), and bait such as sea mullet and yellow-eye mullet form 19% to 29% of the catch (Fisher et al. 2020). Hence, a score of <100% has been assigned for discard rate/landings.

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

< 100%

In the Peel-Harvey Estuary, bycatch of other species (that are retained or discarded) is minimal (Fisher et al. 2020). Data from 2018/19 indicate that sea mullet and yellow-eye mullet, which are used as bait together, form 27% of the catch (Fisher et al. 2020). The discards of blue swimmer crab from 2014 to 2019, on average, were 32% of the catch (Fisher et al. 2020). Considering both discards and bait, a score of <100% has been assigned for discard rate/landings.

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

< 100%

Fishery-independent surveys conducted indicate that discards form approximately 49.2% of the catch (DPIRD 2020). Based on this information, it can be assumed that discards from the Shark Bay Prawn Managed Fishery are < 100%.

Criterion 3: Management Effectiveness

Five factors are evaluated in Criterion 3: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either 'highly effective', 'moderately effective', 'ineffective,' or 'critical'. The final Criterion 3 score is determined as follows:

- *5 (Very Low Concern) — Meets the standards of 'highly effective' for all five factors considered.*
- *4 (Low Concern) — Meets the standards of 'highly effective' for 'management strategy and implementation' and at least 'moderately effective' for all other factors.*
- *3 (Moderate Concern) — Meets the standards for at least 'moderately effective' for all five factors.*
- *2 (High Concern) — At a minimum, meets standards for 'moderately effective' for Management Strategy and Implementation and Bycatch Strategy, but at least one other factor is rated 'ineffective.'*
- *1 (Very High Concern) — Management Strategy and Implementation and/or Bycatch Management are 'ineffective.'*
- *0 (Critical) — Management Strategy and Implementation is 'critical'.*

The Criterion 3 rating is determined as follows:

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

Rating is Critical if Management Strategy and Implementation is Critical.

Guiding principle

- The fishery is managed to sustain the long-term productivity of all impacted species.

Five factors are evaluated in Criterion 3: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either 'highly effective', 'moderately effective', 'ineffective,' or 'critical'. The final Criterion 3 score is determined as follows:

Criterion 3 Summary

FISHERY	MANAGEMENT STRATEGY	BYCATCH STRATEGY	DATA COLLECTION AND ANALYSIS	ENFORCEMENT	INCLUSION	SCORE
Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia	Highly effective	Moderately Effective	Moderately Effective	Highly effective	Moderately Effective	**Green (4.000)**
Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia	Highly effective	Highly effective	Moderately Effective	Moderately Effective	Highly effective	**Green (4.000)**

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Highly effective	**Yellow (3.000)**
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia	Highly effective	Highly effective	Moderately Effective	Moderately Effective	Highly effective	**Green (4.000)**
Southwest Pacific | Pots | Australia | New South Wales	Moderately Effective	Moderately Effective	Moderately Effective	Highly effective	Highly effective	**Yellow (3.000)**
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia	Highly effective	Moderately Effective	Moderately Effective	Highly effective	Moderately Effective	**Green (4.000)**
Western Central Pacific | Pots | Australia | Queensland	Moderately Effective	Ineffective	Ineffective	Highly effective	Highly effective	**Red (1.000)**

The Australia blue swimmer crab fisheries are generally well-managed, although in some states research/monitoring could be improved. Some blue swimmer crab populations are currently at low abundances (Gulf St. Vincent, Cockburn Sound, Shark Bay), but recovery efforts are in place. There are few bycatch concerns in the New South Wales, South Australia, and Western Australia pot fisheries, so bycatch management is considered highly effective. In the Queensland pot fishery and the Shark Bay trawl fishery, some species of concern are incidentally caught and bycatch management is only moderately effective.

Criterion 3 Assessment

SCORING GUIDELINES

Factor 3.1 - Management Strategy and Implementation

Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? Do manages follow scientific advice? To achieve a highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

Factor 3.2 - Bycatch Strategy

Considerations: What type of management strategy/measures are in place to reduce the impacts of the fishery on bycatch species and when applicable, to minimize ghost fishing? How successful are these management measures? To achieve a Highly Effective rating, the fishery must have no or low bycatch, or if there are bycatch or ghost fishing concerns, there must be effective measures in place to minimize impacts.

Factor 3.3 - Scientific Research and Monitoring

Considerations: How much and what types of data are collected to evaluate the fishery's impact on the species? Is there adequate monitoring of bycatch? To achieve a Highly Effective rating, regular, robust population assessments must be conducted for target or retained species, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are met.

Factor 3.4 - Enforcement of Management Regulations

Considerations: Do fishermen comply with regulations, and how is this monitored? To achieve a Highly Effective rating, there must be regular enforcement of regulations and verification of compliance.

Factor 3.5 - Stakeholder Inclusion

Considerations: Are stakeholders involved/included in the decision-making process? Stakeholders are individuals/groups/organizations that have an interest in the fishery or that may be affected by the management of the fishery (e.g., fishermen, conservation groups, etc.). A Highly Effective rating is given if the management process is transparent, if high participation by all stakeholders is encouraged, and if there a mechanism to effectively address user conflicts.

Factor 3.1 - Management Strategy And Implementation

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Highly effective

The blue swimmer crab fishery in South Australia is managed by the Department of Primary Industries and Regions (PIRSA), under the legislation of the Fisheries Management Act of 2007 (GSA 2007).

Access to the fishery is provided by a license for the blue swimmer crab fishery or the Marine Scalefish fishery, through an individual transferable quota system, with quota units in either the Gulf of St. Vincent zone or Spencer Gulf zone (PIRSA 2020). The commercial fishery accesses approximately 70% of the fishery each year (PIRSA 2020). The areas in which blue swimmer crab license holders are permitted to fish are shown in Figure 26. A total allowable commercial catch (TACC) is set and is divided equally among license holders of each zone (PIRSA 2020).

The main management strategies for ensuring sustainability of the fishery are the major output controls: restrictions on the total commercial catch each year through the quota system, bag and boat limits for recreational fishers, a minimum legal-size limit of 110 mm, and restrictions on taking berried females (PIRSA 2020).

The harvest strategy for the blue swimmer crab defines separate operational objectives, performance indicators, and reference points based on fishery independent surveys (PIRSA 2020). Harvest control rules have been designed to provide guidance in setting the TACC, such that the TACC may be reduced when biomass declines, and it may be increased when biomass increases, as shown in Figures 27 and 28 (PIRSA 2020). Thus, a specific response will be triggered based on fishery performance (PIRSA 2020). Because the commercial sector accesses approximately 70% of the fishery each year, the harvest control rules and reference points for determining the annual TACC in the harvest strategy are important to ensure ecologically sustainable stock levels. This harvest strategy may be reviewed at any time to address significant, unanticipated issues. Because adequate management strategies are in place to ensure that the blue swimmer crab stock is healthy in South Australia, this factor has been rated highly effective.

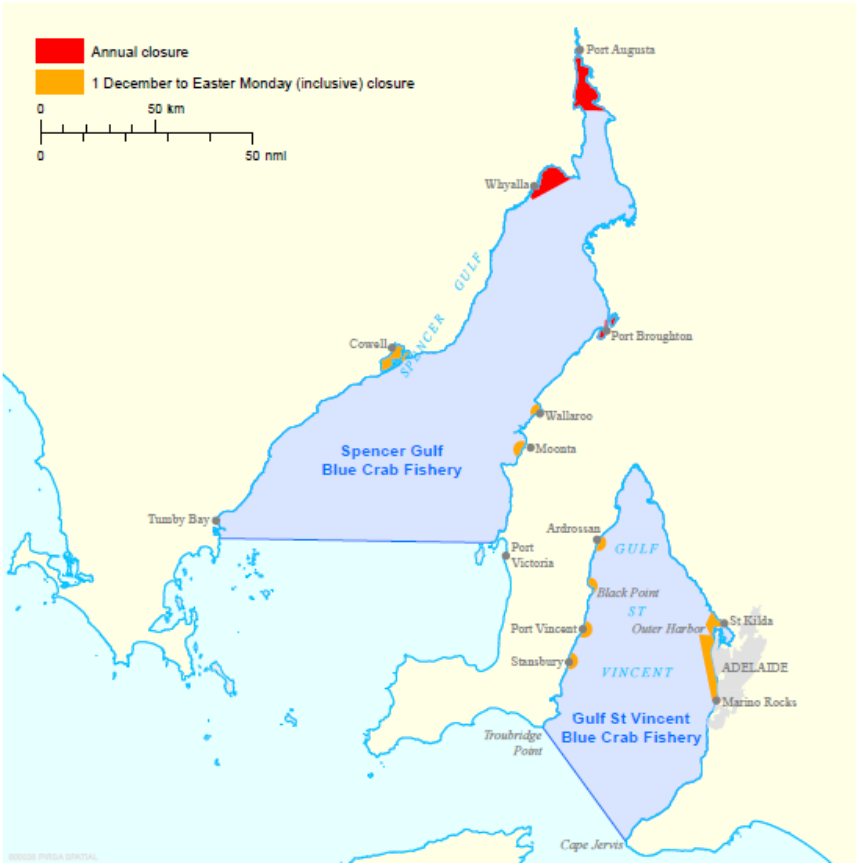


Figure 26: Map showing regions where the blue swimmer crab is permitted to be harvested. Taken from (PIRSA 2020).

Legal-size FIS CPUE (kg/potlift)	Maximum biological sustainable catch (Tonnes)
3.3 or above	294.18
2.5 to 3.29	269.66
1.7 to 2.49	245.15
1.2 to 1.69	196.12
0.8 to 1.19	147.09
Below 0.8	0

DECISION RULES

Dependent on the Legal-size FIS CPUE (kg/potlift) in the decision rule table above the following rules apply:

- TACC set for each fishing zone will not be higher than that described in the decision rule table (Table 3) relevant to the Legal-size FIS CPUE.
- When Legal-size CPUE is above 1.7kg/potlift, TACC can increase by only one level per year.
- The maximum biologically acceptable TACC or any lower value can be taken.

Figure 27: Gulf of St. Vincent harvest control rules. Taken from (PIRSA 2020).

Legal-size FIS CPUE (kg/potlift)	Maximum biological sustainable catch (Tonnes)
5.0 or above	458
3.7 to 4.99	419.84
2.4 to 3.69	381.67
1.7 to 2.39	305.34
1.0 – 1.69	229.00
Below 1.0	0

DECISION RULES

Dependent on the Legal-size FIS CPUE (kg/potlift) in the decision rule table above the following rules apply:

- TACC set for each fishing zone will not be higher than that described in the decision rule table (Table 4) relevant to the Legal-size FIS CPUE.
- When Legal-size CPUE is above 2.4 kg/potlift, TACC can increase by only one level per year.
- The maximum biologically acceptable TACC or any lower value can be taken.

Figure 28: Spencer Gulf harvest control rules. Taken from (PIRSA 2020).

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Highly effective

Blue swimmer crab and other aquatic resources are managed by the Department of Primary Industries and Regional Development (DPIRD) in southwest Western Australia (Johnston et al. 2020)(DPIRD 2020c)(DPIRD 2020d), following specific key legislations (Table 3).

The blue swimmer crab resource of southwest Western Australia is harvested using a constant exploitation approach, where the catches vary in proportion to variations in stock abundance (Johnston et al. 2020)(DPIRD 2020c). Annual catch tolerance levels have also been developed for the commercial fisheries that target the blue swimmer crab in the Peel-Harvey Estuary (PHE) (DPIRD 2020c). The harvest strategy involves: 1) a formal review of targeted stocks and other ecological assets against defined reference levels to determine performance against management objectives relating to ecological sustainability; and 2) an annual fishery-level review that determines whether the current catch/effort by the fishery is consistent with the levels expected when ecological objectives are met (DPIRD 2020c).

To determine the status of the blue swimmer crab resource in PHE, suitable indicators have been selected, against defined reference levels established to separate acceptable from unacceptable performance (DPIRD 2020c). These reference levels include: 1) a target level; 2) a threshold level; and 3) a limit level (DPIRD 2020c). Harvest Control Rules (HCRs) define the management actions that relate to the status of each indicator compared to the reference levels (Johnston et al. 2020) (DPIRD 2020c). These HCRs are designed to maintain the resource above the threshold level and close to a target level, or rebuild it where it has fallen below the threshold (undesirable) or the limit (unacceptable) levels (DPIRD 2020c). For the blue swimmer crab stock, a decrease in the performance indicator below the threshold reference level will trigger a reduction in catch by up to 50% of the current harvest level. In such a case, a review would be undertaken within three months to determine the level of reduction that is expected to rebuild the stock to the target level, which will be dependent on the extent to which the threshold has been breached, and the required rebuilding rate (DPIRD 2020c). The catch reduction may be achieved by setting a nominal catch limit to ensure that commercial catches do not exceed the benchmark that is expected to rebuild the stock (DPIRD 2020c). Alternatively, an equivalent decrease in catch can be achieved by reducing the fishing effort; for example, by gear restrictions or reducing the length of the fishing season through the implementation of temporal closures (DPIRD 2020c).

The commercial fishery targeting blue swimmer crab is managed using a range of input and output controls (DPIRD 2020c). Commercial fishing effort is constrained by a cap on the number of licenses/vessels operating in each fishery (limited entry) and restrictions on fishing gear, including the number and size of crab traps and the length of nets (DPIRD 2020c). Specific areas may be permanently closed to commercial fishing (DPIRD 2020c). Temporal closures prohibit licensed commercial fishers from operating during weekends (DPIRD 2020c). Seasonal closures during the breeding season also prohibit commercial crab fishing (DPIRD 2020c). All fishers are also prohibited from retaining berried female crabs (DPIRD 2020c). Minimum size limits for the commercial sector in the Peel-Harvey Estuary are currently 127 mm carapace width (CW). Commercial fishing licenses have been reduced from 10 to 6, and this is expected to improve the breeding stock over the next 5 years (Fisher et al. 2020).

Because adequate management strategies are in place to ensure that the blue swimmer crab stock is healthy in the Peel-Harvey Estuary, this factor has been rated highly effective.

Justification:
Table 3. Legislations for management of blue swimmer crab and other aquatic resources

Name of legislation	Abbreviation (if any)
Fish Resources Management Act 1994	FRMA/ARMA
Fish Resources Management Regulations 1995	FRMR
West Coast Estuarine Managed Fishery Management Plan 2014	
Prohibition on Fishing for Blue Swimmer Crabs Order 2019	
Prohibition on Fishing for Crabs (Peel Inlet and Harvey Estuary) Order 2007	
Commonwealth Environment Protection and Biodiversity Conservation Act 1999	EPBC Act
Marine Safety (Domestic Commercial Vessel) National Law Act 2012	
Western Australia Marine Act 1982	
Western Australia Biodiversity Conservation Act 2016	
Western Australia Conservation and Land Management Act 1984	
Any other legislation governing the use of the marine environment in which fishing activities occur	

Defining annual (or periodic) catch or effort tolerance levels for fisheries provides a formal and efficient basis to evaluate the effectiveness of current management arrangements in delivering the levels of catch and/or effort specified by the HCRs {Fletcher et al. 2017}. If the catch breaches the specified tolerance level and this cannot be adequately explained (e.g., clear environmental impacts or marketing reasons), the performance is termed "Unacceptable" (DPIRD 2020c). This would also trigger a review to determine if management arrangements are still appropriate and if a reassessment of resource status is necessary to inform adjustments to the HCRs and/or tolerance levels (DPIRD 2020c).

Overall, decision-making processes can be triggered following the identification of new or potential issues as part of an ecological risk assessment (generally reviewed every 3–5 years); results of research, management, or compliance projects or investigations; monitoring or assessment outcomes (including those assessed as part of the harvest strategy); and/or expert workshops and peer review of aspects of research and management (DPIRD 2020c). Annual decision-making processes may result in measures to meet the short-term operational fishery objectives (driven by the harvest control rules), whereas longer-term decision-making processes result in new measures and/or strategies to achieve the long-term fishery objectives (i.e., changes to the management system) (DPIRD 2020c). If there is an urgent issue, consultation with stakeholders may be undertaken to discuss the issue and determine appropriate management action, as needed (DPIRD 2020c).

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Moderately Effective

Trawls in Shark Bay that make up the Shark Bay Prawn Managed Fishery (SBPMF) may also catch blue swimmer crab (DPIRD 2022). This fishing sector is managed under the DPIRD, under key legislations (Table 4).

There are currently 18 licenses in the SBPMF, each for vessels using demersal otter trawl gear (DPIRD 2022). Catches of blue swimmer crab and western saucer scallop by prawn trawl fishers are managed by quota as part of the Shark Bay Crab Managed Fishery (SBCMF) and the Shark Bay Scallop Managed Fishery (SBSMF), respectively. The SBCMF Management Plan provides the statutory quota management framework for the commercial take of blue swimmer crab by the prawn trawl, scallop trawl, and crab trap sectors in the waters of the SBCMF (DPIRD 2020e). The SBCMF is

divided into two zones separating the inner gulfs (Zone 2) from the rest of Shark Bay (Zone 1) (DPIRD 2020e). There are 32 licenses in the SBCMF, which are divided into Class A and B licenses across the trap and trawl fisheries; trawl fisheries have Class A licenses, and may fish in Zones 1 and 2, in permitted trawl areas (DPIRD 2020e). The formal commercial catch share arrangement to divide the annual blue swimmer crab resource across the commercial sectors is: trap sector, 66.0%; prawn trawl sector, 33.8%; and scallop trawl sector, 0.2% (DPIRD 2020e). Quota unit entitlement is fully transferable between licenses (DPIRD 2020e).

The SBPMF is subject to an input and output control management system. Overall effort in the fishery is constrained by a cap on the number of licenses, limits on fishing gear (headrope capacity), seasonal closures, and temporal closures (e.g., restricted trawl hours during the night, monthly closures around each full moon); in addition, significant permanent and temporary spatial closures throughout the fishery also reduce the effective fishing effort (Figure 29) (DPIRD 2022). The SBPMF is managed based on a constant escapement harvesting approach, which aims to maintain sufficient abundance of prawns before spawning (DPIRD 2022). Annual catch tolerance levels have also been developed for the SBPMF (DPIRD 2022). Management depends on the strength and timing of recruitment as prawns migrate from the inshore nursery areas and enter the trawl grounds during autumn (DPIRD 2022). The harvest strategy has been designed to provide sufficient protection to spawning stocks and allow flexibility to achieve economic objectives (DPIRD 2022).

The prawn fishing season in Shark Bay extends from March–April through September–October each year, where opening and closing dates are set according to the lunar phase and other information (DPIRD 2022). Each year, the season arrangements for the SBPMF are developed in consultation with industry, following a review of the previous fishing season (DPIRD 2022). The development of season arrangements is guided by a set of principles (Figure 30) based on the performance against the index of spawning stock abundance for western king and brown tiger prawns and consideration of all available data, including fishery-independent survey information, fishery-dependent catch rates and size information, and environmental data (DPIRD 2022). Season arrangements outline the fishing periods, spatial closures, moon breaks, and annual survey schedule, and include guidelines for in-season decision-making to consider survey data and associated operational responses (DPIRD 2022). For example, in-season decision-making is centered around two main review points in April and June (Figure 31), which are used to inform a series of rolling spatial openings and closures of defined areas within Shark Bay (DPIRD 2022).

Suitable indicators have been selected to determine the status of targeted prawn species in Shark Bay and other ecological assets, against defined reference levels established to separate acceptable from unacceptable performance (DPIRD 2022). Where relevant, these levels include: 1) a target level (optimal); 2) a threshold level (undesirable); and 3) a limit level (unacceptable) (DPIRD 2022). Harvest Control Rules (HCRs) define the management actions that should occur in relation to the value of each performance indicator relative to the reference levels (DPIRD 2022). These HCRs are designed to maintain the resource above the threshold level and close to a target level, or rebuild it where it has fallen below the threshold or the limit levels (DPIRD 2022). Management responses outlined by the HCRs in the SBPMF include: 1) revising the season arrangements (i.e., overall season length and structure); 2) modifying the timing and spatial extent of fishing during the season; and 3) adjustment of other effort restrictions (DPIRD 2022).

Regarding other retained species, where reliable quantitative information is available, reference levels used to monitor performance against management objectives relating to these ecological assets have been set based on data available from ongoing monitoring (DPIRD 2022). The retained catch of each other prawn species is compared annually to a threshold level of 5% of the total retained catch of the SBPMF (DPIRD 2022). For all ecological components, reference levels have also been set to differentiate acceptable fishery impacts from unacceptable fishery impacts according to the risk levels, through an Environmental Risk Assessment (DPIRD 2020).

The risk of prawn fishing on saucer scallop and blue swimmer crab in Shark Bay is assessed annually as part of the risk-based weight-of-evidence assessment of these resources, which informs the harvest strategies for the Shark Bay scallop and blue swimmer crab resources (DPIRD 2020e) (DPIRD 2020f) (Tables 5 and 6) and considers if additional management measures are necessary (such as spatial and temporal restrictions).

Management of some of the targeted species in this fishery (including western king prawn and blue swimmer crab) is well defined, with appropriate reference points; however, in the case of saucer scallops, the recent November abundance index has not provided an accurate prediction of catches for northern Shark Bay (DPIRD 2020f). Further, management of some main targeted and retained species is not as well defined for species that lack quantitative data, and it relies on periodic risk assessments. Therefore, this factor has been rated moderately effective.

Justification:

Table 4. Legislations for management of trawls in Shark Bay

Name of legislation	Abbreviation (if any)
Fish Resources Management Act 1994	FRMA/ARMA
Fish Resources Management Regulations 1995	FRMR
FRMA Part 6—Shark Bay Prawn Managed Fishery Management Plan 1993	SBPMF Management Plan
FRMA Section 43 Order—Prohibition on Commercial Fishing (Shark Bay Marine Park) Order 2004	
FRMA Section 7 instruments of exemption	
Commonwealth Environment Protection and Biodiversity Conservation Act 1999	EPBC Act
Marine Safety (Domestic Commercial Vessel) National Law Act 2012	
Western Australia Marine Act 1982	
Western Australia Biodiversity Conservation Act 2016	
Western Australia Conservation and Land Management Act 1984	
Any other legislation governing the use of the marine environment in which fishing activities occur	

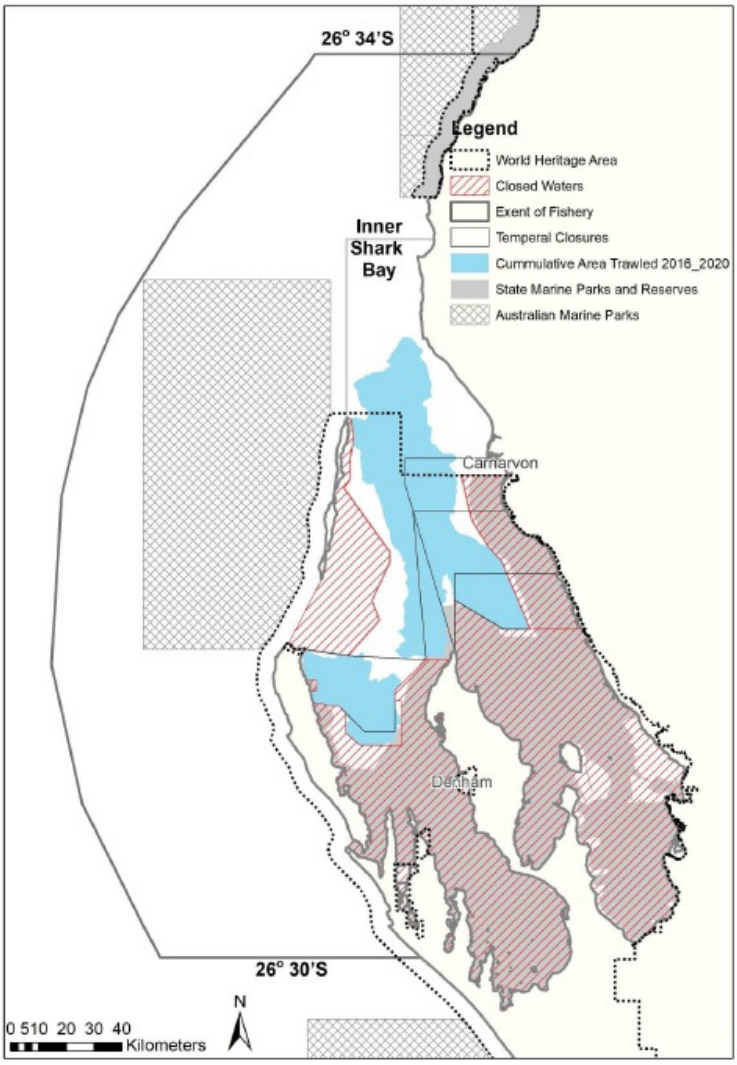


Figure 29: Map of areas included in the SBPMF, showing trawled and closed regions. Taken from (DPIRD 2022).

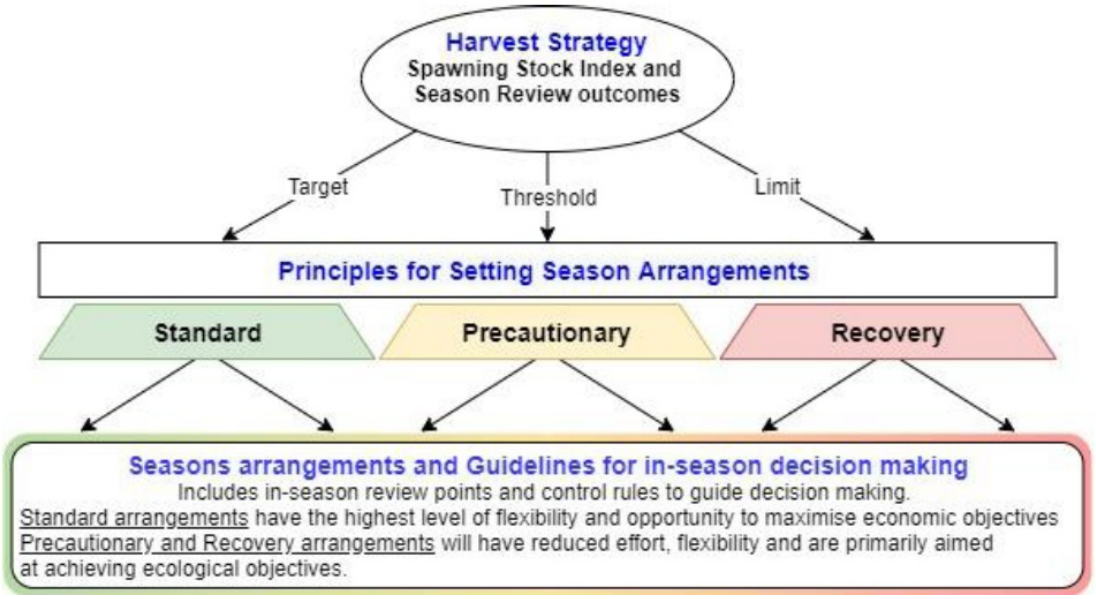


Figure 30: Harvest strategy principles for setting seasonal arrangements in the SBPMF. Taken from (DPIRD 2022).

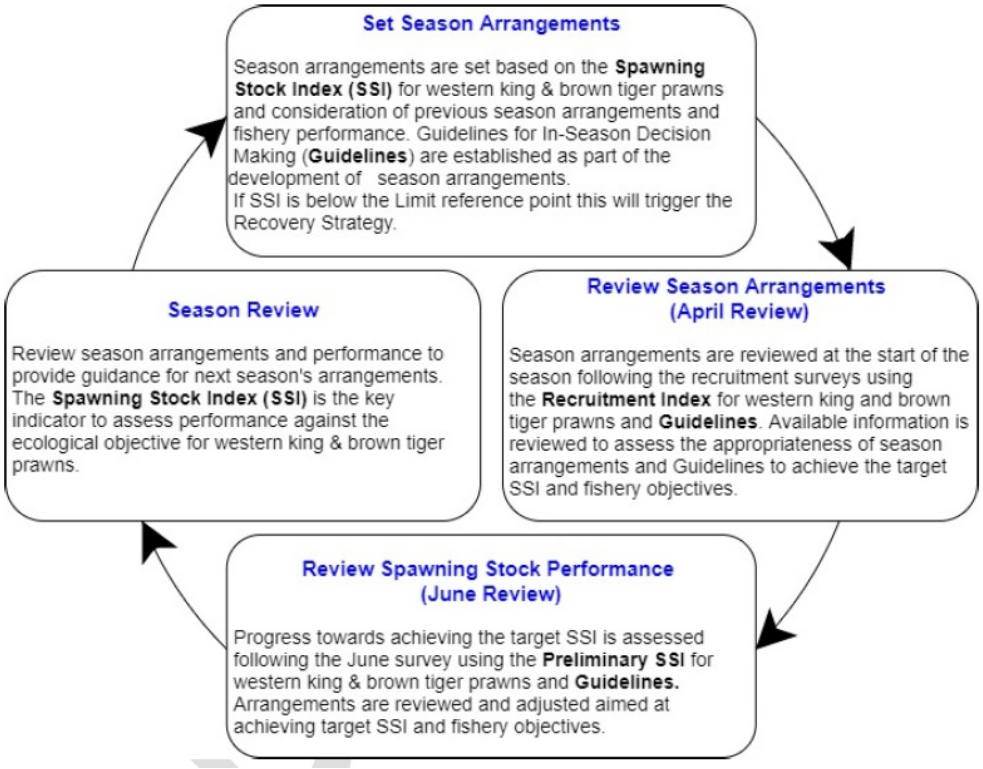


Figure 31: Process of setting season arrangements based on reviewing the target species performance indicators in the SBPMF. Taken from (DPIRD 2022).

Table 5. Resource assessments and harvest strategies for blue swimmer crab in Shark Bay

Fishery	Species	Performance Indicator	Reference Level	Harvest Control Rules
Shark Bay Crab Managed Fishery	Blue swimmer crab	Primary		
		Annual standardized index of harvestable size stock biomass (November survey)	Target: Harvestable size stock index >350 kg/nm^2	If the harvestable size stock index is above the threshold, and recruitment and spawning stock indices are above their respective limit levels, the TACC is set between 50% and 100% of the capacity specified in the SBCMP.
		Annual standardized index of peak recruitment stock biomass (February/November survey)	Threshold: Harvestable size stock index is 350 kg/nm^2	if the harvestable size stock index is between the threshold and limit levels, and the recruitment and spawning stock indices are above their limit levels, the TACC is reduced to a level between the current level and 50% of the capacity.
		Annual standardized index of peak spawning stock biomass (June survey)	Limit: Harvestable size stock index is 150 kg/nm^2 Peak recruitment index is 991 kg/nm Peak spawning stock index is 200 kg/nm^2	If any primary performance indicator is equal to or below its respective limit, the TACC is set between 0% and 50% of the capacity specified in the SBCMP.
		Secondary	Target: ≥90% of previous season TACC caught Annual standardized trap CPUE is ≥1.4 kg/trap lift	If both targets are met, the TACC is set at the higher end of its range identified by the primary indicators. If either target is not met, a more precautionary TACC is set, within the range identified by the primary indicators.
		Achievement of TACC for previous season		
		Annual standardized commercial trap CPUE (kg/traplift) based on monthly data from ongoing season		

Table 6. Resource assessments and harvest strategies for saucer scallop in Shark Bay

Fishery	Species/ Region	Performance Indicator	Reference Level	Harvest Control Rules

Shark Bay Scallop Managed Fishery	Saucer scallop Northern Shark Bay = NSB Denham Sound = DS	Primary: November abundance index	Target: November index >130 scallops/nm (NSB) November index >160 scallops/nm (DS)	If the November index is above the threshold, the TACC for the next season is set based on the February survey, using a weight-of-evidence approach. Depending on the proximity to the threshold level, additional management measures may be considered to reduce the fishing before spawning.
		Secondary: February abundance index	Threshold: November index ≤130 scallops/nm (NSB) November index ≤160 scallops/nm (DS)	If the November index breaches the threshold, the TACC for the next season is set to a precautionary level (<100 t), based on the February survey and a weight-of-evidence approach. Additional monitoring and/or management may be considered to reduce fishing before spawning.
			Limit: November index ≤90 scallops/nm (NSB) November index ≤100 scallops/nm (DS)	If the November survey index is equal to or below the limit, the TACC for the next season is set to 0, unless the February survey shows a marked improvement in scallop abundance. Additional monitoring and/or management is immediately implemented to protect scallops over the summer fishing period, until the February survey provides additional information.

Defining annual (or periodic) catch or effort tolerance levels for fisheries provides a formal and efficient basis to evaluate the effectiveness of current management arrangements in delivering the levels of catch and/or effort specified by the HCRs {Fletcher et al. 2017}. If the catch breaches the specified tolerance level and this cannot be adequately explained (e.g., clear environmental impacts or marketing reasons), the performance is termed "Unacceptable" (DPIRD 2022). This would also trigger a review to determine if management arrangements are still appropriate and if a reassessment of resource status is necessary to inform adjustments to the HCRs and/or tolerance levels (DPIRD 2022).

Overall, decision-making processes can be triggered following the identification of new or potential issues as part of an ecological risk assessment (generally reviewed every 3–5 years); results of research, management, or compliance projects or investigations; monitoring or assessment outcomes (including those assessed as part of the harvest strategy); and/or expert workshops and peer review of aspects of research and management (DPIRD 2022). Annual decision-making processes may result in measures to meet the short-term operational fishery objectives (driven by the harvest control rules), whereas longer-term decision-making processes result in new measures and/or strategies to achieve the long-term fishery objectives (i.e., changes to the management system) (DPIRD 2022). If there is an urgent issue, consultation with stakeholders may be undertaken to discuss the issue and determine appropriate management action, as needed (DPIRD 2022).

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Highly effective

Blue swimmer crab and other aquatic resources are managed by the DPIRD in Shark Bay, Western Australia, following specific key legislations (DPIRD 2020e) (Table 7).

The Shark Bay Crab Managed Fishery (SBCMF) Management Plan was implemented in November 2015 and provides the statutory quota management framework for the commercial take of blue swimmer crab by the prawn trawl, scallop trawl, and crab trap sectors in the waters of the SBCMF (DPIRD 2020e). The SBCMF is divided into two zones separating the inner gulfs (Zone 2) from the rest of Shark Bay (Zone 1) (Figure 32) (DPIRD 2020e). There are 32 licenses in the SBCMF, which are divided into Class A and B licenses across the trap and trawl fisheries (Table 8) (DPIRD 2020e). The formal commercial catch share arrangement to divide the annual blue swimmer crab resource across the commercial sectors is: trap sector, 66.0%; prawn trawl sector, 33.8%; and scallop trawl sector, 0.2% (DPIRD 2020e). Quota unit entitlement is fully transferable between licenses (DPIRD 2020e).

The SBCMF voluntarily closed in late 2011 in response to a recruitment failure of the blue swimmer crab stock, as a result of increased fishing pressure combined with a marine heatwave and flooding events in 2010–11 (DPIRD 2020e). During the closure, the DPIRD conducted additional monitoring programs to improve their understanding of the crab stock and better inform management decisions (DPIRD 2020e). As recruitment and the harvestable size crab stock improved in Shark Bay, the commercial take of crab was permitted again in September 2013 under a conservative TACC, which has gradually increased since then (DPIRD 2020e). The status of blue swimmer crab in Shark Bay is now fully recovered, and the stock is managed through a detailed harvest strategy (DPIRD 2020e).

The harvest strategy for the blue swimmer crab resource in Shark Bay is based on a constant exploitation approach, where the annual catch varies in proportion to variations in stock abundance (DPIRD 2020e). The current harvest strategy involves: 1) a formal review of targeted stocks and other ecological assets against defined reference levels to determine performance against management objectives relating to ecological sustainability; and 2) an annual fishery-level review that determines whether the current catch/effort by the fishery is consistent with the levels expected when ecological objectives are met (DPIRD 2020e). Other ecological assets incorporated in this harvest strategy include other retained species that may be affected by commercial crab trap fishing (DPIRD 2020e). In line with this harvesting approach, the commercial sector that targets this resource is primarily managed using: 1) output controls in the form of an annual TACC, allocated to license holders as individual transferable quota (ITQ) units; and 2) input controls, including spatial closures, species restrictions, size limits, and reporting requirements (DPIRD 2020e).

Commercial trap fishers of the SBCMF are permitted to operate for 12 months of the year (November 1 to October 31) (DPIRD 2020e). The licensing period commences on November 1 each year, when entitlement is allocated to each license in line with the TACC and the resulting unit value (DPIRD 2020e). Currently, the capacity for the SBCMF is specified in the SBCMF Management Plan as 650 tonnes, based on estimates from 2018 of the long-term maximum sustainable yield (MSY) for the blue swimmer crab resource under normal environmental conditions (DPIRD 2020e). The TACC is reviewed each year in April–May based on the state of the resource relative to specific reference

levels (DPIRD 2020e). DPIRD and industry have implemented a comanagement arrangement, whereby the industry abides by a TACC that is less than the legislated capacity (DPIRD 2020e). This voluntary agreement provides DPIRD with the flexibility to increase or decrease the TACC in accordance with fluctuations in the crab stock (DPIRD 2020e). The Shark Bay Crab Working Group recommends and reviews the annual TACC, based on available stock status information (DPIRD 2020e). If the June or November survey or fishery-dependent data indicate that a significant and unexpected change in stock levels may have occurred (e.g., due to a heatwave), an earlier review of the TACC can occur (DPIRD 2020e). This adds further precaution to the harvesting approach and ensures that fishing pressure on the stock can be rapidly altered (DPIRD 2020e).

Suitable indicators have been selected to determine the status of the blue swimmer crab resource in Shark Bay and other ecological assets against defined reference levels established to separate acceptable from unacceptable performance (DPIRD 2020e). Where relevant, these levels include a target level (optimal), a threshold level (undesirable), and a limit level (unacceptable) (DPIRD 2020e). Harvest Control Rules (HCRs) define the management actions that should occur in relation to the value of each performance indicator relative to the reference levels (Figure 33) (DPIRD 2020e). These HCRs are designed to maintain the resource above the threshold level and close to a target level, or to rebuild it where it has fallen below the threshold or the limit levels (DPIRD 2020e).

The primary performance indicators for the blue swimmer crab stock are based on fishery-independent survey data and are compared annually to specified reference levels to determine an appropriate TACC (DPIRD 2020e). The TACC setting process also considers secondary performance indicators based on fishery dependent data and other lines of evidence, including: spatial distribution of effort for the trap sector, total catch of trap and trawl sectors, environmental factors, a biodynamics model, and economic factors (DPIRD 2020e). Annual catch tolerance levels have been developed for the commercial fisheries that catch the blue swimmer crab in Shark Bay (DPIRD 2020e). The management measures that may be used to achieve the management responses include reducing catch (i.e., TACC of the commercial fishery) and restricting fishing effort by implementing spatial and/or temporal closures (DPIRD 2020e).

Because the stock appears to be healthy and adequate management strategies are in place, this factor has been rated highly effective.

Justification:

Table 7. Legislation for blue swimmer crab and other resources in Shark Bay

Name of legislation	Abbreviation (if any)
Fish Resources Management Act 1994	FRMA/ ARMA
Fish Resources Management Regulations 1995	FRMR
FRMA Part 6—SBCMF Management Plan	
FRMA Section 43 Order—Prohibition on Commercial Fishing (Shark Bay Marine Park) Order 2004	
FRMA Section 7 instruments of exemption	
Commonwealth Environment Protection and Biodiversity Conservation Act 1999	EPBC Act
Marine Safety (Domestic Commercial Vessel) National Law Act 2012	
Western Australia Marine Act 1982	
Western Australia Wildlife Conservation Act 1950	

Western Australia Conservation and Land Management Act 1984	
Any other legislation governing the use of the marine environment in which fishing activities occur	

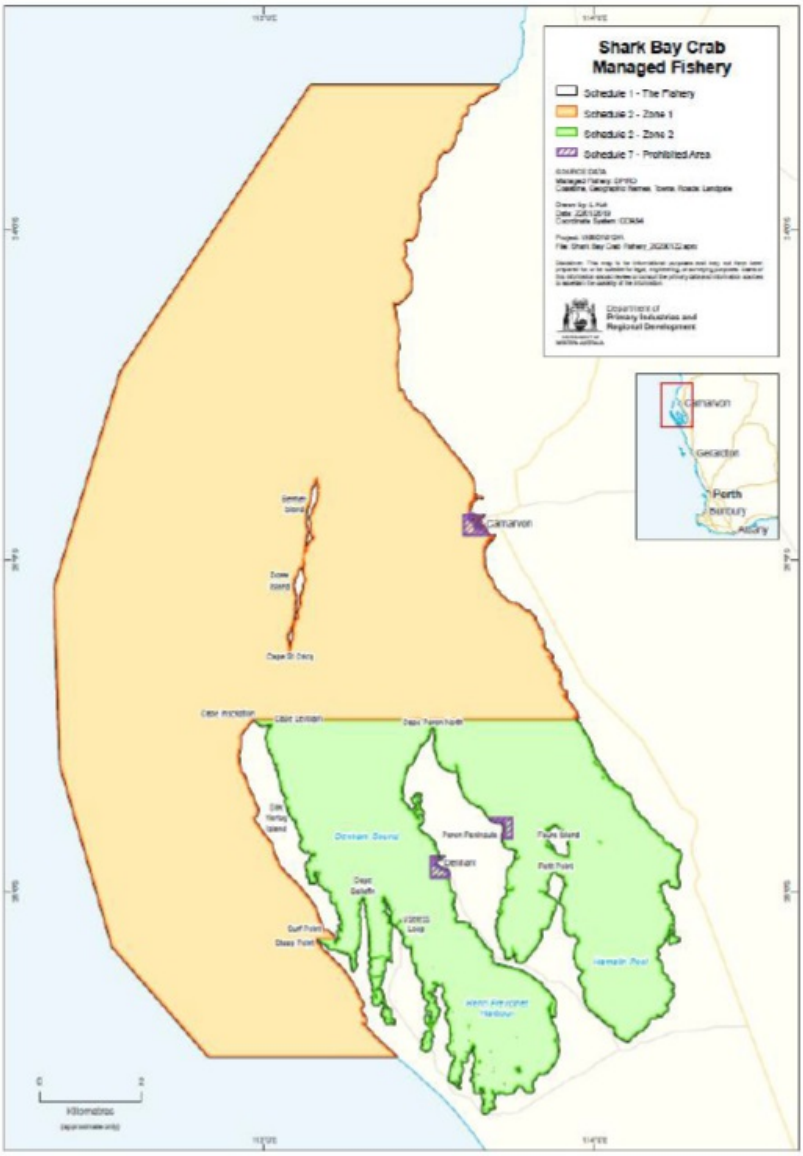
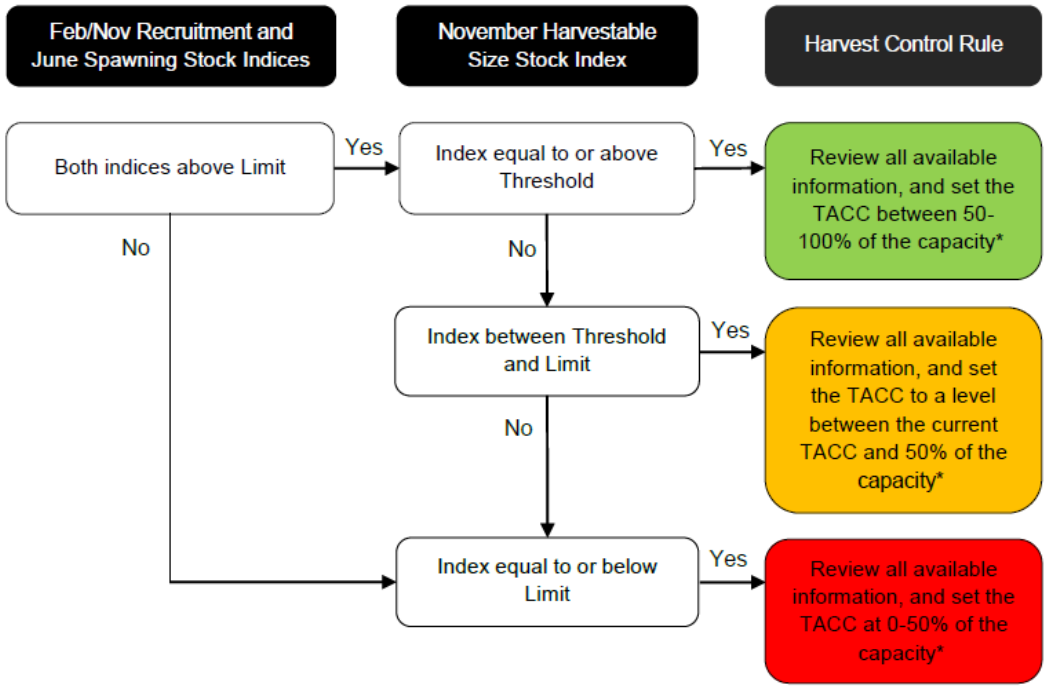


Figure 32: Management zones of the Shark Bay Crab Managed Fishery. Taken from (DPIRD 2020e).

Table 8. Shark Bay Crab Managed Fishery license types

License type/fishery type	Trap fishery	Trawl fishery
Class A	Can fish in Zone 1 only. There are three licenses of this type.	Can fish in Zone 1 and Zone 2 in permitted trawl areas.
Class B	Can fish in Zone 1 and Zone 2. There are two licenses of this type.	

Total number of licenses	5	27



*The magnitude of any increase or decrease in TACC will be subject to a weight-of-evidence assessment of all available information, including secondary indicators; commercial trap CPUE and achievement of the previous season's TACC.

Figure 33: Diagram of how the harvest control rules in Shark Bay are used to inform the annual TACC for the blue swimmer crab resource. Taken from (DPIRD 2020e).

Defining annual (or periodic) catch or effort tolerance levels for fisheries provides a formal and efficient basis to evaluate the effectiveness of current management arrangements in delivering the levels of catch and/or effort specified by the HCRs {Fletcher et al. 2017}. If the catch breaches the specified tolerance level and this cannot be adequately explained (e.g., clear environmental impacts or marketing reasons), the performance is termed "Unacceptable" (DPIRD 2020e). This would also trigger a review to determine if management arrangements are still appropriate and if a reassessment of resource status is necessary to inform adjustments to the HCRs and/or tolerance levels (DPIRD 2020e).

Overall, decision-making processes can be triggered following the identification of new or potential issues as part of an ecological risk assessment (generally reviewed every 3–5 years); results of research, management, or compliance projects or investigations; monitoring or assessment outcomes (including those assessed as part of the harvest strategy); and/or expert workshops and peer review of aspects of research and management (DPIRD 2020e). Annual decision-making processes may result in measures to meet the short-term operational fishery objectives (driven by the harvest control rules), whereas longer-term decision-making processes result in new measures

and/or strategies to achieve the long-term fishery objectives (i.e., changes to the management system) (DPIRD 2020e). If there is an urgent issue, consultation with stakeholders may be undertaken to discuss the issue and determine appropriate management action, as needed (DPIRD 2020e).

Southwest Pacific | Pots | Australia | New South Wales

Moderately Effective

The commercial blue swimmer crab fishery in New South Wales is managed as part of the Estuary General Fishery by the New South Wales Department of Primary Industries Fishing and Aquaculture (NSW DPI 2022). This fishery operates under the provisions of the Fisheries Management Act 1994 and associated regulations, and follows a general code of practice (NSW DPI 2021).

Since 2017, the blue swimmer crab fishery is being managed by setting a TAC of 225 t, with catch allocations based on a quota system {Johnson, D. 2020}{Johnston et al. 2020b}. Further, an increased legal minimum size of 65 mm carapace length is enforced for commercial fishers, and a daily possession limit of 25 kg for all ocean fisheries has been implemented {Johnson, D. 2020} {Johnston et al. 2020b}. These measures are believed to have reduced fishing pressure on the spawning stock, resulting in a decline in the harvest rate since 2017 {Johnson, D. 2020}{Johnston et al. 2020b}. But, management does not appear to be responsive to changes in stock productivity and biomass. Although New South Wales is currently undergoing fisheries reform, with recently updated harvest strategy guidelines (NSW DPI 2021b) and new harvest strategies developed for several major fisheries, the blue swimmer crab harvest strategy has not been updated. For these reasons, this factor has been rated moderately effective.

Western Central Pacific | Pots | Australia | Queensland

Moderately Effective

The Department of Agriculture and Fisheries of the Queensland government is responsible for management of the commercial blue swimmer crab pot fishery in Queensland (Queensland Government 2021), following key legislations (Table 9).

Management of the fishery is currently in a transition phase from a fishery with high effort and no catch limits to a quota-managed fishery (Queensland Government 2021). This new harvest strategy is designed to manage the fishing mortality of blue swimmer crab through setting a TAC at a level that allows the stock to achieve a 60% exploitable biomass target, and to maintain resource shares between commercial (pot and trawl), recreational, and traditional fishing sectors (Queensland Government 2021). In the commercial fishery, individual quotas are transferable (Queensland Government 2021).

A number of input control management tools are also being used to support this harvest strategy, including spawning closures, harvesting of male crabs only, a harvest minimum size limit of 11.5 cm CW, limited access through primary commercial fishing licenses with a C1 fishery symbol, commercial gear specifications (use of crab pots/collapsible traps/dillies, limiting commercial fishers to 50 pots/traps/dillies per C1 fishery symbol), and a maximum vessel size limit of 25 m (Queensland Government 2021).

Performance in the fishery is measured by key indicators including blue swimmer crab exploitable biomass, with reference points to establish acceptable performance, such as B_{TARG} (60% exploitable biomass) and B_{LIM} (20% exploitable biomass). The decision rules for setting a sustainable harvest in the blue swimmer crab harvest strategy are based on a "hockey stick" approach, in which the TAC is set based on a linear relationship between B_{LIM} (where the level of fishing mortality, F, is equal to zero) and B_{TARG} (where the exploitation rate and TAC are set at the level to achieve MEY) (Figure 34) (Queensland Government 2021).

The recommended TAC is calculated by applying the rate of fishing mortality to the current exploitable biomass level, so that the target reference biomass B_{TARG} (or the level that maintains the exploitable biomass at 60%) is achieved (see Figure 34) (Queensland Government 2021). Consequently, the recommended TAC represents the total catch from all sectors that can be harvested each year, to move the current biomass level toward the target level (Queensland Government 2021). A discount factor may also be included to account for uncertainty and to reduce the risk of a fishery not achieving its objectives (Queensland Government 2021). A decision rule is in place, which considers the current exploitable biomass level of the stock to determine the appropriate TAC (Figure 35) (Queensland Government 2021). Per the harvest strategy, if the exploitable biomass falls below the limit reference point (B_{LIM}), targeted fishing of the stock is stopped until a rebuilding strategy is developed to increase the exploitable biomass above the limit within a biologically reasonable timeframe (e.g., based on mean generation time) (Queensland Government 2021).

This harvest strategy will remain in place for a period of 5 years, after which it will be fully reviewed in accordance with the Fisheries Act 1994 (Queensland Government 2021). The harvest strategy may be subject to further review and amendment as appropriate within the 5-year period if: there is new information that substantially changes the status of the fishery, leading to improved estimates of indicators relative to reference points; drivers external to management of the fishery increase the risk to fish stock/s; a new recreational harvest estimate suggests that the defined sectorial catch shares may have been set incorrectly or may be unrepresentative; or it is clear that the harvest strategy is not working effectively (Queensland Government 2021).

Because the updated harvest strategy was developed in 2021 and the exploitable biomass ratio is currently less than 75% of the target reference point, the effectiveness of the strategy is unknown. Hence, this factor has been scored moderately effective.

Justification:
Table 9. Legislations for management of the commercial blue swimmer crab pot fishery in Queensland

Relevant fisheries legislation	Fisheries Act 1994
	Fisheries (General) Regulation 2019
	Fisheries (Commercial Fisheries) Regulation 2019
	Fisheries Declaration 2019
	Fisheries Quota Declaration 2019
Other relevant legislation	Great Barrier Reef Marine Park Act 1975 and Great Barrier Reef Marine Park Regulations 2019

	Marine Parks Act 2004
	Environmental Protection and Biodiversity Conservation Act 1999
	Environmental Protection and Biodiversity Conservation regulations 2000

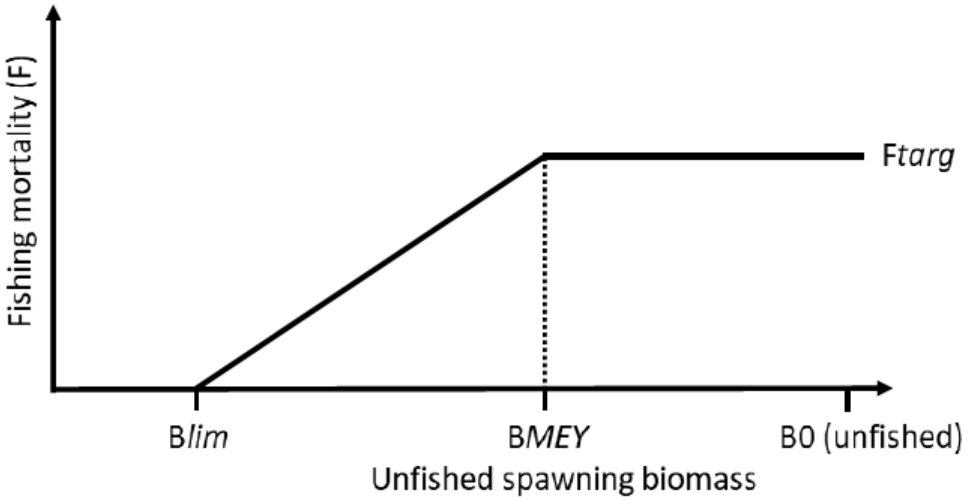


Figure 34: The "hockey stick" approach used to set TAC in the blue swimmer crab pot fishery in Queensland. Taken from (Queensland Government 2021).

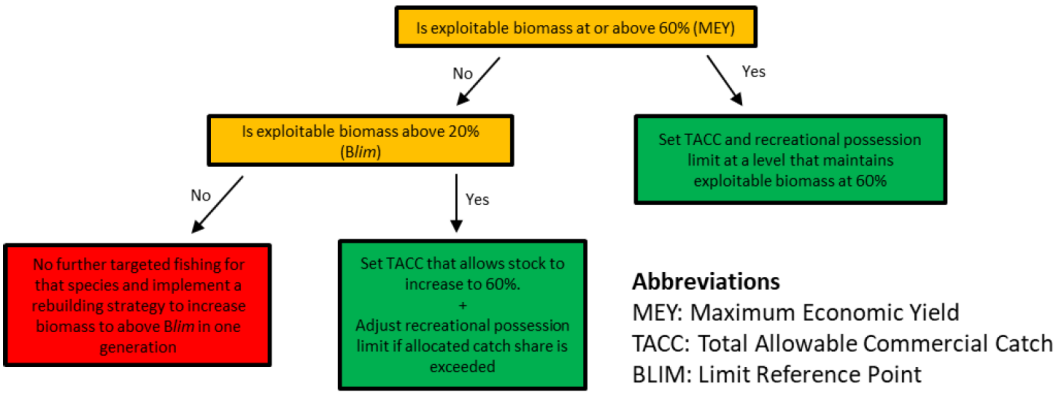


Figure 35: Decision rules/harvest control rules used as part of the harvest strategy to manage blue swimmer crab in the commercial pot fishery in Queensland. Taken from (Queensland Government 2021).

Factor 3.2 - Bycatch Strategy

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Moderately Effective

In comparison to other fisheries, bycatch levels in the South Australia blue swimmer crab fishery are considered relatively low, especially because the trap mesh size and the use of escape gaps have increased in recent years (Hooper 2018). Nevertheless, there are limited data on bycatch species in this fishery, and the extent of bycatch monitoring is unknown, so this factor has been scored moderately effective.

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Highly effective

In the mid-1990s, crab traps were trialed to target blue swimmer crab in the Peel-Harvey Estuary (PHE) (Bellchambers and de Lestang 2005). One of the advantages of shifting from gillnets to traps was that crab traps produced far less bycatch and improved catch quality (Fisher et al. 2020). Thus, collapsible hourglass traps are the only gear currently used in the commercial blue swimmer crab fishery in the PHE (Figure 36) (Fisher et al. 2020). Since 2000, fishers have voluntarily included escape gaps in all crab traps, to reduce the size of undersized and juvenile crabs caught (Fisher et al. 2020); nevertheless, mesh size is not legislated and fishers use mesh sizes ranging from 50 to 90 mm (Fisher et al. 2020).

The bycatch mitigation strategy adopted by the DPIRD in the PHE involves a periodic ecological risk assessment, conducted to assess the impacts of each fishery on various aspects of the aquatic environment, including all relevant bycatch and endangered, threatened, and protected (ETP) species (Fisher et al. 2020). This risk assessment is used to filter and prioritize management issues that are identified (Fisher et al. 2020). During the risk assessment process, the DPIRD engages all stakeholders to participate in a workshop to collectively score risk issues (Fisher et al. 2020). The methodology uses a consequence-likelihood analysis, wherein the magnitude of potential consequences of a fishery and the likelihood that those consequences will occur under current management conditions are examined (Fisher et al. 2020). For both non-ETP and ETP bycatch species, fishing impacts that generate a moderate or lower risk rating are considered the target reference level, those that generate a high risk rating are considered the threshold reference level, and those that generate a severe risk rating are considered the limit reference level; each level is associated with its respective harvest control rules (HCRs) (DPIRD 2020c). The risk rating for blue swimmer crab that is bycatch in the commercial trap fishery was "medium," because the stock is being harvested at a sustainable level and there are no issues with stock sustainability (Fisher et al. 2020). The risk ratings of bycatch species in the commercial trap fishery were negligible (Fisher et al. 2020). Similarly, the risk rating of ETP species such as shore birds in the commercial trap fishery was negligible (Fisher et al. 2020). The risk rating of the commercial trap fishery on ghost fishing of lost gear was also found to be negligible (Fisher et al. 2020). Because the bycatch of other species in the commercial trap fishery is less than 5% and the risk rating of bycatch species and ETP species was negligible, bycatch strategy has been rated highly effective.

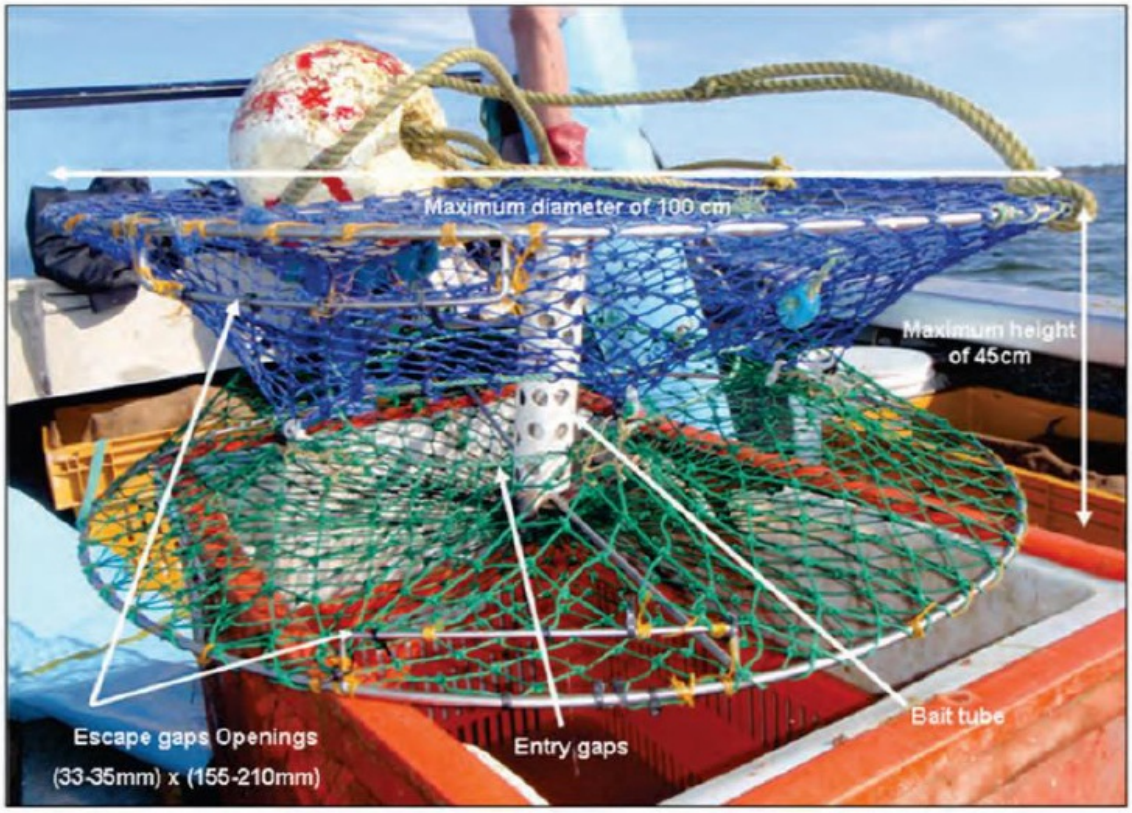


Figure 36: Commercial crab traps used in the Peel-Harvey Estuary, showing the escape gap at the bottom. Taken from (Fisher et al. 2020); original source {Johnston et al. 2015}.

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Moderately Effective

Vessels in the Shark Bay Crab Managed Fishery (SBCMF) are only permitted to catch blue swimmer crab with crab traps or trawl nets (DPIRD 2020). All trawl nets in Western Australia are required to be fitted with bycatch reduction devices (BRDs) (DPIRD 2020). Such BRDs include a grid, square mesh panels, and a fish exclusion device, either in combination or as separate devices (DPIRD 2020) (DPIRD 2022). Grids allow large animals (such as turtles) or objects to escape as soon as they enter the net (DPIRD 2020)(DPIRD 2022). Within the Shark Bay Prawn Managed Fishery (SBPMF), all vessels use an onboard "hopper" or "well" in-water sorting system, which reduces mortality of some bycatch species by allowing the catch to remain in recirculating water for an extended period, thus maximizing the survival of nontarget species (DPIRD 2020)(DPIRD 2022).

The bycatch mitigation strategy adopted by the DPIRD in Shark Bay involves a periodic ecological risk assessment, which is conducted to assess the impacts of each fishery on various aspects of the aquatic environment, including all relevant bycatch and ETP species (DPIRD 2020)(DPIRD 2022). This risk assessment is used to filter and prioritize management issues that are identified (DPIRD 2020)(DPIRD 2022). During the risk assessment process, the DPIRD consults with all stakeholders to collectively score risk issues (see Figure 38) (DPIRD 2020)(DPIRD 2022). The methodology uses a consequence-likelihood analysis, wherein the magnitude of potential consequences of a fishery and

the likelihood that those consequences will occur under current management conditions are examined (DPIRD 2020)(DPIRD 2022). For both non-ETP and ETP bycatch species, fishing impacts that generate a moderate or lower risk rating are considered the target reference level, those that generate a high risk rating are considered the threshold reference level, and those that generate a severe risk rating are considered the limit reference level; each level is associated with its respective HCRs (DPIRD 2020e). The risk ratings of bycatch species in the commercial trawl fishery were either "low" or "negligible" (DPIRD 2020e). Similarly, the risk ratings of most ETP species in the commercial trawl fishery were either "low" or "negligible," but the risk rating of sea snakes was "medium" (DPIRD 2020e).

Although bycatch of other species and ETP species in the commercial trawl fishery does not appear to be significant (from fisher logbook data and the risk assessment conducted) (DPIRD 2020e), independent observer coverage is unknown and discards make up 49.2% of the catch in the trawl fishery. Hence, collectively, bycatch strategy for the trawl fishery in Shark Bay has been rated moderately effective.

Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Highly effective

Vessels in the SBCMF are only permitted to catch blue swimmer crab with crab traps or trawl nets (DPIRD 2020). The hourglass crab traps used may or may not be collapsible, and are designed to minimize the capture of juvenile blue swimmer crab and nontarget species, which escape through the entrance gaps when the trap is soaking or being hauled (Figure 37) (DPIRD 2020).

The bycatch mitigation strategy adopted by the DPIRD in Shark Bay involves a periodic ecological risk assessment, conducted to assess the impacts of each fishery on various aspects of the aquatic environment, including all relevant bycatch and ETP species (DPIRD 2020). This risk assessment is used to filter and prioritize management issues that are identified (DPIRD 2020). During the risk assessment process, the DPIRD consults all stakeholders to collectively score risk issues (Figure 38) (DPIRD 2020). The methodology uses a consequence-likelihood analysis, wherein the magnitude of potential consequences of a fishery and the likelihood that those consequences will occur under current management conditions are examined (DPIRD 2020). For both non-ETP and ETP bycatch species, fishing impacts that generate a moderate or lower risk rating are considered the target reference level, those that generate a high risk rating are considered the threshold reference level, and those that generate a severe risk rating are considered the limit reference level; each level is associated with its respective HCRs (DPIRD 2020e). The risk rating for blue swimmer crab bycatch in the commercial trap fishery was "medium," because the stock is being harvested at a sustainable level and there are no issues with stock sustainability (DPIRD 2020). The risk ratings of bycatch species in the commercial trap fishery were either "low" or "negligible" (DPIRD 2020). Similarly, the risk ratings of most ETP species in the commercial trap fishery were either "low" or "negligible," but the risk rating of sea snakes was "medium" (DPIRD 2020).

Because bycatch of other species and ETP species in the commercial trap fishery does not appear to be significant (from fisher logbook data and the risk assessment conducted) (DPIRD 2020), collectively, the bycatch strategy for the trap fishery in Shark Bay has been rated highly effective.

Justification:

Figure 37: Example of a collapsible crab trap (showing an entry gap to minimize bycatch) used in the Shark Bay Crab Managed Fishery. Taken from (DPIRD 2020).

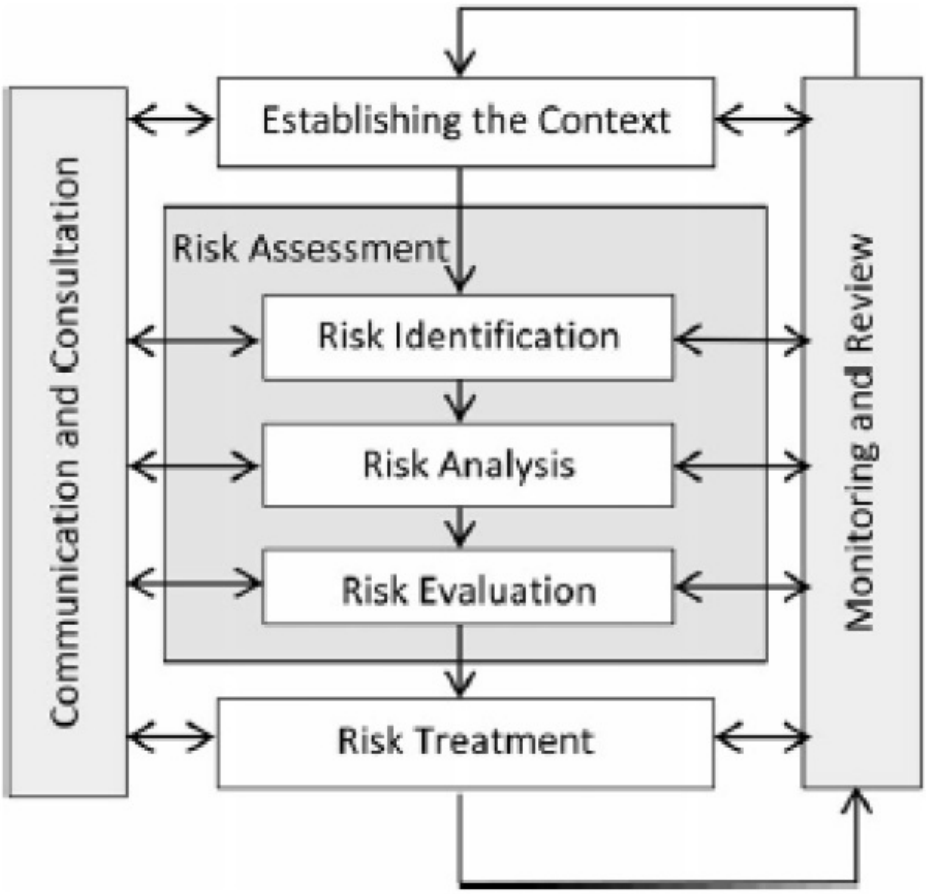


Figure 38: The risk assessment and risk management process that is used as a bycatch mitigation tool in the Shark Bay Crab Managed Fishery. Taken from (DPIRD 2020).

Southwest Pacific | Pots | Australia | New South Wales

Moderately Effective

The blue swimmer crab pot fishery in New South Wales is a highly selective fishery and has little impact on nontarget species (Barnes et al. 2022b). Nevertheless, there is significant bycatch associated with undersized blue swimmer crab, which has resulted in the wide-scale voluntary introduction of escape gaps by commercial fishers, who use collapsible cylindrical traps to target blue swimmer crab {Barnes et al. 2022}(Broadhurst et al. 2017). Although a few recent studies have focused on testing the performance of escape gaps in traps (showing some success), the use of escape gaps is not mandatory by law {Barnes et al. 2022}(Broadhurst et al. 2017). Further, it is unknown if ETP species interact with traps in New South Wales. For these reasons, this factor has been scored moderately effective.

Western Central Pacific | Pots | Australia | Queensland

Ineffective

Permitted commercial crab fishing apparatuses in the blue swimmer crab C1 fishery in Queensland

include crab pots, collapsible traps, and dillies (Queensland Government 2021). These apparatuses may be equipped with bycatch reduction devices (BRDs) such as turtle excluder devices and/or escape vents, so that juveniles and nontarget species may escape if caught (Figure 39) (DAF 2019). But, the use of BRDs is not mandatory in the C1 fishery; therefore, the extent of their use is unknown (DAF 2019). Interactions between commercial crab fishers operating in the C1 fishery and Species of Conservation Interest (SOCI) through logbook data are presented in Figure 40 (DAF 2019).

As part of the guidelines outlined in the Queensland Sustainable Fisheries Strategy 2017–2027 (DAF 2018), an ecological risk assessment (ERA) was conducted to assess fishing-related risks on various ecological components of the fishery, including bycatch and ETP species {Walton and Jacobsen 2019}. These guidelines describe a four-stage framework to assess a fishery, beginning with a scoping study, followed by a Level 1 (qualitative), Level 2 (species-specific and semi-quantitative), and Level 3 (quantitative) assessment, if required {Walton and Jacobsen 2019}. To construct risk profiles, fishing activities were assigned a risk score posed to various ecological components that the fishery affected {Walton and Jacobsen 2019}. The Level 1 risk assessment found that (with respect to other species) the most notable risks were to bycatch species (intermediate risk), marine turtles (high risk), sawfish (intermediate risk), and speartooth shark (intermediate risk) {Walton and Jacobsen 2019}. Discards were found to be one of the highest contributors of risk in the C1 fishery {Walton and Jacobsen 2019}. Ghost fishing was also considered to pose a risk in the C1 fishery; although information on pot loss is scarce, it has been estimated that a single commercial fisher in the C1 fishery will lose an average of 35 pots per year, potentially affecting both target and nontarget species {Walton and Jacobsen 2019}. From the results of the Level 1 ERA, marine turtles were included in the Level 2 ERA {Walton and Jacobsen 2019}. This Level 2 assessment indicated that green sea turtle and loggerhead turtle were at high risk from the C1 crab fishery, whereas hawksbill turtle, flatback turtle, and leatherback turtle were at an intermediate risk, and olive ridley turtle was at low risk {Walton and Jacobsen 2019}. Note that the risk assessments conducted do not differentiate between the commercial and recreational crab fishery.

Bycatch mitigation strategies do exist in the management of the C1 fishery; however, the fishery poses a high threat to turtles (from the ERAs conducted) {Walton and Jacobsen 2019} and to whales (from logbook data) (DAF 2019), and an intermediate risk to sawfish and speartooth shark (from the Level 1 ERA conducted) {Walton and Jacobsen 2019}, with no mitigation measures currently being implemented; in addition, there is a high risk of unmanaged ghost fishing from this fishery {Walton and Jacobsen 2019}, with no mitigation strategies being planned. Overall, the bycatch strategy adopted is considered inadequate. Therefore, this factor has been assigned a score of ineffective.

Justification:
Based on the ERAs conducted, in February 2021, the Queensland Department of Agriculture and Fisheries recommended that this fishery be accredited under Part 13 of the EPBC Act, which would allow for trade of blue swimmer crab caught in the Queensland C1 fishery, subject to managers developing and implementing risk mitigation strategies for marine turtles, implementation of plans to improve monitoring and reporting of protected species interactions, and implementation of an independent system to validate commercial fishery interactions with protected species (DAWE 2021). There was also recognition that ghost fishing was an ongoing risk in the fishery, but no mitigation

measures were suggested to address the issue (DAWE 2021). But, in December 2021, the Minister for Agricultural and Industry Development in Queensland revoked the WTO declaration for this fishery, presumably because of the risk it poses to protected species, thus prohibiting the export of blue swimmer crab from Queensland (QDAWE 2021)(Commonwealth of Australia 2021).

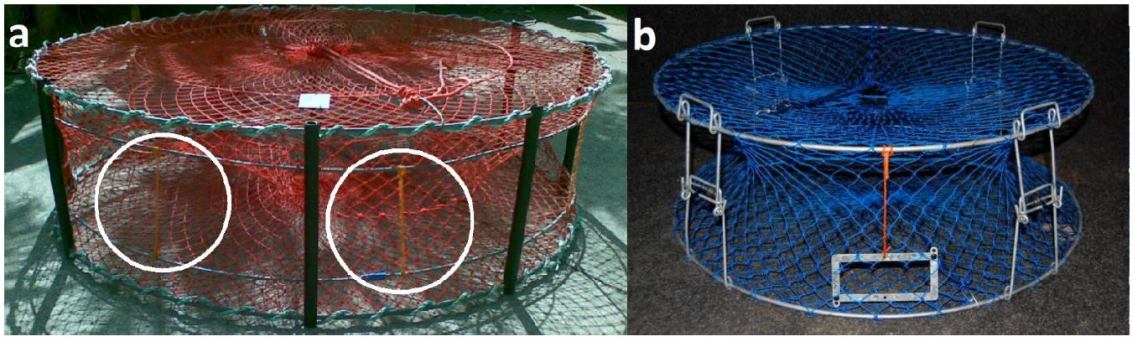


Figure 39: Bycatch reduction devices used in crab pots in Queensland may include (a) turtle excluder devices and (b) escape vents. Taken from (Queensland Government 2019).

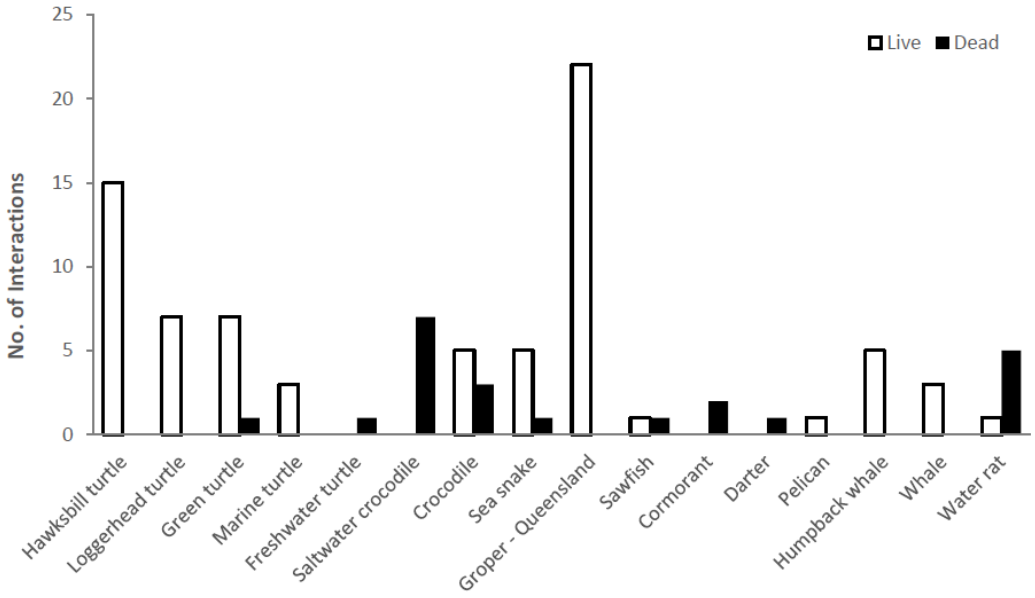


Figure 40: Fisher logbook data, showing interactions with Species of Conservation Interest recorded from crab fishing activities in the C1 fishery from 2002 to 2017. Taken from (DAF 2019).

Factor 3.3 - Scientific Data Collection and Analysis

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Moderately Effective

PIRSA contracts core research on the blue swimmer crab in South Australia to the South Australian Research and Development Institute (SARDI) (PIRSA 2020). Fishers are required to complete and submit daily catch records through compulsory logbooks, once a month (PIRSA 2020).

Data collected include fishing location (or block), depth, effort, catch weight, catch abundance, number of undersized crabs, berried females, and the sex ratio of the catch (PIRSA 2020). SARDI maintains a detailed catch and effort database for the fishery using logbook data (PIRSA 2020). Licensed fishers are also required to record interactions with endangered, threatened, and protected (ETP) species using a "wildlife interaction" logbook (PIRSA 2020). Fishery-independent surveys have also been conducted annually since 2002 (PIRSA 2020). These surveys collect data on abundance and size composition of blue swimmer crab during winter, when juvenile crabs are recruited into the fishery (PIRSA 2020). The surveys are also used to inform the harvest strategy for blue swimmer crab
(PIRSA 2020). Two publications are produced on the blue swimmer crab in South Australia annually: a fishery independent advice note or report and a stock assessment report (PIRSA 2020). Nevertheless, because the abundance of nontarget species is not monitored and a data-limited approach is used when assessing the blue swimmer stock, this factor has been scored moderately effective.

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Moderately Effective

Catch and effort statistics are collected from licensed commercial fishers, who are required to report on catches (kg), effort, and ETP species interactions on a monthly basis (DPIRD 2020c). These statistics are used to calculate blue swimmer crab catch rates, which are the primary performance indicator used to assess stocks in the Peel-Harvey Estuary (DPIRD 2020c). Data are cross-checked by the DPIRD and also validated by onboard observers (DPIRD 2020c). Fishery-independent data collection and monitoring is also conducted; however, recruitment and breeding stock indices from these data are preliminary, and a sufficient time series of data is required before these data can be used as performance indicators (DPIRD 2020c). Recreational surveys are conducted every 2 to 3 years to collect information on fish catch, location, effort, and demographic information (DPIRD 2020c). But, fishery-dependent data from the commercial fishery are the primary source of data used, the stock assessment conducted is data-limited, and recreational information is only periodically collected, so this factor has been rated moderately effective.

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Moderately Effective

Licensed commercial trap fishers in the SBCMF are required to submit daily logbook records of catch (number of crabs) and effort (days fished, number of traps, soak-time, etc.), plus the spatial coordinates for the start and end of each line of traps. Trap catch rates calculated from logbook data represent a secondary performance indicator of stock status, and are used to examine fishery performance against a trigger level, above which the fishery is considered to be economically viable (DPIRD 2020e). Prawn trawl fishers are also required to submit detailed catch and effort records in daily logbooks, although the catch of bycaught species such as blue swimmer crab is aggregated over each night of fishing (DPIRD 2020e). Fishing effort cannot be accurately attributed to crabs

(DPIRD 2020e). Catch data derived from these trawl logbooks are used in the overall weight-of-evidence assessment of the blue swimmer crab resource in Shark Bay (DPIRD 2020e). All commercial fishers are also required to report retained species catches and ETP species interactions through logbooks (DPIRD 2020e), and to complete a Catch and Disposal Record (CDR) when landing catch (DPIRD 2020e). Whereas the trap sector lands catch and completes its records daily, the trawl sector remains at sea for long periods, so it submits CDRs at the end of each fishing trip, with cumulative catch data (DPIRD 2020e).

The stock assessment conducted uses a data-limited approach, with three primary performance indicators: peak spawning stock biomass (females 110 mm+ CW, collected in the June survey), peak recruitment stock biomass (males and females <100 CW, collected as an average of November and February survey), and harvestable size stock biomass levels (males and females 135 mm+ CW, collected in November survey), as well as two secondary indicators: quota achievement and standardized commercial trap catch rates {Johnston et al. 2020b} (DPIRD 2020e). Whereas the primary performance indicators for the stock assessment are based on fishery-independent survey data, the secondary indicators are based on fishery-dependent data (DPIRD 2020e). Because the stock assessment uses a data-limited approach, a score of moderately effective has been awarded for this factor.

Southwest Pacific | Pots | Australia | New South Wales

Moderately Effective

Fishers are required to report the total weight of each species in the catch via the FisherMobile application, preferably before landing the catch. Alternatively, fishers may submit these reports through the Interim Fishing Activity Report (IFAR) logbook or the New South Wales DPI Commercial Fisheries catch and effort logbook (NSW DPI 2018). The stock assessment conducted uses a data-limited, weight-of-evidence approach, with a Catch-MSY model-assisted catch only assessment, where indicators include catch and standardized catch rates {Johnson, D. 2020} {Johnston et al. 2020b}. Because a data-limited approach is used in the stock assessment, this factor has been scored moderately effective.

Western Central Pacific | Pots | Australia | Queensland

Ineffective

Catch and effort data are collected through commercial fisher logbooks and real-time landing reports (Lovett et al. 2020). These data and vessel tracking data are used to determine the standardized commercial catch rate of blue swimmer crab (Lovett et al. 2020). Surveys of recreational fishers at boat ramps and data from statewide recreational fishing surveys and the Keen Angler Program provide data on recreational harvests (Lovett et al. 2020). Fishery-independent trawl surveys on blue swimmer crab have been conducted since 2006, and sampling is conducted in November and December each year, using a beam trawl apparatus (Lovett et al. 2020). These data are used in the stock assessment as an index of relative abundance (Lovett et al. 2020). The stock assessment conducted used a length-based model with a monthly time step, length-based selectivity, and an inshore and offshore region spatial component (Lovett et al. 2020). Nevertheless, the level of discards is expected to be high but is unknown and not monitored {Walton and Jacobsen 2019}.

Bycatch data are recorded through commercial crab fishers operating in the C1 fishery, who are required to report on interactions with Species of Conservation Interest (SOCI) through logbooks (DAF 2019). But, there are concerns that not all interactions with protected species are being reported via fisher logbooks, and the commercial fishery interactions with protected species need to be independently validated (DAWE 2021). Therefore, reporting and monitoring of interactions with protected species need to be improved. Further, ghost fishing is a high risk issue that has been identified in the fishery and is not being adequately monitored {Walton and Jacobsen 2019}(DAWE 2021).

Because ghost gear is not being appropriately measured and monitored in this fishery, a score of ineffective has been assigned to this factor.

Factor 3.4 - Enforcement of and Compliance with Management Regulations

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Highly effective

The Department of Primary Industries and Regions of the Government of South Australia runs a compliance program to maximize voluntary compliance with fisheries rules, and to create effective deterrence to breaching these rules, in line with the National Fisheries Compliance Policy (PIRSA 2020). Voluntary compliance is maximized by ensuring that fishers are aware of and understand fishing rules and the purpose of these rules, thus creating a culture of voluntary compliance (PIRSA 2020). In addition, effective deterrence is created through Fisheries Officers, who create awareness of compliance operations and also detect and prosecute illegal activity (PIRSA 2020). Thus, Fisheries Officers are authorized to stop, enter, and search any boat or vehicle; seize fish, gear, and equipment; issue written cautions and legal notices for illegal activities; and check safety gear and licenses (PIRSA 2022). Marine Safety Officers have the authority to check fish catches and to conduct safety checks by intercepting vessels on the water (PIRSA 2022)(PIRSA 2022b). In case of minor infractions, an educational advice may be provided or formal notice may be issued (PIRSA 2022)(PIRSA 2022b). Serious infractions may be processed through the court system (PIRSA 2022b). Because adequate measures are in place to ensure enforcement and compliance to management regulations, this factor has been scored highly effective.

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Moderately Effective

The DPIRD is responsible for enforcement and compliance of blue swimmer crab regulations in the Peel-Harvey Estuary (DPIRD 2020c), following the Western Australian Fisheries Compliance Strategy (DPIRD 2018). Management of blue swimmer crab in the Peel-Harvey Estuary is enforced under Operational Compliance Plans, which are informed by a compliance risk assessment that is reviewed every 2 years (DPIRD 2020c).

Compliance strategies and activities that are used in the commercial fishery targeting blue swimmer crab in southwest Western Australia include land patrols; on-water patrols; roadside checkpoints;

catch, license, and gear inspections; wholesale and retail inspections; and covert surveillance under approved operations (DPIRD 2020c). Licensed commercial crab fishers are required to report all retained species catches, effort, ETP species interactions, and fishing locations through monthly logbooks (DPIRD 2020c). Onboard observer monitoring takes place twice a month in the Peel-Harvey Estuary (DPIRD 2020c).

Generally, the DPIRD's compliance program is aligned to support three key compliance strategies: maximizing voluntary compliance, effective deterrence, and organizational capability and capacity (DPIRD 2018). The compliance program deploys a wide range of tools to encourage compliant behavior with the DPIRD's control measures (DPIRD 2018). To maximize voluntary compliance, the Department ensures that fishers know and understand why the control measures are in place, while retaining the enforcement capacity to apprehend those who intentionally decide not to comply (DPIRD 2018). In cases of illegal activity, sophisticated compliance tools such as covert surveillance and covert operations are used (DPIRD 2018).

Effective enforcement is one type of deterrence, and strong enforcement is applied in cases of intentional noncompliance, in proportion to the seriousness of the alleged offense and/or the environmental impact, taking into account the conduct of the parties (DPIRD 2018). A four-tier approach is taken toward offenders under fisheries legislation, with the following enforcement tools: Infringement Warning Notice, which involves issuing a written warning in lieu of a penalty; Infringement Notice, which involves a penalty; Letter of Warning, a written warning in lieu of a prosecution; and prosecution, which entails instigation of legal proceedings and/or proposed court action (DPIRD 2018). In addition to these enforcement tools, Fisheries Officers have the power to seize fish and fishing gear that, on reasonable grounds, is believed to be the subject of or to have been used in the commission of an offense (DPIRD 2018). Likewise, Fisheries Officers may seize any item where the item may afford evidence of the commission of an offense. Fisheries Officers may also seize a vehicle, vessel, or any other thing where there are reasonable grounds to suspect it has been used in the commission of an offense (DPIRD 2018).

Nevertheless, a recent audit by the Office of the Auditor General has shown that there are important gaps in compliance and enforcement, and the effectiveness of fisheries compliance by the DPIRD in Western Australia is not monitored (OAGWA 2022). For all these reasons, enforcement and compliance with management regulations has been rated moderately effective.

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Moderately Effective

The DPIRD is responsible for enforcement and compliance of blue swimmer crab regulations in Shark Bay (DPIRD 2020e), following the Western Australian Fisheries Compliance Strategy (DPIRD 2018). Management of blue swimmer crab in Shark Bay is enforced under Operational Compliance Plans, which are informed by a compliance risk assessment that is reviewed every 2 years (DPIRD 2020e).

Compliance strategies and activities that are used in the commercial fishery targeting blue swimmer crab in Shark Bay include land patrols and sea patrols, catch validation against managed fishery

licenses, inspection of crab wholesale and retail outlets, inspection of crab processing facilities, inspection of vessels in port, preseason briefings, at-sea inspection of fishing boats, and closed area/season monitoring via vessel monitoring systems (VMS; in the trawl sector) (DPIRD 2020e) (DPIRD 2022). Boats operating within the SBPMF are fitted with a device known as the automatic location communicator (ALC), which is used to track the location and speed of a boat to DPIRD compliance officers; this allows for real-time monitoring of adherence to closures (DPIRD 2022). Inspections may involve inspection of all compartments onboard the vessel, all authorizations, logbooks, and catch onboard the boat (DPIRD 2020e). Department staff regularly cross-check logbook data against CDRs and processor receipts (DPIRD 2020e). Erroneous entries are verified with skippers (DPIRD 2020e). Spatial data validation is conducted by plotting maps from reported logbook effort against VMS location records (DPIRD 2020e).

Generally, the DPIRD's compliance program is aligned to support three key compliance strategies: maximizing voluntary compliance, effective deterrence, and organizational capability and capacity (DPIRD 2018). The compliance program deploys a wide range of tools to encourage compliant behavior with the DPIRD's control measures (DPIRD 2018). To maximize voluntary compliance, the Department ensures that fishers know and understand why the control measures are in place, while retaining the enforcement capacity to apprehend those who intentionally decide not to comply (DPIRD 2018). In cases of illegal activity, sophisticated compliance tools such as covert surveillance and covert operations are used (DPIRD 2018).

Effective enforcement is one type of deterrence, and strong enforcement is applied in cases of intentional noncompliance, in proportion to the seriousness of the alleged offense and/or the environmental impact, taking into account the conduct of the parties (DPIRD 2018). A four-tier approach is taken toward offenders under fisheries legislation, including the following enforcement tools: Infringement Warning Notice, which involves issuing a written warning in lieu of a penalty; Infringement Notice, which involves a penalty; Letter of Warning, a written warning in lieu of a prosecution; and prosecution, which entails instigation of legal proceedings and/or proposed court action (DPIRD 2018). In addition to these enforcement tools, Fisheries Officers also have the power to seize fish and fishing gear that, on reasonable grounds, is believed to be the subject of or to have been used in the commission of an offense (DPIRD 2018). Likewise, Fisheries Officers may seize any item where the item may afford evidence of the commission of an offense. Fisheries Officers may also seize a vehicle, vessel, or any other thing where there are reasonable grounds to suspect that it has been used in the commission of an offense (DPIRD 2018).

Nevertheless, a recent audit by the Office of the Auditor General has shown that there are important gaps in compliance and enforcement, and the effectiveness of fisheries compliance by the DPIRD in Western Australia is not monitored (OAGWA 2022). As a result, enforcement and compliance with management regulations has been rated moderately effective.

Southwest Pacific | Pots | Australia | New South Wales

Highly effective

The New South Wales Department of Primary Industries is responsible for enforcement of laws governing fisheries resources, through the Fisheries Compliance Unit (NSW DPI 2022c). Fisheries Officers on patrol help detect and prevent illegal fishing and damage to fishing habitats (NSW DPI

2022c). Citizens may report illegal or suspect fishing activities through Fisheries offices, a dedicated phone line, or through on online report form (NSW DPI 2022c). In 2020–21, across all fishery programs, 52,688 client contacts were made, of which 7,463 offenses were detected; these resulted in 4,306 written warnings, 2,752 penalty notices (totaling AU 925,475 in value), the commencement of 185 prosecution actions, and 220 verbal warnings or stop work orders (NSW DPI 2022d). Of these, 125 offenses were successfully prosecuted, including 110 court-imposed fines amounting to AU 108,450; 5 community correction orders; and 1 intensive correction order (NSW DPI 2022d). Therefore, enforcement and compliance in New South Wales is considered highly effective.

Western Central Pacific | Pots | Australia | Queensland

Highly effective

All commercial vessels that are licensed as part of the C1 fishery are required to have installed an active vessel tracking system onboard (DAWE 2021). Vessel tracking data are used to verify effort reported in fishing logbooks (DAWE 2021). Compulsory quota unload reports provide an accurate record of the catch (DAWE 2021). Queensland Boating and Fisheries Patrol undertake routine and intelligence-based inspections, both at sea and when landing, to check compliance and validate reported information (DAWE 2021). Therefore, this factor has been rated highly effective.

Factor 3.5 - Stakeholder Inclusion

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Moderately Effective

PIRSA consults with the South Australian community, including fishers, on decisions, policies, programs, and use of resources (PIRSA 2022c). Fisheries Officers and Fishcare volunteers also deliver education programs to the fishing community (PIRSA 2022d). Further, PIRSA consults with the South Australian Blue Crab Pot Fishers Association Inc. (the representative industry body of the Blue Crab Fishery), to inform day-to-day management of the Blue Crab Fishery (PIRSA 2020). Currently, the Blue Crab Fishery comanagement committee is in the process of being developed; once developed, PIRSA will consult with this body on strategic management matters, including setting the TACC (PIRSA 2020). Because comanagement is currently in the process of being developed, this factor has been scored moderately effective.

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Highly effective

The Western Australian Fishing Industry Council (WAFIC) is the primary source of advice and representation from the commercial fishing sector (DPIRD 2020c). WAFIC undertakes statutory consultation functions related to fisheries management and the facilitation of management meetings for licensed fisheries (DPIRD 2020c). The commercial Peel-Harvey Estuary fishers are represented by the Mandurah Licensed Fishermen's Association (DPIRD 2020c). Annual management meetings between the DPIRD, WAFIC, and licensed blue swimmer crab commercial fishers are held and serve as forums to consult on management of these fisheries (DPIRD 2020c). During these meetings, the

DPIRD's scientists, managers, and compliance staff, licensed fishers, and WAFIC discuss present and future management issues in the previous fishing season, and proposed changes to the management plan; follow-up meetings are held if required (DPIRD 2020c).

Consultation on blue swimmer crab management also takes place with other groups, including customary fishers, nonfisher stakeholders such as other government agencies, nongovernmental organizations, and other affected or interested parties, following the Departmental Stakeholder Engagement Guideline (Department of Fisheries 2016). Thus, stakeholder engagement includes collaborating with and seeking input from key stakeholders through a public consultation process. Important fishery-specific documents and plans such as harvest strategies, recovery plans, and bycatch action plans are subjected to key stakeholder consultation and public consultation. For all these reasons, stakeholder inclusion has been scored highly effective.

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Highly effective

The Western Australian Fishing Industry Council (WAFIC) is the primary source of advice and representation from the commercial fishing sector (DPIRD 2020e). WAFIC undertakes statutory consultation functions related to fisheries management and the facilitation of management meetings for licensed fisheries such as the Shark Bay Crab Managed Fishery (SBCMF) (DPIRD 2020e). Annual management meetings between the DPIRD, WAFIC, and licensed holders in the SBDMF are held and serve as forums to consult on management of these fisheries (DPIRD 2020e). During these meetings, the DPIRD's staff, licensed fishers, and WAFIC discuss present and future management issues in the previous fishing season and propose changes to the management plan; follow-up meetings are held if required (DPIRD 2020e). The DPIRD also consults directly with the fishing industry, where required, on certain management and operational issues (DPIRD 2020e). The Shark Bay Crab Working Group was established in 2017 and includes representatives from both the commercial trap and trawl sectors, Recfishwest, and DPIRD's scientists and managers (DPIRD 2020e). This Working Group formulates recommendations for all license holders and decision-makers to consider, in relation to seasonal and longer-term management arrangements, annual TACC reviews, and stock assessment discussions (DPIRD 2020e). The detailed process of consultation in advance of determining the annual TACC is shown in Figure 41.

Consultation on blue swimmer crab management also takes place with other groups, including customary fishers, nonfisher stakeholders such as other government agencies, nongovernmental organizations, statutory advisory committees, and other affected or interested parties, following the Departmental Stakeholder Engagement Guideline (SEG) (Department of Fisheries 2016). Because the fishery also operates within the Shark Bay World Heritage Area and the Shark Bay Marine Parks, in accordance with the SEG, key stakeholders such as the Shark Bay World Heritage Advisory Committee and the Department of Biodiversity and Conservation are included in consultations (DPIRD 2020e). Thus, stakeholder engagement includes collaborating with and seeking input from various key stakeholders through a public consultation process. Important fishery-specific documents and plans such as harvest strategies, recovery plans, and bycatch action plans are subjected to key stakeholder consultation and public consultation. Therefore, stakeholder inclusion has been scored highly effective.

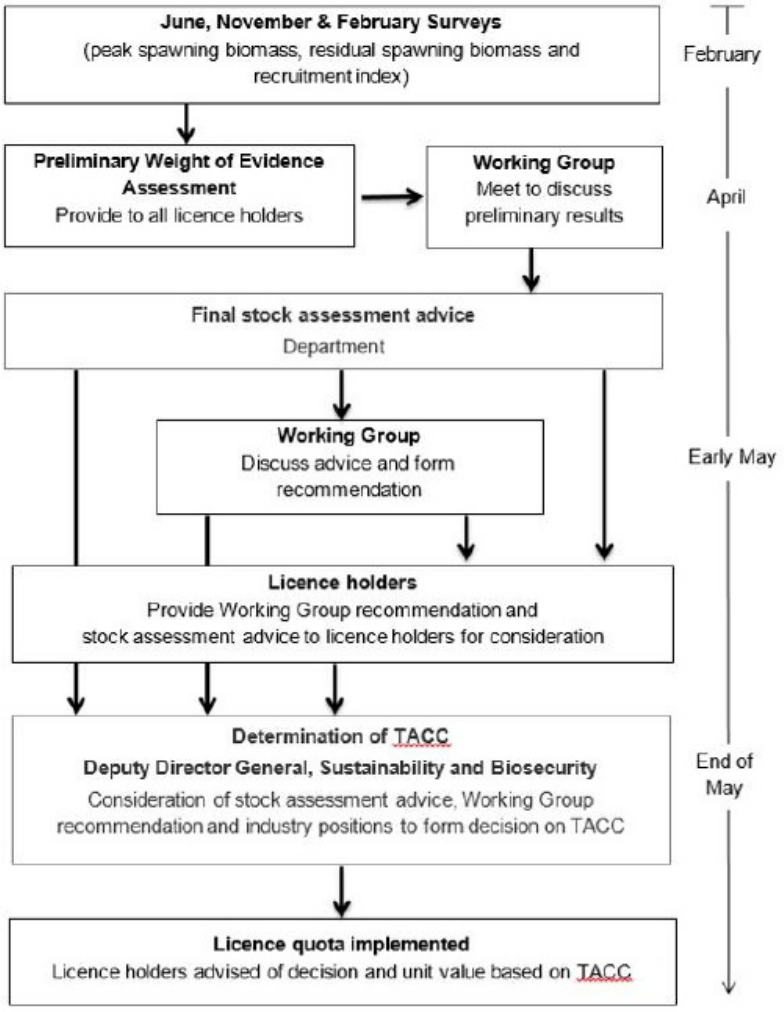


Figure 41: The consultation process for reviewing the annual TACC for the Shark Bay Crab Managed Fishery. Taken from (DPIRD 2020e).

Southwest Pacific | Pots | Australia | New South Wales

Highly effective

The Ministerial Fisheries Advisory Council provides cross-sectoral advice on strategic policy issues to the Minister for Primary Industries (NSW DPI 2022e). The Council includes representatives from the commercial, recreational, indigenous, aquaculture, and conservation sectors and has an independent chair (NSW DPI 2022e). In addition, the Commercial Fishing NSW Advisory Council is the advisory body, which has greater representation among commercial fishing stakeholders, and it provides advice to the government on policy issues related to the commercial fishing industry (NSW DPI 2022e). Further, working groups that comprise commercial fishers and the NSW Department of Primary Industries are formed only when specific fisheries management issues must be resolved. Commercial fisheries management advice is open for public comment (NSW DPI 2022e). Similarly,

in the interest of transparency, the proceedings of all meetings and all submissions that are used in the fisheries management decision-making process are posted on the NSW Department of Primary Industries website (NSW DPI 2022e). As a result, a score of highly effective has been awarded for this factor.

Western Central Pacific | Pots | Australia | Queensland

Highly effective

The Queensland Government engages stakeholders in fisheries management through working groups (Queensland Government 2021b). Working group advice is considered as a form of stakeholder engagement in addition to public consultation (Queensland Government 2021b). The crab fishery working group assists with the implementation of the blue swimmer crab harvest strategies and provides advice on management options, fishing rules, and the operational aspects and general management of the blue swimmer crab fishery (Queensland Government 2021b). The crab working group comprises all major user groups, including fisheries managers, scientists, representatives from the Great Barrier Reef Marine Park Authority and the Department of Environment and Science, commercial fishers, recreational fishers, a member of the fishing tackle industry, and an indigenous representative (Queensland Government 2021b). Summaries of all working group meetings are uploaded on the official website of the Department of Agriculture and Fisheries in Queensland (DAF 2020). Therefore, stakeholder inclusion has been scored highly effective.

Criterion 4: Impacts on the Habitat and Ecosystem

This Criterion assesses the impact of the fishery on seafloor habitats, and increases that base score if there are measures in place to mitigate any impacts. The fishery's overall impact on the ecosystem and food web and the use of ecosystem-based fisheries management (EBFM) principles is also evaluated. Ecosystem Based Fisheries Management aims to consider the interconnections among species and all natural and human stressors on the environment. The final score is the geometric mean of the impact of fishing gear on habitat score (factor 4.1 + factor 4.2) and the Ecosystem Based Fishery Management score. The Criterion 4 rating is determined as follows:

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

Guiding principles

- Avoid negative impacts on the structure, function or associated biota of marine habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.
- Follow the principles of ecosystem-based fisheries management.

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

FISHERY	FISHING GEAR ON THE SUBSTRATE	MITIGATION OF GEAR IMPACTS	ECOSYSTEM-BASED FISHERIES MGMT	FORAGE SPECIES?	SCORE
Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia	Score: 3	Score: 0	Low Concern		**Green (3.464)**
Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia	Score: 3	Score: 0	Low Concern		**Green (3.464)**
Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia	Score: 1	+.5	Low Concern		**Yellow (2.449)**
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia	Score: 3	Score: 0	Low Concern		**Green (3.464)**
Southwest Pacific | Pots | Australia | New South Wales	Score: 3	+.5	Low Concern		**Green (3.742)**
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia	Score: 3	Score: 0	Low Concern		**Green (3.464)**
Western Central Pacific | Pots | Australia | Queensland	Score: 3	+.5	Moderate Concern		**Green (3.240)**

Criterion 4 Assessment

SCORING GUIDELINES

Factor 4.1 - Physical Impact of Fishing Gear on the Habitat/Substrate
Goal: The fishery does not adversely impact the physical structure of the ocean habitat, seafloor or associated biological communities.

- *5 - Fishing gear does not contact the bottom*
- *4 - Vertical line gear*
- *3 - Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Or bottom seine on resilient mud/sand habitats. Or midwater trawl that is known to contact bottom occasionally. Or purse seine known to commonly contact the bottom.*
- *2 - Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Or gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Or bottom seine except on mud/sand. Or there is known trampling of coral reef habitat.*
- *1 - Hydraulic clam dredge. Or dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 - Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl)*
  Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts
Goal: Damage to the seafloor is mitigated through protection of sensitive or vulnerable seafloor habitats, and limits on the spatial footprint of fishing on fishing effort.

- *+1 —>50% of the habitat is protected from fishing with the gear type. Or fishing intensity is very*

low/limited and for trawled fisheries, expansion of fishery's footprint is prohibited. Or gear is specifically modified to reduce damage to seafloor and modifications have been shown to be effective at reducing damage. Or there is an effective combination of 'moderate' mitigation measures.

- *+0.5 —At least 20% of all representative habitats are protected from fishing with the gear type and for trawl fisheries, expansion of the fishery's footprint is prohibited. Or gear modification measures or other measures are in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing that are expected to be effective.*
- *0 —No effective measures are in place to limit gear impacts on habitats or not applicable because gear used is benign and received a score of 5 in factor 4.1*

Factor 4.3 - Ecosystem-Based Fisheries Management

Goal: All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web. Fishing activities should not seriously reduce ecosystem services provided by any retained species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity. Even non-native species should be considered with respect to ecosystem impacts. If a fishery is managed in order to eradicate a non-native, the potential impacts of that strategy on native species in the ecosystem should be considered and rated below.

- *5 — Policies that have been shown to be effective are in place to protect species' ecological roles and ecosystem functioning (e.g. catch limits that ensure species' abundance is maintained at sufficient levels to provide food to predators) and effective spatial management is used to protect spawning and foraging areas, and prevent localized depletion. Or it has been scientifically demonstrated that fishing practices do not have negative ecological effects.*
- *4 — Policies are in place to protect species' ecological roles and ecosystem functioning but have not proven to be effective and at least some spatial management is used.*
- *3 — Policies are not in place to protect species' ecological roles and ecosystem functioning but detrimental food web impacts are not likely or policies in place may not be sufficient to protect species' ecological roles and ecosystem functioning.*
- *2 — Policies are not in place to protect species' ecological roles and ecosystem functioning and the likelihood of detrimental food impacts are likely (e.g. trophic cascades, alternate stable states, etc.), but conclusive scientific evidence is not available for this fishery.*
- *1 — Scientifically demonstrated trophic cascades, alternate stable states or other detrimental food web impact are resulting from this fishery.*

Factor 4.1 - Physical Impact of Fishing Gear on the Habitat/Substrate

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia
Southwest Pacific | Pots | Australia | New South Wales
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia
Western Central Pacific | Pots | Australia | Queensland

Score: 3

The crab pots/traps used in the blue swimmer crab fishery throughout Australia have a low impact on the physical and biological structures of the seafloor. There is minimal dragging of the pots on the bottom during trap retrieval. Blue swimmer crab lives in sandy and muddy habitats, which are resilient habitat types (Beckmann et al. 2020). Retrieval of traps may result in minor dragging over sandy substrate (Gaughan and Santoro 2020). The small amounts of seagrass that are occasionally removed result in minimal habitat damage, so trapping is considered a low risk to benthic habitats. Therefore, this factor is assigned a score of "3."

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

Score: 1

Bottom trawls are dragged along the seafloor during fishing and can negatively affect the physical and biological structures of the seafloor. In this fishery, trawling is primarily considered to occur over mud/sand/shell habitats, which are considered more resilient to trawl damage compared to rocky or coral habitats (Gaughan and Santoro 2020)(DPIRD 2022). But, the habitats in the area where the trawl fishery occurs have not been well studied. The habitats and species that occur in Shark Bay are known to be quite diverse and may include some sensitive structural organisms. Soft-sediment substrates can contain various sponge and soft coral species, and may have once been highly populated with these species. Soft sediments are typically unsuitable habitats for most hard corals, but a small number of coral patches are scattered irregularly throughout these habitats in Shark Bay (Kangas et al. 2007). Because the habitat where trawling occurs has not been well studied and trawling may occur over some sensitive habitat features, we have conservatively awarded this factor a score of "1."

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Score: 0

In South Australia, blue swimmer crab is found in the Gulf of St. Vincent, Spencer Gulf, and the west coast bays off the upper western Eyre Peninsula. Fishing for blue swimmer crab primarily occurs in the Gulf of St. Vincent and Spencer Gulf. In the Spencer Gulf, there are three closed fishing areas, and in both regions there are seasonal fishing closures (PIRSA 2020). Also, several Aquatic Reserves and Marine Parks have been established in South Australia's marine and estuarine waters,

some of which are in the Gulf of St. Vincent and Spencer Gulf and either prohibit or restrict fishing (PIRSA 2022e)(Department of Environment and Water 2019). Fishing is not permitted in "sanctuary zones" within the Marine Parks but is permitted in other areas (Department of Environment and Water 2019). The "sanctuary zones" account for 6% of the state's marine habitat (National Parks and Wildlife Service 2022). In the blue swimmer crab fishery, access to the fishery is limited, and each fisher is restricted to a certain number of pots and to catching their allotted amount of the total annual catch limit (PIRSA 2020). There are various measures in place to reduce fishing effort and intensity; however, less than 20% of representative habitats are protected, so this factor is given a score of "0."

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Score: 0

In Western Australia, effective measures are being taken to protect bottom habitats from the impacts of fishing gear. Various kinds of marine protected areas in Western Australia ensure sustainability in these marine environments and high aquatic biodiversity. These protected areas include marine natural reserves, marine parks, marine management areas, and fish habitat protection areas (Department of Fisheries WA 2020)(Department of Biodiversity, Conservation and Attractions WA 2022). Sensitive habitat areas are strongly protected, and there are restrictions on the level of impacts that can occur in less sensitive areas. Also, fishing intensity in the blue swimmer crab pot fishery is actively controlled through caps on the numbers of licensed fishers, limits on the number of pots that can be used for fishing, seasonal closures, and gear restrictions (DPIRD 2020c)(DPIRD 2020e)(Fisher et al. 2020). Nevertheless, it is unknown whether the 20% of representative habitats at each site are protected from bottom contact, so this factor is given a score of "0."

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia

+.5

In Western Australia, effective measures are being taken to protect bottom habitats from the impacts of fishing gear. Various kinds of marine protected areas in Western Australia ensure sustainability within these marine environments and high aquatic biodiversity. These protected areas include marine natural reserves, marine parks, marine management areas, and fish habitat protection areas (Department of Fisheries WA 2020)(Department of Biodiversity, Conservation and Attractions WA 2022). Because of the outstanding universal value of its natural environment, since 1991 Shark Bay has been a UNESCO World Heritage Site (UNESCO 2022). Although the Outer Shark Bay is not trawled, within the Inner Shark Bay, the permitted trawl area is 6,063 km^2, with trawling occurring in approximately 40–50% of this trawlable area each season, which represents 14–18% of the total Inner Shark Bay area (Figure 42) (DPIRD 2020)(DPIRD 2022). The harvest strategy of the prawn trawl fishery in Shark Bay ensures that the effects of trawling do not cause serious or irreversible harm to the habitat structure and function of the Inner Shark Bay region, through reference levels and harvest control rules if trawling within this region exceeds specific levels (DPIRD 2022). Trawling within Shark Bay is also restricted by permanent and temporary fishing closures (to protect habitats with seagrass beds and corals), nursery grounds, and spawning grounds (DPIRD 2022). Other measures in place to limit overall fishing effort include a limited number of licenses (18) and a seasonal closure from October to March each year, with the number of fishing days specified

annually (DPIRD 2022). Although a large proportion of Shark Bay habitats are protected from trawling, it is unclear if greater than 50% of prawn and blue swimmer crab habitats are protected. Therefore, this factor has been scored "+0.5."

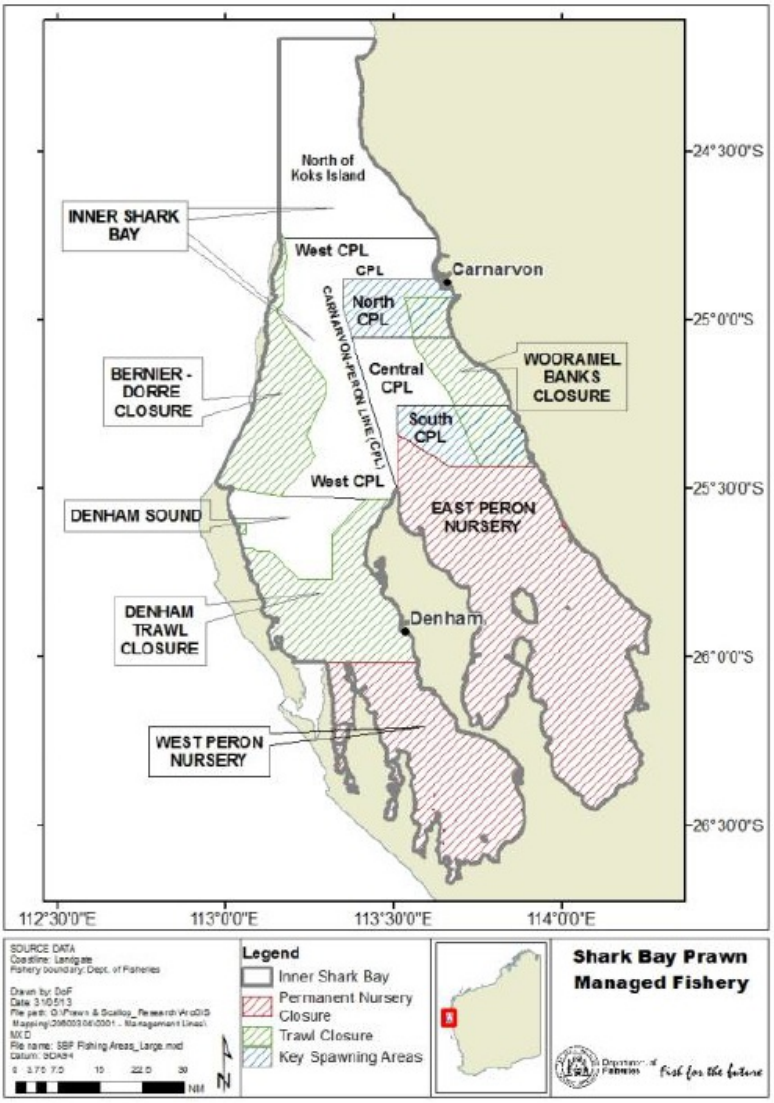


Figure 42: Boundaries, management areas, and area closures (red and green) of the SBPMF in Shark Bay. Taken from (DPIRD 2020).

Southwest Pacific | Pots | Australia | New South Wales

+.5

In New South Wales, vulnerable habitats are strongly protected though Marine Protected Areas. There are several different types of Marine Protected Areas, including 6 multiple-use Marine Parks, Commonwealth Marine Reserves, 12 Aquatic Reserves, and National Parks and Reserves that include around 20,000 hectares of estuarine and oceanic habitats (Figure 43) (NSW DPI 2022f). These areas

cover more than one-third of New South Wales coastal waters. Managers regulate activities in each of these marine protected areas. Fishing is permitted in some places within these marine protected areas and prohibited in others. There are also Intertidal Protected Areas, which are designed to help protect the biodiversity and structure in intertidal communities, to protect species' breeding areas so exploited areas nearby can be recolonized or sustained, and to help ensure sustainable harvesting of intertidal invertebrates (NSW DPI 2022g). The blue swimmer crab fishery is managed as part of the Estuary General Fishery. There are various location closures that pertain directly to the Estuary General Fishery, and the Fisheries Management (General) Regulation 2010 outlines fishing gear provisions (NSW DPI 2022b). In addition, recreational havens along the New South Wales coast are closed to commercial fishing and may provide protection from commercial crabbing (DPI 2023). For the various measures in place to reduce the fishery's spatial footprint and gear provisions, this factor is given a score of "+0.5."

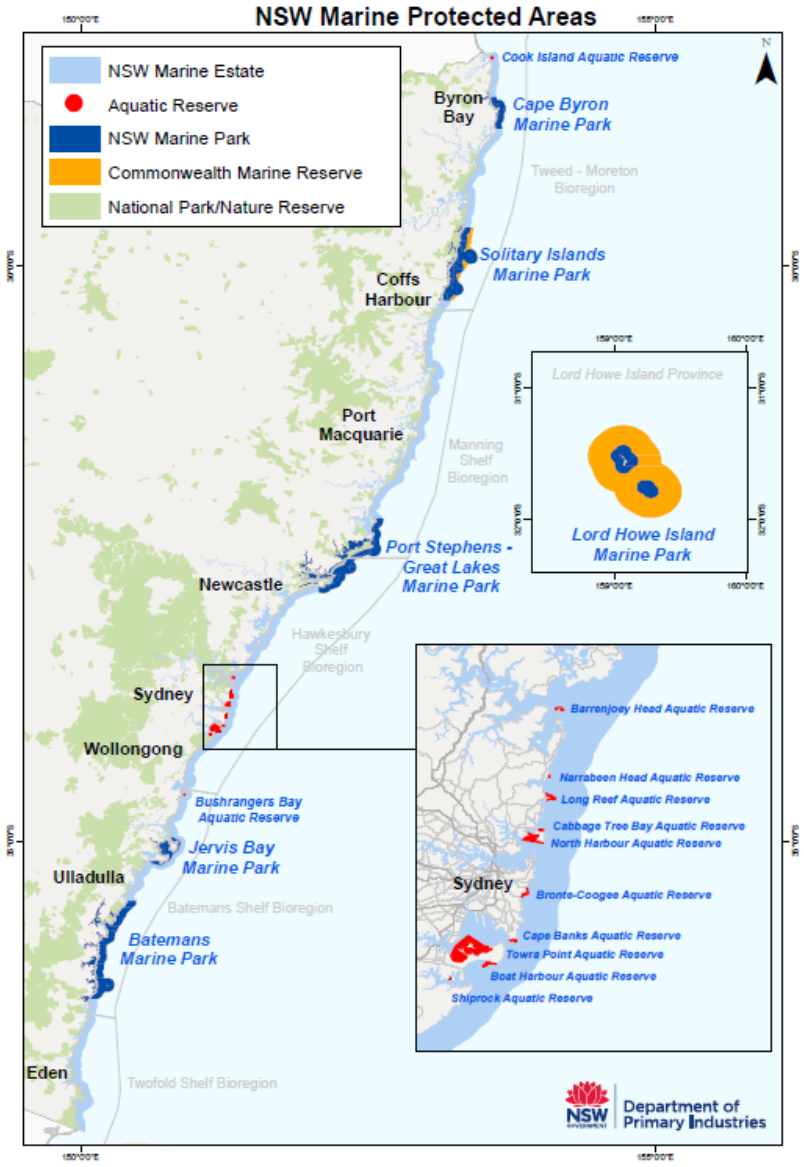


Figure 43: Map of Marine Protected Areas in New South Wales, Australia. Taken from (NSW DPI 2022f).

Western Central Pacific | Pots | Australia | Queensland

+.5

In Queensland, there are several spatial closures and Marine Parks to help protect vulnerable habitats and the ecological community. Inshore juvenile blue swimmer crab habitats such as seagrass beds and sand and mud banks are protected by fisheries and marine park closures (Queensland Government 2022). There are three Marine Parks in Queensland: Great Barrier Reef Marine Park, Great Sandy Marine Park, and Moreton Bay Marine Park (Figure 44). In each park, there are different zones that provide different levels of protection (Queensland Government 2019). In the Great Barrier Reef Marine Park, the largest of the Marine Parks, fishing with crab pots is not allowed in approximately one-third of the park area (GBRMPA 2022). Also, the lightweight and stable

structure of the crab pots reduces their impact on the seafloor, and there are limits on the number of pots that can be used per fisher (Queensland Government 2021). Because of the various measures in place to reduce the fishery's spatial footprint and fishing effort, this factor is given a score of "+0.5."

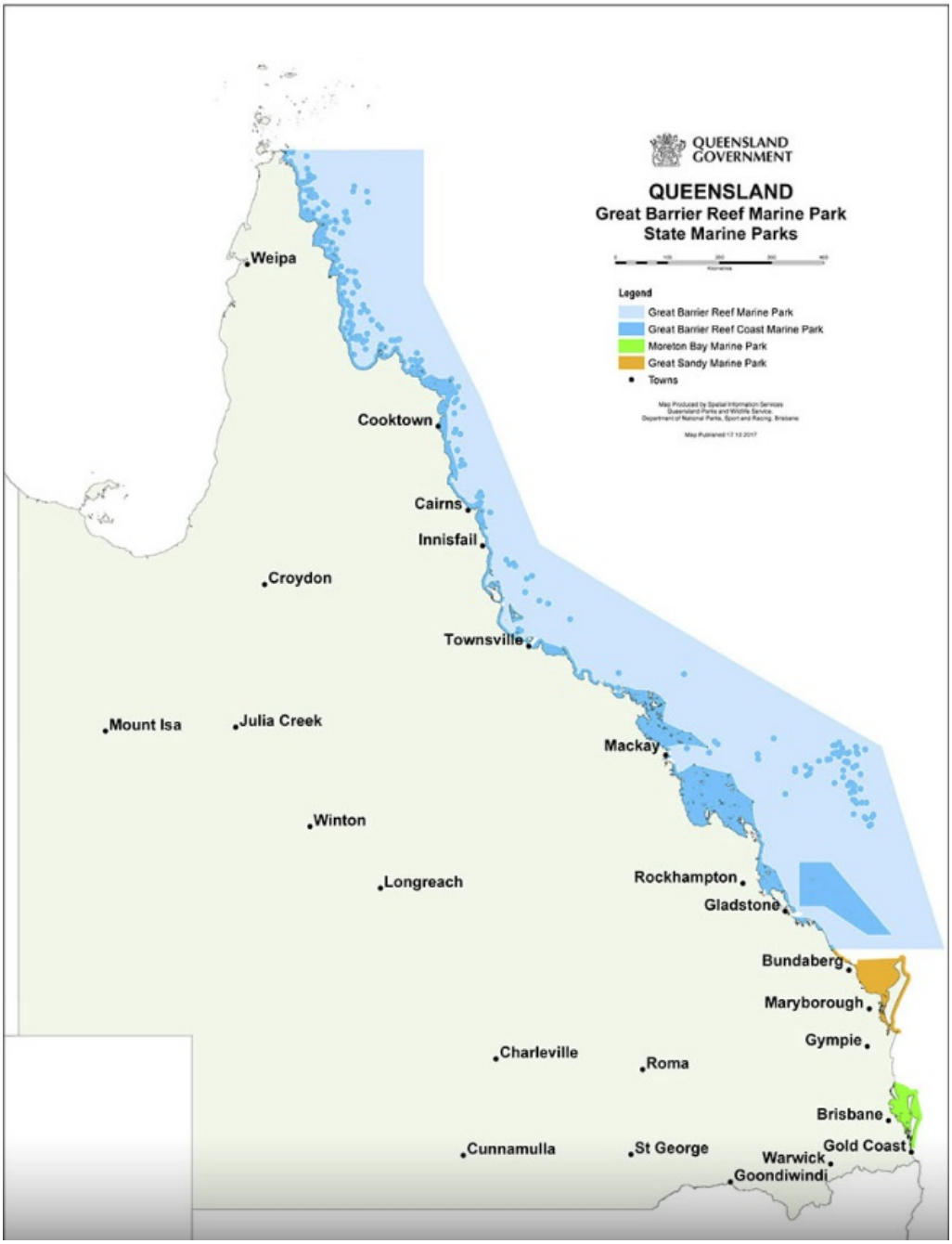


Figure 44: Map of Marine Parks in Queensland, Australia. Taken from (Queensland Government 2022).

Factor 4.3 - Ecosystem-based Fisheries Management

Gulf of St. Vincent | Indian Ocean, Eastern | Pots | Australia | South Australia
Spencer Gulf | Indian Ocean, Eastern | Pots | Australia | South Australia

Low Concern

The blue swimmer crab fishery in South Australia does not catch species of exceptional ecological importance, and scientific assessment and management efforts to account for species' ecological roles are underway. An objective of the Fisheries Management Act 2007 is to protect and conserve aquatic habitats and maintain ecosystem diversity (GSA 2007). The Fisheries Management Act 2007 requires fishery management plans to describe the biological, economic, and social characteristics of a fishery. They also must include a risk assessment of the impacts of the fishery on relevant ecosystems (ibid). In 2009, an Ecological Risk Assessment of the blue swimmer crab fishery was performed to examine the fishery's impact on the target species, other species, habitats, and the broader environment (PIRSA 2020). This assessment identified areas where specific management might be needed to meet ecosystem goals. Overall, the fishery was found to have a low impact on the ecosystem (ibid). But, an updated environmental impact assessment of the fishery has not been conducted. Managers have established several Marine Parks and Aquatic Reserves within South Australia to protect species and their habitats (PIRSA 2020)(PIRSA 2022e)(Department of Environment and Water 2019). Hence, this factor is rated a low concern.

Peel-Harvey Estuary | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern

The Department of Fisheries in Western Australia was one of the first fishery management agencies in the world to introduce ecosystem-based fisheries management (DPIRD 2018b). To manage their coastal ecosystems, they have divided the area into "bioregions" (Newman et al. 2021). Comprehensive assessments of each bioregion and each major fishery in the bioregion are completed each year, which aim to examine the impacts on target species, bycatch species, habitats, and food webs (Newman et al. 2021). All activities affecting the bioregion (e.g., fishing, aquaculture, and other industries) are also described (Newman et al. 2021). In the Peel-Harvey Estuary, the cumulative impact of the Estuarine Fishery on trophic interactions by removing retained species and by discards was found to be low (Fisher et al. 2020). In particular, blue swimmer crab and sea mullet (used as bait) are not considered primary prey species to predators in the estuary, and their stocks are sustainable (Fisher et al. 2020). Further, bycatch monitoring surveys show that the post-release survival of discarded blue swimmer crab is high (Fisher et al. 2020). The impact of ghost fishing gear from crab trapping on the Peel-Harvey Estuary ecosystem was found to be negligible (Fisher et al. 2020). A number of Marine Protected Areas exist in Western Australia (Department of Fisheries WA 2020)(Department of Biodiversity, Conservation and Attractions WA 2022). In the Peel-Harvey Estuary as well, specific areas are closed to the fishery (Figure 45) (Fisher et al. 2020). Therefore, this factor is scored a low concern.

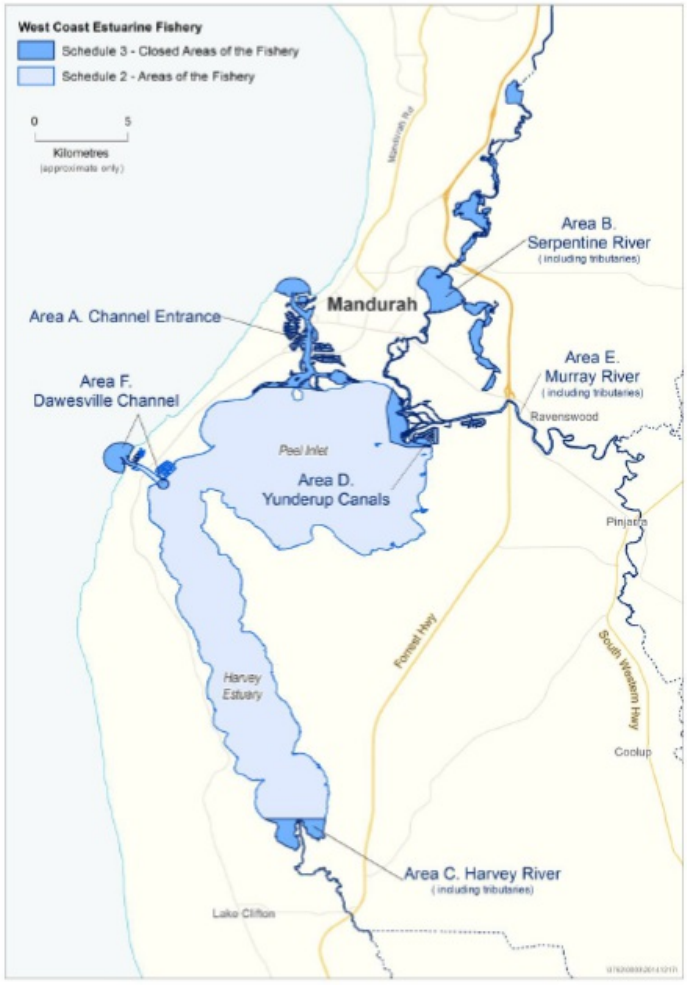


Figure 45: Boundaries and closed areas in the Peel-Harvey Estuary. Taken from (Fisher et al. 2020).

Shark Bay | Indian Ocean, Eastern | Bottom trawls | Australia | Western Australia
Shark Bay | Indian Ocean, Eastern | Pots | Australia | Western Australia

Low Concern

The Department of Fisheries in Western Australia was one of the first fishery management agencies in the world to introduce ecosystem-based fisheries management (DPIRD 2018b). To manage their coastal ecosystems, they have divided the area into "bioregions" (Newman et al. 2021). Comprehensive assessments of each bioregion and each major fishery in the bioregion are completed each year, which aim to examine the impacts on target species, bycatch species, habitats, and food webs (Newman et al. 2021). All activities affecting the bioregion (e.g., fishing, aquaculture, and other industries) are also described (Newman et al. 2021). In Shark Bay, the impact of the Shark Bay invertebrate fisheries on trophic interactions by the removal of the retained species was found to be low; however, the impact on trophic interactions by discarding and provisioning was found to be of medium risk, because there is the potential for certain species to become reliant on discards (DPIRD 2020). A number of Marine Protected Areas exist in Western Australia (Department of Fisheries WA 2020)(Department of Biodiversity, Conservation and

Attractions WA 2022), and in particular, there are a number of areas closed to fishing in the Inner Shark Bay region (DPIRD 2020). It is possible that this fishery has some negative consequences on food webs, but spatial and temporal management effectively protects the ecosystem, particularly foraging areas for predators (e.g., dolphins) of fished species. Hence, this factor is deemed a low concern.

Southwest Pacific | Pots | Australia | New South Wales

Low Concern

In New South Wales, various marine reserves, marine parks, aquatic reserves, and intertidal protected areas have been established to protect marine species and their habitats (NSW DPI 2021b) (NSW DPI 2022f)(NSW DPI 2022g). In these areas, managers regulate what marine activities are allowed and where they can occur. These areas cover more than one-third of New South Wales' coastal waters. An Environmental Impact Assessment of the Estuary General Fishery that blue swimmer crab is caught in was completed in 2001 (NSW Fisheries 2001)(SMEC 2001). This assessment evaluated the total impacts of fishing on all potentially affected species and habitats. These assessments were undertaken to ensure that the fishery management strategies for each fishery were sufficient to sustain species and protect the environment. But, an updated environmental impact assessment of the fishery has not been conducted. Managers have established numerous marine protected areas, there have been efforts to evaluate the impacts of the fishery on affected environments, and the fishery does not catch any species of exceptional ecological importance, so this factor is rated a low concern.

Western Central Pacific | Pots | Australia | Queensland

Moderate Concern

The blue swimmer crab fishery does not target species of exceptional ecological importance, and scientific assessment and management efforts to account for species' ecological roles are underway. In 2019, a Level 1 Ecological Risk Assessment of the Queensland blue swimmer crab fishery was conducted {Walton and Jacobsen 2019}. This assessment investigated the fishery's impact on ecosystem processes, which was found to be of low risk {Walton and Jacobsen 2019}. The loss of fishing gear was considered to pose a high risk to target and other retained species, an intermediate risk to bycatch species of nonconservation concern, a high risk to sea turtles, an intermediate risk to batoids and sharks, and an intermediate risk to ecosystem processes overall {Walton and Jacobsen 2019}. In Queensland, several Marine Parks have been established, including the Great Barrier Reef Coast Marine Park, Great Sandy Marine Park, and Moreton Bay Marine Park (Queensland Government 2019)(Queensland Government 2022). These Marine Parks are managed by creating different zones in the park, and each allows for different activities (Queensland Government 2019). This zoning technique ensures that each marine park remains a diverse, resilient, and productive ecological system while allowing people access to its resources (Queensland Government 2019). Because it is possible that this fishery has some negative consequences on food webs but spatial and temporal management (such as zoning) is likely to be effective in protecting the ecosystem, this factor is deemed a moderate concern.

Acknowledgements

Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

Seafood Watch would like to thank eleven anonymous reviewers for graciously reviewing this report for scientific accuracy.

References

Abreu-Grobois, A. and P. Plotkin. 2008. *Lepidochelys olivacea*. The IUCN Red List of Threatened Species 2008: e.T11534A3292503. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T11534A3292503.en

Barnes, T. C., M. K. Broadhurst, and D. D. Johnson 2022b. Fleet-wide acceptance of escape gaps and their utility for reducing bycatch in south-eastern Australian *Portunus armatus* traps - supplementary material. Fisheries Management and Ecology 00:1-10. DOI: 10.1111/fme.12586

Beckmann, C. L., C. Noell, and G. E. Hooper. 2020. Blue crab *(Portunus armatus)* fishery 2018/19. Fishery assessment report to PIRSA Fisheries and Aquaculture. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. SARDI Publication No. F2007/000729-16. SARDI Research report series no 1058. 45pp.

Bellchambers L. M. and S. de Lestang. 2005. Selectivity of different gear types for sampling the blue swimmer crab, *Portunus pelagicus* L. Fisheries Research 73(1-2):21-27.

Braulik, G., A. Natoli, J. Kiszka, G. Parra, S. Plön, and B. D. Smith. 2019. *Tursiops aduncus.* The IUCN Red List of Threatened Species 2019: e.T41714A50381127. http://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T41714A50381127.en

Broadhurst, M. K., R. B Millar, and B. Hughes 2017. Performance of industry-developed escape gaps in Australian *Portunus pelagicus* traps. *Fisheries Research*. 187: 120-126.

Casale, P. and A. D. Tucker. 2017. *Caretta caretta*. The IUCN Red List of Threatened Species 2017: e.T3897A119333622. http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T3897A119333622.en

Chan, T.Y. 2013. *Eduarctus martensii*. The IUCN Red List of Threatened Species 2013: e.T170037A6716526. http://dx.doi.org/10.2305/IUCN.UK.2011-1.RLTS.T170037A6716526.en

Chandrapavan, A., N. Caputi, and M. I. Kangas. 2019. The decline and recovery of a crab population from an extreme marine heatwave and a changing climate. Frontiers in Marine Science 6(510): 1-12.

Commonwealth of Australia 2021. Approved Wildlife trade operation declarations (Queensland blue swimmer crab fishery and Queensland mud crab fishery) revocation instrument, Queensland.

DAF 2020. Crab fishery working group communiques. Accessed from: https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/fishery-working-groups/crab-working-group/communiques

D'Anastasi, B., C. Simpfendorfer and L. van Herwerden. 2013. (errata version published in 2019). *Anoxypristis cuspidata*. The IUCN Red List of Threatened Species 2013: e.T39389A141789456. http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T39389A141789456.en

D'Anastasi, B., L. van Herwerden, J. A. Hobbs, C. A. Simpfendorfer, and V. Lukoschek. 2016. New range and habitat records for threatened Australian sea snakes raise challenges for conservation. Biological

Conservation 94.:66-70.

Department of Agriculture and Fisheries 2018. Sustainable Fisheries Strategy 2017-2027: Fisheries Queensland Ecological Risk Assessment Guideline, Queensland.

Department of Agriculture and Fisheries. 2019. Sustainable Fisheries Strategy 2017-2017: Mud and blue swimmer crab (c1) fishery scoping study, Queensland.

Department of Agriculture and Fisheries. Sustainable Fisheries Strategy 2017-2027: Mud & blue swimmer crab (C1) fishery scoping study, Queensland.

Department of Agriculture, Water and the Environment 2021. Assessment of the Queensland blue swimmer crab fishery for the purposes of Part 13 of the Environmental Protection and Biodiversity Conservation Act 1999, Queensland.

Department of Biodiversity, Conservation and Attractions WA 2022. Marine Parks and Reserves. Accessed from: https://www.dpaw.wa.gov.au/management/marine/marine-parks-and-reserves

Department of Environment and Water 2019. South Australia's Marine Parks, South Australia.

Department of Fisheries 2016. Guidelines for stakeholder engagement on aquatic resource management-related processes. Fisheries Occasional Publication No. 131. Department of Fisheries, Western Australia.

Department of Fisheries WA 2020. Management of marine protected areas. Accessed from: https://www.fish.wa.gov.au/Sustainability-and-Environment/Aquatic-Biodiversity/Marine-Protected-Areas/Pages/default.aspx

Department of Fisheries WA. 2011. Fisheries Fact Sheet: Blue Swimmer Crab. Government of Western Australia, Department of Fisheries. 4 pp.

Department of Fisheries WA. 2013b. Blue Swimmer Crabs. Government of Western Australia, Department of Fisheries. Available online at http://www.fish.wa.gov.au/species/blue-swimmer-crabs/Pages/default.aspx

Department of Primary Industries and Regional Development (2018). Fisheries compliance strategy. September 2018.

Department of Primary Industries and Regional Development (DPIRD). 2020. Ecological Risk Assessment of the Shark Bay Invertebrate Fisheries. Western Australian Marine Stewardship Council Report Series No 16. DPIRD, Western Australia.

Department of Primary Industries and Regional Development 2018b. Next generation fisheries, Western Australia.

Department of Primary Industries and Regional Development. 2020b. Estuarine and Nearshore Finfish Resource of South-West Western Australia Harvest Strategy : 2020-2025 : Version 1.0. Fisheries Management Paper No. 303, Western Australia.

Department of Primary Industries and Regional Development. 2020c. Blue swimmer crab resource of south-west Australia harvest strategy 2020-2025: Version 1.0. Fisheries Management paper no. 304, Perth, Western Australia.

Department of Primary Industries and Regional Development. 2020d. Estuarine and Nearshore Finfish Resource of South-West Western Australia Harvest Strategy 2020-2025. Version 1.0. Fisheries Management Paper No. 303, Western Australia.

Department of Primary Industries and Regional Development. 2020e. Blue swimmer crab resource of Shark Bay harvest strategy 2020-2025. Version 1.0. Fisheries Management paper no. 300, Perth, Western Australia.

Department of Primary Industries and Regional Development. 2020f. Saucer scallop resource of Shark Bay Harvest Strategy 2020-2025. Version 1.0. Fisheries Management paper no 301, Western Australia.

Department of Primary Industries and Regional Development. 2022. Prawn resource of Shark Bay, harvest strategy 2022-2017. Version 2.0. Fisheries Management paper no. 267, Western Australia. Draft version.

Department of Primary Industries, New South Wales Government 2023. Recreational Fishing Havens. Accessed on 2nd February, 2023 from: https://www.dpi.nsw.gov.au/fishing/recreational/resources/info/recreational-fishing-areas/rfh

Department of the Environment 2022c. Species Profile and Threats Database - *Pristis zijsron* — Green Sawfish, Dindagubba, Narrowsnout Sawfish. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?showprofile=Y&taxon_id=68442

Department of the Environment 2022d. *Hippocampus trimaculatus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: https://www.environment.gov.au/sprat. Accessed Sat, 25 Jun 2022 06:40:02 +1000.

Department of the Environment 2022e. Species Profile and Threats Database - *Chelonia mydas* — Green Turtle. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1765

Department of the Environment 2022f. Species Profile and Threats Database - *Aipysurus foliosquama* — Leaf-scaled Seasnake. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1118

Department of the Environment 2022h. Species Profile and Threats Database - *Lepidochelys olivacea* — Olive Ridley Turtle. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1767

Department of the Environment 2022i. Species Profile and Threats Database - *Dermochelys coriacea* Leatherback Turtle. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=176

Department of the Environment 2022j. Species Profile and Threats Database: *Eretmochelys imbricata* — Hawksbill Turtle. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1766

Department of the Environment 2022k. Species Profile and Threats Database: *Chelonia mydas* — Green Turtle. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59257

Department of the Environment 2022m. Species Profile and Threats Database: *Crocodylus porosus* — Salt-water Crocodile, Estuarine Crocodile. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?showprofile=Y&taxon_id=1774

Department of the Environment 2022o. Species profile and threats database: *Xeromys myoides* - Water Mouse, False Water Rat, Yirrkoo. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66

Department of the Environment 2022p. Species profile and threats database: *Glyphis glyphis* - Speartooth Shark. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=82453

Department of the Environment 2022q. Species profile and threats database: *Anoxypristis cuspidata* — Narrow Sawfish, Knifetooth Sawfish. Accessed from: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68448

Department of the Environment 2022r. Species profile and threats database: *Pristis pristis* - Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=60756

Department of the Environment. 2021. Dugongs - Legislative Protection. Accessed from: https://www.awe.gov.au/environment/marine/marine-species/dugongs

Department of the Environment. 2021. Whale conservation. Accessed from: https://www.awe.gov.au/environment/marine/marine-species/cetaceans/whale-conservation

Department of the Environment. 2022. Species profile and threats database - *Dugong dugon.* Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=28

Department of the Environment. 2022g. Species Profile and Threats Database - *Caretta caretta* — Loggerhead Turtle. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1763

Earl, J., H. Gorfine, R. Duffy, and N. Krueck. 2020. Status of Australian fish stocks report. Yelloweye mullet (2020). Accessed from: https://fish.gov.au/report/379-Yelloweye-Mullet-2020?jurisdictionId=2#

FishBase 2022. Growth parameters for *Saurida undosquamis.* Accessed from:

https://www.fishbase.se/popdyn/PopGrowthList.php?
ID=1055&GenusName=Saurida&SpeciesName=undosquamis&fc=160

FishBase 2022b. Fecundity for *Saurida undosquamis.* Accessed from:
https://www.fishbase.se/Reproduction/FecundityList.php?
ID=1055&GenusName=Saurida&SpeciesName=undosquamis&fc=160&StockCode=1071

FishBase 2022c. *Saurida undosquamis* (Richardson, 1848) Brushtooth lizardfish. Accessed from:
https://www.fishbase.se/summary/Saurida-undosquamis.html

FishBase 2022d. Life History Data on *Thamnaconus degeni* Degen's leatherjacket. Accessed from:
https://fishbase.net.br/popdyn/KeyfactsSummary_2v2.php?
ID=14556&GenusName=Thamnaconus&SpeciesName=degeni&vStockCode=14307&fc=517

FishBase 2022e. *Thamnaconus degeni* (Regan, 1903) Degen's leatherjacket.

Fisher, E. A., S. N. Evans, C. J. Desfosses, D. J. Johnston, R. Duffy, and K. A. Smith. 2020. Ecological Risk Assessment for the Peel-Harvey Estuarine Fishery. Fisheries Research Report No. 311. Department of Primary Industries and Regional Development, 102pp, Western Australia.

Food and Agriculture Organization 2022. FishStatJ v4.02.07. Accessed from:
https://www.fao.org/fishery/en/statistics/software/fishstatj/en

Gaughan, D. J. and K. Santoro. 2020. Status reports of the fisheries and aquatic resources of Western Australia 2018/19. State of fisheries. Department of Primary Industries and Regional Development, Perth. Book.

GBRMPA 2022. Interpreting zones. Accessed from: https://www.gbrmpa.gov.au/access-and-use/zoning/interpreting-zones

Government of South Australia 2007. South Australia Fisheries Management Act 2007, South Australia.

Hooper, G. 2018. Assessing Bycatch in the South Australian Blue Swimmer Crab Pot Fishery. Page 45 *in* A. Chandrapavan, A. editor, Improving confidence in the management of the blue swimmer crab (*Portunus armatus*) in Shark Bay PART III: Proceedings of the Third National Workshop on Blue Swimmer Crab *Portunus armatus* Western Australian Fisheries and Marine Research Laboratories, Hillarys, Perth, 3 – 4 June 2015. FRDC Project No. 2012/15. Department of Primary Industries and Regional Development, Report 285, Perth, Western Australia.

Johnson, D. 2020. NSW Stock Status Summary 2018/19 – Blue Swimmer Crab (*Portunus armatus*). NSW Department of Primary Industries. Fisheries. 8 pp, New South Wales.

Johnston, D and D. Yeoh 2021. Temperature drives spatial and temporal variation in the reproductive biology of the blue swimmer crab *Portunus armatus* A. Milne-Edwards, 1861 (Decapoda: Brachyura: Portunidae). Journal of Crustacean Biology 41(3). https://doi.org/10.1093/jcbiol/ruab032

Johnston, D., D. Yeoh, D. Harris, and E. Fisher. 2020. Blue Swimmer Crab (*Portunus armatus*) Resource in the West Coast Bioregion, Western Australia Part 1: Peel Harvey Estuary, Cockburn Sound and Swan Canning Estuary. Fisheries Research Report No. 307. Department of Primary Industries and Regional Development, 190pp, Western Australia.

Kadarsha, K., P Mohanchander, P. S. Lyla, and S. A. Khan. 2013. Feeding and reporductive biology of *Saurida undosquamis* (Richardson, 1848), from Parangipettai coat, Southeast coast of India. Pakistan Journal of Biological Sciences. ISSN 1028-8880 / DOI: 10.3923/pjbs.2013.

Kangas, M and S. Morrison 2013. Trawl impacts and biodiversity management in Shark Bay, Western Australia. *Marine and Freshwater Research*. 64: 1135-1155.

Kangas, M. I. 2000. Synopsis of the biology and exploitation of the blue swimmer crab, *Portunus pelagicus* Linnaeus, in Western Australia. Fisheries Research report no 121. Published by the Fisheries Research Division, Fisheries Western Australia, Western Australia.

Kangas, M., S. Wilkin, E. Sporer, A. Chandrapavan, N. Breheny, and D. Meredith. 2019. Resource Assessment Report No. 3 - Scallop resource. Department of Primary Industries and Regional Development, Government of Western Australia, Western Australia.

Kangas, M.I., S. Morrison, P. Unsworth, E. Lai, I. Wright and A. Thomson. 2007. Development of biodiversity and habitat monitoring systems for key trawl fisheries in Western Australia. Final report to Fisheries Research and Development Corporation on Project No. 2002/038. Fisheries Research Report No. 160, Department of Fisheries, Western Australia, 334p.

Kyne, P.M., C. L. Rigby, W. R. T. Darwall, I. Grant and C. Simpfendorfer. 2021. *Glyphis glyphis*. The IUCN Red List of Threatened Species 2021: e.T39379A68624306. https://dx.doi.org/10.2305/IUCN.UK.2021-2.RLTS.T39379A68624306.en

Kyne, P.M., J. Carlson and K. Smith. 2013. (errata version published in 2019). *Pristis pristis*. The IUCN Red List of Threatened Species 2013: e.T18584848A141788242. http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T18584848A141788242.en

Lovett, R., M. F. O'Neill and A. Garland 2020. Stock assessment of Queensland east coast blue swimmer crab (*Portunus armatus*). Fisheries Queensland, Department of Agriculture and Fisheries, Queensland.

Marsh, H. and S. Sobtzick. 2019. *Dugong dugon* (amended version of 2015 assessment). The IUCN Red List of Threatened Species 2019: e.T6909A160756767. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T6909A160756767.en

Milton, D. A., G. C. Fry, and Q. Dell. 2009. Reducing impacts of trawling on protected sea snakes: by-catch reduction devices improve escapement and survival. Marine and Freshwater research 60:824-832.

Mortimer, J.A. and M. Donnelly. 2008. *Eretmochelys imbricata*. The IUCN Red List of Threatened Species 2008: e.T8005A12881238. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T8005A12881238.en

National Parks and Wildlife Service 2022. About Marine Parks. Accessed from: https://www.marineparks.sa.gov.au/about

New South Wales Department of Primary Industries 2018. Fact sheet - October 2018: Estuary General - Trapping.

New South Wales Department of Primary Industries 2020e. Consultation. Accessed from: https://www.dpi.nsw.gov.au/fishing/commercial/consultation

New South Wales Department of Primary Industries 2021. NSW Estuary General Fishery Code of Practice.

New South Wales Department of Primary Industries 2021. NSW Fisheries Harvest Strategy Guidelines, New South Wales.

New South Wales Department of Primary Industries 2022. Estuary General Fishery. Accessed from: https://www.dpi.nsw.gov.au/fishing/commercial/fisheries/egf

New South Wales Department of Primary Industries 2022b. Estuary general fishery closures. Accessed from: https://www.dpi.nsw.gov.au/fishing/closures/commercial/estuary-general-fishery-closures

New South Wales Department of Primary Industries 2022c. Compliance. Accessed from: https://www.dpi.nsw.gov.au/fishing/compliance

New South Wales Department of Primary Industries 2022d. Fisheries compliance enforcement. Accessed from: https://www.dpi.nsw.gov.au/fishing/compliance/fisheries-compliance-enforcement

New South Wales Department of Primary Industries 2022f. Marine Protected Areas. Accessed from: https://www.dpi.nsw.gov.au/fishing/habitat/protecting-habitats/mpa

New South Wales Department of Primary Industries 2022g. Intertidal Protected Areas. Accessed from: https://www.dpi.nsw.gov.au/fishing/closures/ipa

Newman, S. J., B. S. Wise, K. G. Santoro, and D. J. Gaughan (eds). 2021. Status reports of the fisheries and aquatic resources of Western Australia 2020/21: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia.

NMFS 2022. Foreign trade: US trade in fishery products. Accessed from: https://www.fisheries.noaa.gov/foss/f?p=215:2:17844220183635::NO:::

NMFS 2022b. Foreign trade: US trade in fishery products - Australia. Accessed from: https://www.fisheries.noaa.gov/foss/f?p=215:2:17844220183635::NO:::

Noell, C., C. Beckmann, L. McLeay, M. Kangas, and A. Roelofs. 2020. Status of Australian fish stocks report. Western King Prawn (2020),

Northrop A. R., M.F. O'Neill and J.B. Robins 2019. Towards an initial quota for the Queensland mud crab

fishery. Department of Agriculture and Fisheries, Queensland.

NSW Fisheries 2001. Estuary General Fishery: Environmental Impact Statement.

Office of the Auditor General Western Australia. 2022. Performance audit: Regulation is commercial fishing.

PIRSA 2022. Fishing closures. Accessed from: https://www.pir.sa.gov.au/recreational_fishing/rules/fishing_closures

PIRSA 2022b. Marine Safety SA: Marine Safety Officers. Accessed from: https://marinesafety.sa.gov.au/compliance/marine-safety-officers

PIRSA 2022c. Community consultations. Accessed from: https://pir.sa.gov.au/recreational_fishing/community_engagement/community_consultations

PIRSA 2022d. Fishcare volunteers. Accessed from: https://pir.sa.gov.au/recreational_fishing/community_engagement/fishcare_volunteers

Primary Industries and Regions South Australia. 2020. Management Plan for the South Australian Commercial Blue Crab Fishery. Paper number 75, Adelaide, South Australia.

Primary Industries and Regions South Australia. 2022e. Fisheries Officers. Accessed from: https://www.pir.sa.gov.au/recreational_fishing/community_engagement/fisheries_officers

Queensland Department of Agriculture, Water and the Environment 2021. Letter from the Hon Sussan Ley MP, Minister for the Environment, Member for Farrer, Queensland.

Queensland Government 2019. Zoning and designated areas. Accessed from: https://www.qld.gov.au/environment/coasts-waterways/marine-parks/zoning

Queensland Government 2021. Queensland blue swimmer crab fishery harvest strategy: 2021-2026. Version 1, Queensland.

Queensland Government 2021b. Crab fishery working group terms of reference. Accessed from: https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/fishery-working-groups/crab-working-group/crab-working-group-terms-of-reference

Queensland Government 2021c. Qld crocs recover from near extinction. Accessed on 3rd February, 2021, from: https://statements.qld.gov.au/statements/92842

Queensland Government 2022. About Marine Parks. Accessed from: https://www.qld.gov.au/environment/coasts-waterways/marine-parks/about

Red List Standards & Petitions Subcommittee. 1996. *Natator depressus.* The IUCN Red List of Threatened Species 1996: e.T14363A4435952. http://dx.doi.org/10.2305/IUCN.UK.1996.RLTS.T14363A4435952.en

Saunders, T, D. Johnson, D. Johnston, and L. Walton 2020. Status of Australian fish stocks report: Mud crabs (2020).

SealifeBase 2022. Growth parameters for *Portunus pelagicus.* Accessed from: https://www.sealifebase.ca/PopDyn/PopGrowthList.php?ID=9329&GenusName=Portunus&SpeciesName=pelagicus&fc=473

SealifeBase 2022b. Reproduction of *Nectocarcinus antarcticus.* Accessed from: https://www.sealifebase.ca/Reproduction/FishReproSummary.php?ID=152801&GenusName=Nectocarcinus&SpeciesName=antarcticus&fc=473&StockCode=96958

Seminoff, J.A. (Southwest Fisheries Science Center, U.S.). 2004. *Chelonia mydas*. The IUCN Red List of Threatened Species 2004: e.T4615A11037468. http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en

Simpfendorfer, C. 2013. *Pristis zijsron* (errata version published in 2019). The IUCN Red List of Threatened Species 2013: e.T39393A141792003 http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T39393A141792003.en

SMEC 2001. Estuary General EIA report. Prepared for NSW Fisheries.

UNESCO 2022. Shark Bay, Western Australia. Accessed from: https://whc.unesco.org/en/list/578/

Wiswedel, S. 2015. *Hippocampus trimaculatus*. The IUCN Red List of Threatened Species 2015: e.T10087A17252219. http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T10087A17252219.en

Woinarski, J. & A. A. Burbidge. 2016. *Xeromys myoides*. The IUCN Red List of Threatened Species 2016: e.T23141A22454469. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T23141A22454469.en

Zouari-Ktari R. and M. N. Bradai. 2011. Reproductive biology of the lessepsian reticulated leatherjacket *Stephanolepis diaspros* (Fraser - Bru¨ nner, 1940) in the Gulf of Gabes (Eastern Mediterranean Sea). Rev Fish Biol Fisheries 21: 641-648.