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Status reports of the fisheries and aquatic resources of Western Australia 2020/21

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Status reports of the fisheries and aquatic resources of Western Australia **2020/21**

State of the fisheries

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Important disclaimer

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EDITOR'S OVERVIEW

The *Status Reports of the Fisheries and Aquatic Resources of Western Australia* (*SRFAR*) provide an annual update on the state of the fish stocks and other aquatic resources of Western Australia (WA). These reports outline the most recent assessments of the cumulative risk status for each of the aquatic resources (assets) within WA's six Bioregions using an Ecosystem Based Fisheries Management (EBFM) approach. The Departments' risk based EBFM framework is the State government's basis for management of all Western Australia's aquatic resources.

Assets examined in each bioregion include the meso-scale ecosystems and aquatic resources, along with the associated fisheries. A summary at the start of each chapter displays the stock and fishery performance levels, along with the current performance and risk levels for each of the other EBFM outcomes (bycatch, listed species, habitats, ecosystem, social and economics, governance). Major external drivers, such as COVID-19, climate change, coastal development and introduced pests/diseases, are examined to determine their impact on WA's aquatic resources.

The 2020/21 financial year saw a continuation of the outstanding results achieved in fisheries management to ensure the continued sustainability of the State's aquatic resources. The unique contribution that the state's fishing sectors, and aquaculture industries make to Western Australia are acknowledged in the state's 2020 – 2024 Primary Industries Plan (the Plan). The Plan recognizes and responds to these times of significant disruptions to historical ways of doing business by providing a high-level roadmap to maintain and grow the primary industries of Western Australia.

This year, 98% of our fish stocks were assessed as not being at risk or vulnerable through exploitation (fishing); this includes those classified as **sustainable – adequate** where more than 90% of the State's fishery value comes from independently certified sustainable fisheries, including the Marine Stewardship Council (MSC) certified fisheries of Western Rock Lobster, West Coast Deep Sea Crab, West and South Coast Abalone, Shark Bay Prawn, Exmouth Gulf Prawn, Peel-Harvey Sea Mullet and Blue Swimmer Crab, Pearl Oyster, Octopus and Sea Cucumber.

Several resources were classified as **sustainable – recovering**, indicating that management actions taken to date have resulted in these resources recovering at acceptable rates. These included Australian herring and the Wilson Inlet cobbler stocks supporting nearshore and estuarine fisheries of the south and west coasts, dusky and sandbar shark stocks that support the Temperate Demersal Gillnet and Demersal Longline Fishery and fish resources supporting the West Coast and Gascoyne Demersal Scalefish Fisheries.

Three resources, the Cockburn Sound crab resource, white bait and southern garfish in the West Coast Nearshore resource and the northern Shark Bay scallop resource continue to be **environmentally limited** with stocks recovering from the 2010/11 marine heat wave with highly restricted management arrangements or are closed to fishing.

Only one resource was classified as **inadequate** – the Greenlip Abalone of the Abalone Managed Fishery is considered inadequate as a result of exploitation with management actions already implemented to assist stock recovery.

Considerable work continues towards implementing the *Aquatic Resources Management Act 2016* (ARMA). This will *be* a once-in-a-generation change that will provide a modern, innovative framework that will create a sound basis for effective, efficient and integrated fisheries and aquatic resource management for decades to come. It is expected that full proclamation of ARMA will occur in late 2022/early 2023.

A key feature of the ARMA is that it is based around aquatic resources, rather than the traditional approach based on a fishery or fishing activity. This enables an integrated approach to providing secure fishing access rights for all sectors, with resource sustainability at its core. The ARMA allows for existing management arrangements and resource access rights to remain effective for the State's commercial fishing and pearling industries, until each is migrated to the new legislative framework.

Many staff at the Department of Primary Industries and Regional Development (DPIRD) have contributed to the production of this report, along with the stakeholders who contributed to managing the state's aquatic resources. The ongoing involvement of our Aboriginal, commercial, recreational and aquaculture stakeholders in specific research projects and monitoring programs remains critical. Logbook data, voluntary participation in recreational fishing surveys, the provision of biological samples, and access to vessels and sharing of information are integral to aquatic resource management in this state. The input from other science groups located within WA plus those from other parts of Australia and internationally is also acknowledged.

This volume provides the public, fishers and other stakeholders with a starting reference source. This meets the reporting requirements of the Department, including the need to report on the Key Performance Indicators (KPIs) section of the Annual Report to Parliament in 2021 (See Overview).

Key species can also be found in the Status of Australian Fish Stocks (SAFS) reports at http://fish.gov.au.

This year's *Status Reports of the Fisheries and Aquatic Resources of Western Australia 2020/21* is directly accessible on the Department's website (www.fish.wa.gov.au), where users are encouraged to download relevant sections for personal use. If quoting from the document, please give appropriate acknowledgment using the citation format provided at the front of the report.

HOW TO USE THIS VOLUME

To obtain full benefit from the information provided in this edition of the *Status Reports of Fisheries and Aquatic Resources of Western Australia*, the following descriptions outline the various terms and headings used in the text, the fishery status overview table (which also appears in the Department of Primary Industries and Regional Development's *Annual Report* 2020/21 to Parliament) and the ecological resource level reports.

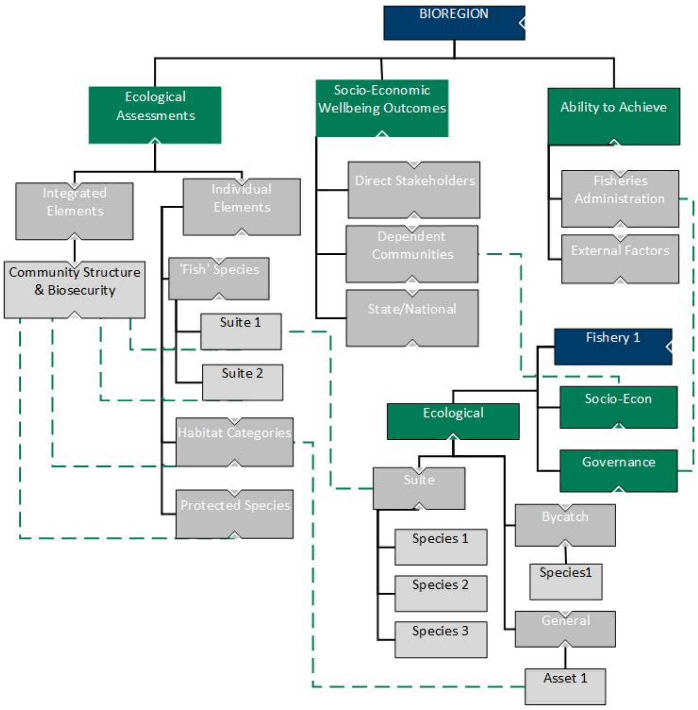
The terms and headings are a combination of the reporting structures first outlined in the National Ecologically Sustainable Development (ESD) reporting structure (Fletcher *et al.* 2002)[1], plus the Ecosystem Based Fisheries Management (EBFM) framework (Fletcher *et al.* 2010, 2012)[2] and the Resource Assessment Framework (DoF, 2011)[3]. The terminology used in reports has now been updated to be consistent with the MSC criteria, and where possible, that used within the national *Status of Key Australian Fish Stocks reports*[4].

In addition to the explanations provided below, acronyms are expanded at their first occurrence in each section of the text. It also needs to be noted that references are only presented as footnotes once within each report.

ECOSYSTEM BASED FISHERIES MANAGEMENT

As outlined above the Department has fully adopted EBFM, which is a risk based management approach. EBFM recognises the social, economic and ecological values at a regional level and the links among individual exploited fish stocks, effects on habitats and protected species (which collectively form the broader marine ecosystem), to ensure the sustainable management of all fisheries resources into the future. EBFM provides a mechanism for assessing and reporting on the regional level risk status of all WA's aquatic resources and therefore the effectiveness of the aquatic resource management arrangements in delivering community outcomes.

Given the potential complexity we use a practical, step-wise, risk-based approach to integrate all the fishery level assessments and management systems into a form that can be used for aquatic resource management planning by the Department (Introduction Figure 1).



INTRODUCTION FIGURE 1.

The high level EBFM component tree framework showing how each of the fishery level issues are mapped into cumulative, regional-level individual assets and outcomes. Furthermore, the component tree shows how ecosystem elements are composed of the integrated set of individual elements.

1 Fletcher WJ, Chesson J, Fisher M, Sainsbury KJ, Hundloe T, Smith ADM, and Whitworth B. 2002. National ESD reporting framework for Australian fisheries: The 'how to' guide for wild capture fisheries. FRDC project 2000/145, Fisheries Research and Development Corporation, Canberra.

2 Fletcher WJ, Shaw J, Metcalf SJ, and Gaughan DJ. 2010. An Ecosystem Based Fisheries Management framework: the efficient, regional-level planning tool for management agencies. Marine Policy 34: 1226–1238

Fletcher WJ, Gaughan DJ, Metcalf SJ, and Shaw J. 2012. Using a regional level, risk-based framework to cost effectively implement Ecosystem Based Fisheries Management (EBFM). In: Kruse *et al.* (eds). Global Progress on Ecosystem-Based Fisheries Management. pp. 129-146. Alaska Sea Grant College Program. doi: 10.4027/gpebfm.2012.07.

3. DoF. 2011. Resource Assessment Framework for Finfish Resources in Western Australia. Fisheries Occasional Publication. No. 85. Department of Fisheries, Western Australia.

4 Piddocke *et al.* 2021. Status of Australian fish stocks reports 2020. Fisheries Research & Development Corporation, Canberra.

Each set of Bioregional level risks is made up of individual ecological risks at a species or stock level, and social and economic risks at a fishery level. The consolidation process into broader asset categories utilises the branch structure of the EBFM component trees. Each of these represents groups of 'like risks' that can be managed collectively. For example, the status of an entire suite (e.g. Demersal Finfish) is evaluated based on the risk status of several indicator species, which have been chosen to be representative of the more vulnerable species within the suite (Newman *et al*. 2018)[1].

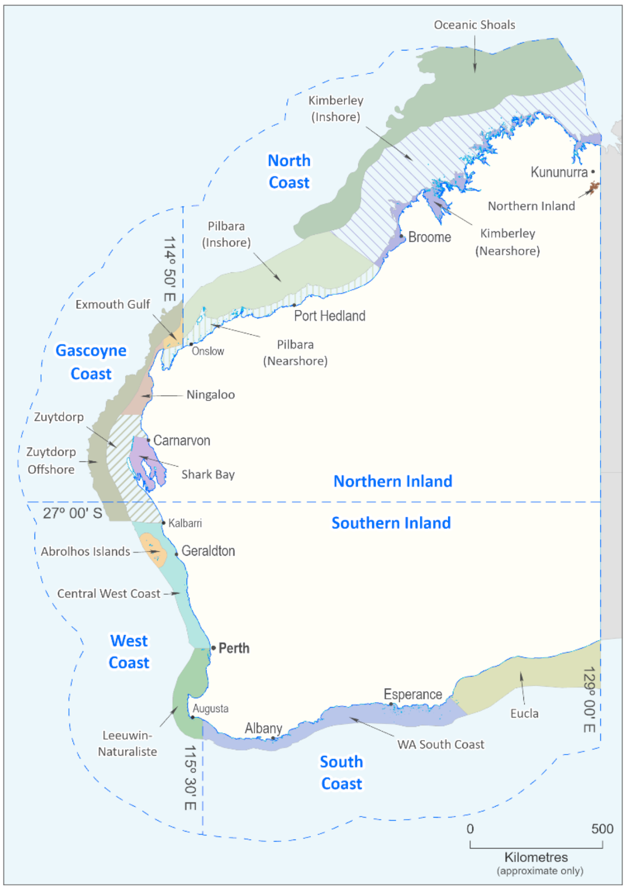
A similar process is applied to consolidate the items across the other EBFM components. Furthermore, the assessment of ecosystem status recognises that community structure and biodiversity within an ecosystem can be effectively assessed as the 'integrated' sum of the status of the 'individual' ecological elements.

Finally, as we manage the set of ecological assets to generate economic and social benefits for the community, each of the ecological assets is used as the unit to integrate its associated ecological, social and economic values and risks using a simple multi-criteria function. The shifts in these priority scores among years for each of the 80 regional level ecological assets is integral for the annual planning cycle used for assigning priorities for all aquatic resource management related activities across the Department (see Fletcher *et al.,* 2010, 2012 for full details).

BIOREGIONS

With the adoption of the EBFM approach, a fully bioregional structure is used for the Annual Status Reports whereby a 'Bioregion' refers to a region defined by common oceanographic characteristics in its marine environment, or by climate/rainfall characteristics in its inland river systems.

Each individual Bioregion has a *general introduction* section outlining the main features of its aquatic environment plus the major commercial and recreational fisheries, and aquaculture industries that operate in the area. Important cultural values and resources, whether exploited or not, will also be highlighted. This section also outlines the current cumulative risk status of each of the high-level, ecological resources/assets located within each Bioregion (see Introduction Figure 2).



INTRODUCTION FIGURE 2:
Map of WA showing the boundaries of the Bioregions and Integrated Marine and Coastal Regionalisation of Australia (IMCRA) ecosystems.

1 Newman, S.J., Brown, J.I., Fairclough, D.V., Wise, B.S., Bellchambers, L.M., Molony, B.W., Lenanton, R.C.J., Jackson, G., Smith, K.A., Gaughan, D.J., Fletcher, W.J., McAuley, R.B. and Wakefield, C.B. 2018. A risk assessment and prioritisation approach to the selection of indicator species for the assessment of multi-species, multi-gear, multi-sector fishery resources. Marine Policy 88: 11-22.

ASSESSMENT OF REGIONAL LEVEL ECOLOGICAL RESOURCES (ASSETS) IN EACH BIOREGION

The ecological resources/assets in each Bioregion include the ecosystems and their constituent habitats, captured species and listed species.

Captured Fish: Captured fish species are subdivided into finfish, crustaceans and molluscs with each of these further divided into estuarine/embayments, nearshore, inshore/offshore demersal and pelagic (finfish only) suites (see DoF, 2011).

Listed (protected) species: This category, which includes Endangered, Threatened and Protected Species (ETPS) under State or Commonwealth Acts, was subdivided into listed 'fish[1]' (e.g. white sharks, corals) and listed 'non-fish' (e.g. mammals) as defined in the *Fish Resources Management Act* 1994. ETPS are similarly defined under the new *Aquatic Resources Management Act* 2016.

Habitats: Habitat assets in each Bioregion are divided into estuarine and marine categories and again where necessary the latter category was further divided into nearshore and offshore components.

Ecosystems: Within each Bioregion, one or more meso-scale ecosystems, as defined by the IMCRA process (Introduction Figure 2), were used as a starting point, but merging of these or further division into separate estuarine/embayment and marine components was undertaken where relevant.

RISK ASSESSMENT

The Department's objective is to manage the sustainability of the community's aquatic ecological resources and assets to generate economic and/or social outcomes. Risks associated with each individual ecological asset and community outcomes were therefore examined separately using qualitative risk assessments (Consequence x Likelihood) (modified from Fletcher 2015)[2]. This enables the analysis of risk (using a five-year time horizon) for objectives related to captured species, habitat and community structure/ecosystem sustainability, plus social and economic outcomes to be completed in a practical and consistent manner.

The internationally accepted definition of risk is "the uncertainty associated with achieving objectives" (*ISO,* 2009). Uncertainties are therefore explicitly incorporated into assessments to enable each risk assessment to be completed with whatever data are available. All risk scoring considers the current level of management activities and controls already in place or planned. The management and reporting implications for each of the different risk categories are defined (Introduction Table 1).

The various ecological, social and economic risks and values associated with ecological assets are integrated using a multi-criteria analysis to generate approximately 80 Departmental-level priorities across the six Bioregions.

INTRODUCTION TABLE 1
Links between the Risk Category and the likely reporting and management response

Risk Category	Description	Likely Reporting and Monitoring Requirement	Likely Management Action
Negligible	Acceptable; not an issue	Brief notes – no monitoring	Nil
Low	Acceptable; no specific control measures needed	Full notes needed – periodic monitoring	None specific
Medium	Acceptable; with current risk control measures in place (no new management required)	Full performance report – regular monitoring	Specific management and/or monitoring required
High	Not desirable; continue strong management actions OR new / further risk control measures to be introduced in the near future	Full Performance report – regular monitoring	Increased management activities needed
Severe	Unacceptable; major changes required to management in immediate future	Recovery strategy and detailed monitoring	Increased management activities needed urgently

1 Under the FRMA and ARMA, fish include all aquatic organisms except birds, reptiles, mammals and amphibians.

2 Fletcher WJ. 2015. Review and refinement of an existing qualitative risk assessment method for application within an ecosystem-based management framework. ICES Journal of Marine Research 72: 1043-1056.

SEASON REPORTED

Individual fishery production figures relate to the latest full year or season for which data were available. Therefore, statistics in this volume generally refer either to the 2019/20 financial year or the 2020 calendar year, whichever is more appropriate.

In contrast, sections on Departmental activities in the areas of fishery management, new compliance activities and research summaries may include information up to June 2021.

ECOLOGICAL ASSETS

Captured Fish

Commercial Fishing Estimates

There is a legislative requirement for information to be submitted by various sectors of the fishing industry including commercial fishers, fish processors, charter operators and aquaculture producers.

Monthly returns or daily/ trip returns are provided that include information on the composition, quantity and location of catches and fishing effort that was used. Monthly returns from fish processors request quantity and price paid for fish products.

Recreational Fishing Estimates

The Department has implemented an integrated survey design to monitor recreational fisheries in a cost effective way[1]. These surveys provide estimates of catch and effort by boat-based recreational fishers at both state-wide and bioregional levels. These surveys utilise the Recreational Boat Fishing Licence as the sampling frame to contact fishers and multiple survey methods to validate estimates by enabling comparisons across the various methods.

The integrated surveys include three complementary components: (i) off-site phone surveys encompassing an initial Screening Survey, a 12-month Phone-Diary Survey, followed by post-enumeration surveys; (ii) on-site boat-ramp surveys; and (iii) remote Camera Surveys.

The state-wide survey of boat-based recreational fishing has been repeated biennially between 2011/12 and 2017/18. Methods to cost effectively monitor shore-based recreational fishing as part of the integrated survey are currently under development.

Estimates of catch and effort at state-wide and bioregional levels from 2017/18 presented in Ryan *et al*. (2019[2]) provide information for the recreational sector throughout this report.

The most recent (fifth) survey was undertaken from 1 September 2020 to 31 August 2021 with post-enumeration surveys from September to December 2021. Estimates of catch and effort at state-wide and bioregional levels from these surveys will be available in 2022.

Stock Assessment Methodologies

Each of the stock assessment reports now clearly identifies the types of data and assessment method(s) that have been used to determine the status of stocks. The specific methods used for monitoring and assessment vary among resources and indicator species and is influenced by many factors including; the level of ecological risk; the biology and the population dynamics of the relevant indicator species; the type, size and value of the fishery exploiting the species; data availability and historical level of monitoring.

The analyses that can be applied for assessing stock status vary according to data availability (and resourcing). At one end of the spectrum, are relatively simple simulation (i.e. Catch-MSY) models applied to catch data only, but requiring relatively strong assumptions regarding stock productivity and stock depletion levels. At the other end are highly complex age and/or size-structured integrated stock assessment models, which use all available catch, effort, biological, compositional data (and sometimes also tagging data). Regardless of assessment level, where possible, model-based assessment analyses are used to produce quantitative estimates of key performance indicators (fishing mortality and spawning biomass), compared against internationally-accepted biological reference points (i.e. relating to B_{MSY}, expected spawning biomass required to achieve long-term maximum sustainable yield, MSY). Stock assessments are categorised into five levels (Introduction Table 2).

1 Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS. 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297. Department of Primary Industries and Regional Development, Western Australia.

2 Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS. 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297. Department of Primary Industries and Regional Development, Western Australia.

INTRODUCTION TABLE 2
Levels and descriptions of the categories of assessment methods

Level	Description
Level 1	Catch data and biological/fishing vulnerability. Catch-MSY analysis (if sufficient data).
Level 2	Level 1 and nominal or standardised fishery-dependent effort. Simple biomass dynamics models, depletion analysis (if sufficient data), or performance-indicator reference levels based on historical catch and/or CPUE time series.
Level 3	Levels 1 and/or 2 plus fishery-dependent biological sampling of landed catch (e.g. average size; fishing mortality, etc. estimated from representative samples). Equilbrium assessment models (e.g. catch curve and per recruit analysis).
Level 4	Levels 1, 2 and (data-permitting) 3 plus reliable/informative abundance time series (e.g. spawning stock and/or recruitment indices from standardised fishery-dependent and/or fishery-independent data). Empirical analyses (e.g. stock-recruitment-environment relationships), dynamic stock assessment models (e.g. state-space production model, age-structured production model, statistical catch-at-age model without abundance information).
Level 5	Levels 1, 2, 3 and 4 plus dynamic, integrated stock assessment model (incorporating biological information, catch, abundance and compositional data, and potentially other information e.g. from tagging).

While there are five different categories of quantitative analysis methodologies, all stock assessments undertaken by the Department now take a Weight of Evidence (WoE), Risk-based approach (Fletcher, 2015). This requires specifically considering each available line of evidence both individually and collectively to generate the most appropriate overall assessment conclusion. The lines of evidence include outputs that are generated from each available quantitative method, plus any qualitative lines of evidence such as biological and fishery information that describe the productivity and vulnerability of the species/stock and information from fishers, stakeholders and other sources. The strength of the WoE risk-based approach is that it explicitly shows which lines of evidence are consistent or inconsistent with a specific consequence level and therefore where there are uncertainties, which assists in determining the overall risk level and areas of further research (see also Fletcher, 2015).

Breeding Stock Status

The assessments of breeding stock for captured species are undertaken using a number of techniques (see above) to determine if the stock is considered to be at an adequate level or not. Stock status levels are defined as:

Sustainable-Adequate: reflects levels and structure of parental biomass for a stock where annual variability in recruitment of new individuals (recruits) to the stock is considered to be mostly a function of environmental effects on recruit survival, not the level of the egg production.

Sustainable-Recovering: reflects situations where the egg production has previously been depleted to unacceptable levels by fishing or some other event (e.g. marine heatwave) but is now considered to be recovering at an acceptable rate due to the implementation of effective management actions and/or natural processes.

Inadequate: The indicator(s) reflects that the stock status is (are) below the threshold or limit level(s) and management actions to support recovery have not yet been implemented, or the management actions are not yet confirmed as operating effectively to reasonably assume that they are generating a sufficient rate of recovery. This outcome includes situations where excessive fishing pressure (catch), or in combination with some external event, has led to the breeding stock biomass falling to levels where there is now a high risk of future recruitment levels being measurably reduced. This is equivalent to MSC's point of recruitment impairment.

Environmentally Limited: This indicates situations where the stock is at unacceptable levels due primarily to environmentally driven impacts (e.g. marine heat wave impacts), not from fishing activities.

By-Catch and Listed Species

These last two categories include those species caught during a fishing operation that are not retained. This covers the potential impact on unwanted 'bycatch' species and also any captures or interactions with listed species, which includes Endangered, Threatened and Protected (ETP) species. In each case, an explanation is provided of the situation and the level of risk to the stock from fishing operations. This section does not include release of target species for reasons such as under size or over bag limits. These issues are covered in individual assessments of retained species.

Habitat and Ecosystem Effects

These two categories refer to the potential indirect impacts generated by the direct physical interactions of fishing gear with the sea floor and by the removal of animals from the ecosystem

(food chain effects). Each fishery or resource is considered in terms of its potential/relative effects on habitat and the food chain with an outline of the assessment of current ecological risk (‘negligible’, ‘low’, ‘medium’, ‘high’ or ‘severe’) provided.

The Department is conducting periodic ecological risk assessments across the various resources. These ecological risk assessments involve workshops with a broad range of stakeholders and provide risk scores based on available scientific monitoring, research information and expert knowledge on species, fishing activities, fishery regulations and management.

Social Effects

The Department has categorised the different level of social amenity generated by each aquatic asset. Note, by definition, there is no asset that has no social amenity (Introduction Table 3).

INTRODUCTION TABLE 3
Levels and descriptions of the categories of social amenity.

Social Amenity	Description
Level 1	No recreational fishing for the asset and no specific broader community interests.
Level 2	Some caught recreationally &/or some interest to specific sections of the community.
Level 3	Locally important to recreational sector &/or it has some importance to the broader community.
Level 4	Major catch by recreational sector in the region &/or generates major interest for some of the general community.
Level 5	Primary recreational target across the region &/or iconic for general community.

Economic Effects

The Department has categorised the different levels of Gross Value of Product (GVP) for commercial fisheries into six levels to measure their relative economic importance (Intoduction Table 4). This provides a mechanism for reporting on all fisheries including those where the small number of operators would not allow specific values to be provided. It also covers situations where specific GVP values may not be available.

INTRODUCTION TABLE 4
Levels of relative economic importance

Economic Value	Description
Level 0	Nil
Level 1	< $1 million
Level 2	$1 – 5 million
Level 3	$5 -10 million
Level 4	$10 - 20 million
Level 5	> $20 million

Governance Systems

Harvest Strategy

A Harvest Strategy Policy (DoF, 2015) for the aquatic resources of WA provides the framework for developing harvest strategies for each resource. Each harvest strategy establishes clear and specifically articulated reference levels and associated management actions designed to achieve each of the agreed objectives, both for the resource and all relevant fishery sectors.

To ensure a holistic and integrated approach, the Harvest Strategy Policy for WA not only covers target species abundance, it incorporates social and economic considerations including sectoral allocations plus the management of unacceptable risks to other ecological resources.

Annual Catch (or Effort) Tolerance Range

To minimise management interventions and provide greater certainty for when management adjustments may be required, a target catch or effort range has been determined for each of the major commercial fisheries. This indicator provides an assessment of the success of the Department’s management plans and regulatory activities in keeping fish catches at appropriate levels (including those in a recovery phase). This identifies if the stock is being subjected to overfishing or not.

To calculate this range, as outlined in the Harvest Strategy Policy, a tolerance level establishes for each fishery what range of deviations in annual catch or effort is considered acceptable to meet stock based objectives and/or to meet any sectoral allocations (e.g. as developed by IFM determinations). These annual tolerances take into account natural variations in recruitment to a fished stock. Examination of tolerances will

determine when a review and/or intervention is required.

The catch or effort for each major fishery is assessed annually and if catch or effort remains inside an acceptable range it is defined as having acceptable performance. Where annual catch or effort for a fishery/sector falls outside a range and the rise or fall cannot be adequately explained (e.g. environmentally-induced fluctuations in recruitment levels; low market demand or prices), a management review or additional research to assess the underlying cause may be required.

Annual catch tolerance range: For many commercial and recreational fisheries in WA, management plans seek to directly control the amount of fishing effort applied to stocks, with the level of catch taken providing an indication of the effectiveness of a plan. Where a plan is operating effectively, the catch by a fishery should fall within a projected catch tolerance range.

Annual effort tolerance range: For quota-managed fisheries, the measure of success for management arrangements is firstly that the majority of the Total Allowable Catch (TAC) is achieved, but additionally, that it has been possible to take this catch using an acceptable amount of fishing effort.

If an unusually large (or smaller) expenditure of effort was expended to achieve a TAC, or an industry fails to achieve a TAC by a significant margin (i.e. outside of tolerance levels), this may indicate that the abundance of a stock is significantly lower (or higher) than was anticipated. For these reasons, appropriate tolerance ranges of fishing effort required to achieve a TAC has also been incorporated for assessing the performance of quota-managed fisheries.

External Audits

Many of the State's significant fisheries achieved environmental certification for more than a decade under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). Where relevant, this report includes specific performance measures required to meet any EPBC Act requirements. Similarly, the majority of the State's most valuable fisheries have achieved MSC certification. This report provides a valuable input to the annual audit process for these fisheries.

External Factors

This refers to known factors outside of the direct control of fishery legislation which impact on aquatic resources or activities. An understanding of these factors, which are typically environmental (cyclones, ocean currents, climate change, changes in rainfall) but which may also include other factors (e.g. market factors, coastal development), is also necessary to interpret changes in catch and/or effort to fully assess the performance of a fishery.

OVERVIEW OF THE STATUS OF KEY ECOLOGICAL RESOURCES (ASSETS) ECOLOGICAL ASSETS

Captured Species (Fisheries and Stocks)

Annual Weight of Evidence (WOE) stock assessments, including analyses of trends in catch and fishing activity, are used each year to determine the status of each of the State's aquatic resources and fisheries and are presented in detail in the rest of this document. This section provides an overview of the outcomes of the Department's management systems by collectively examining the status of all the commercial and recreational fisheries and harvested fish stocks in WA (Overview Table 1). The material presented in this section is based on the analyses and text presented in the Key Performance Indicators (KPI) section of the Department of Primary Industries and Regional Development (DPIRD) Annual Report to Parliament 2020/21[1].

OVERVIEW TABLE 1

Breeding stock status, catch and effort ranges for WA's major commercial and recreational fisheries. The information underpins the four KPIs measuring the effectiveness of the department's management plans and regulatory activities in:

- ensuring the sustainability status of the State's aquatic resources
- the success of keeping fish catches (or effort) at appropriate levels for
  - commercial and
  - recreational fisheries and
- ensuring that sustainably managed commercial fisheries provide benefits to the State as a result of significant local sales and export earnings from fish and fish products.

The term 'sustainable' is given where the breeding stocks are considered adequate as well as breeding stocks that are recovering. Terms 'inadequate' or 'environmentally limited' include where additional actions need to be taken or confirmation is required to ensure the breeding stocks are either adequate or are now recovering. The term 'overfished' is only given where breeding stocks are inadequate due to exploitation (i.e. overfishing) that have been identified but for which definitive management actions have yet to be fully implemented.

An acceptable catch or effort range may be determined for each of the major commercial and recreational fisheries. Commercial ranges 'under revision' or 'under development' are not assessed. Recreational ranges 'not developed' or 'under revision' are not assessed however 'not formal' ranges are assessed.

Acronyms:

NA – Not applicable

Q – Quota management

TAC – Total Allowable Catch

TACC – Total Allowable Commercial Catch

TARC – Total Allowable Recreational Catch

MSC – Certified by Marine Stewardship Council

CI – Confidence Interval

SE – standard error.

Assessment level (and method):

Level 1 – Catch data and biological/fishing vulnerability

Level 2 – Level 1 plus fishery-dependent effort

Level 3 – Levels 1 and/or 2 plus fishery-dependent biological sampling of landed catch (e.g. average size, fishing mortality, etc. estimated from representative samples)

Level 4 – Levels 1, 2 or 3 plus fishery-independent surveys of relative abundance, exploitation rate, recruitment

Level 5 – Levels 1 to 3 and/or 4 plus outputs from integrated simulation, assessment model

1 https://www.wa.gov.au/system/files/2021-11/DPIRD%20annual%20report%202021.pdf

Resource	Fishery	Assessment level	Breeding stock assessment	Catch (and effort) range	Catch, effort and catch rate for season reported[1,2]	Catch (or effort or catch rate) level acceptable and explanation if needed
West Coast Bioregion						
Western Rock Lobster	West Coast Rock Lobster Managed Fishery (MSC)	Annual: Level 5	Sustainable: Adequate	Commercial: 6615t (12 month season TACC) extended to 9000t (~18 month season TACC) due to Covid19 Recreational: 490t (TARC)	Commercial: 5696 t (12 month) Recreational - licenced: 459 – 578t Recreational - charter: 14t	Acceptable Commercial: Catch within TACC plus 1.5% water loss i.e. 6400 t Recreational: Catch within acceptable range. Review of estimation methods for recreational catch underway.
Statewide Abalone	Abalone (Roe's) Managed Fishery (MSC)	Annual: Level 4	Sustainable: Adequate	Commercial: 73.5t (Q) (530–640 days) Recreational: 28–32t Perth Metro area	Commercial: 18.2t (133 days) Recreational: 29–33t Perth Metro area; 14t Other	Acceptable Commercial: Catch was below TACC due to economic impacts of COVID-19 on overseas markets. Recreational: Perth Metro catch range within TARC range.
Statewide Cephalopod	Octopus Interim Managed Fishery (MSC)	Annual: Level 2	Sustainable: Adequate	Commercial: 200–500t Recreational: Not developed	Commercial: 254t Recreational: 1t	Acceptable Commercial: Catch within acceptable range. Catch declined in 2020 due to COVID-19 issues.
South Coast and West Coast Scallop	Abrolhos Islands and Mid-West Trawl Managed Fishery	Annual: Level 4	Sustainable: Adequate	Commercial: 95–1830t Recreational: NA	Commercial: 1193t	Acceptable Commercial: Catch within acceptable range but below predicted range.
West Coast Estuarine and Nearshore Scalefish and Invertebrates	Cockburn Sound Crab Managed Fishery	Annual: Level 4	Inadequate (environmentally limited)	Commercial: Closed Recreational: Closed	Commercial: 0t Recreational: 0t	NA Cockburn Sound fishery closed since 2014. In 2020 recruitment and egg production improved but remained below limit reference levels. Decline is consistent with an environmentally limited stock.
West Coast Estuarine and Nearshore Scalefish and Invertebrates	West Coast Estuarine Managed Fishery (Area 1 Swan Canning, Area 2 Peel Harvey (MSC), Area 3 Hardy Inlet)	Annual: Levels 1 and 2 Periodic: Level 3 – Sea mullet Underway	Sustainable: Adequate – crabs/ Sea mullet	Commercial: 45–105t (Peel Harvey crab) 46–166t (Peel Harvey finfish) Recreational: Informal (Peel Harvey crab) Not developed (finfish)	Commercial: 57t (Peel Harvey crab) 112t (Peel Harvey finfish) 28t (other West Coast estuaries, crabs and finfish) Recreational: 39-46t (95% CI, boat only in 17/18, crabs in Perth Metro Zone)	Acceptable Commercial: Catch of crabs and finfish within acceptable ranges. Recreational: Crab catch levels are not considered a risk to stocks.

Resource	Fishery	Assessment level	Breeding stock assessment	Catch (and effort) range	Catch, effort and catch rate for season reported[1,2]	Catch (or effort or catch rate) level acceptable and explanation if needed
West Coast Estuarine and Nearshore Scalefish and Invertebrates	Cockburn Sound Fish Net Managed Fishery South West Beach Seine West Coast Nearshore Open Access Net Fishery South West Coast Salmon Managed Fishery West Coast Beach Bait	Annual: Levels 1 and 2 Periodic: Level 3 – Herring (State) 2017	Sustainable: Adequate- Whiting/ Salmon (State)/ Tailor Sustainable: Recovering– Herring Inadequate - (environmentally limited) Whitebait/ Southern Garfish	Commercial: Under revision Recreational: Not developed	Commercial: 75t (Nearshore fisheries, total finfish) Recreational: 49-64t (95% CI, boat only in 17/18,, top 10 species)	NA Metro Zone Garfish fishery closed in 2017. Declines in Garfish and Whitebait consistent with an environmentally limited stock. Large decline in salmon catch due to COVID related market impacts. Review of acceptable catch ranges is required.
Statewide Small Pelagic Scalefish (Purse Seine)	West Coast Purse Seine Managed Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 0–5700t (Q) Recreational: NA	Commercial: 493t (all species) Recreational: <1t	Acceptable
South Coast and West Coast Demersal Finfish	West Coast Demersal Scalefish Fishery	Annual: Level 1 Periodic: Level 3 – 2017	Sustainable: Recovering	Commercial: ≤450t Recreational ≤250t	Commercial: 247t Recreational: 210–253t (95% CI, private boats in 17/18, top 15 species; 2017/18); charter 36t (2019/20)	Commercial: Acceptable Demersal suite catch within range. Recreational: Not acceptable Snapper and Baldchin groper catches were above recovery benchmarks. WA dhufish catches were at or above benchmarks.
Gascoyne Coast Bioregion						
Shark Bay Invertebrate	Shark Bay Prawn Managed Fishery (MSC)	Annual: Level 4	Sustainable: Adequate	Commercial: 1350–2150t Recreational: NA	Commercial: 1268t	Acceptable Commercial: Western king prawn catches below the acceptable range due to lower recruitment levels. Additional in season measures implemented to protect breeding stocks.
Northern Invertebrates	Exmouth Gulf Prawn Managed Fishery (MSC)	Annual: Level 4	Sustainable: Adequate	Commercial: 471–1250t Recreational: NA	Commercial: 673t	Acceptable Commercial: Brown tiger prawns were just below their acceptable catch range.
Shark Bay Invertebrate	Shark Bay Scallop Managed Fishery	Annual: Level 4	Sustainable: Denham Sound: adequate Northern Shark Bay: inadequate (environmentally limited)	Commercial: Quota 900t Recreational: NA	Commercial: 885t	Acceptable Commercial: Quota season to 30 April. 98% of quota achieved. All catch was from Denham Sound as Northern region remained closed to fishing due to recruitment below limit reference level but slightly up on previous year.
Shark Bay Invertebrate	Shark Bay Crab Managed Fishery	Annual: Level 4	Sustainable: Adequate	Commercial: 650t (Q) Recreational: Not formal	Commercial: 638t Recreational: 1–2t (95% CI, boat only in 17/18)	Acceptable Commercial: Spawning and recruitment levels have further increased under the current environmental conditions and harvest levels. Recreational: Catch levels are stable.

Resource	Fishery	Assessment level	Breeding stock assessment	Catch (and effort) range	Catch, effort and catch rate for season reported[1,2]	Catch (or effort or catch rate) level acceptable and explanation if needed
Gascoyne Nearshore Scalefish	Shark Bay Beach Seine and Mesh Net Managed Fishery	Annual: Level 2 Periodic: Level 3 Yellowfin whiting – 2014	Sustainable: Adequate	Commercial: 235–335t Recreational: NA	Commercial: 171t	Acceptable Commercial: Catch below the acceptable range due to ongoing low levels of effort, further impacted by COVID.
South Coast and West Coast Crustacean	West Coast Deep Sea Crustacean Managed Fishery (MSC)	Annual: Level 2	Sustainable: Adequate	Commercial: Class A: 154t (Q); Class B: 20t (Q); Class C: 1t (Q); 60,000–105,000 pot lifts Recreational: NA	Commercial: Class A: 153t Class B: 3.1t; Class C: 0t (113,219 pot lifts)	Not Acceptable Commercial: TAC achieved but effort is above acceptable range. The stock status is currently being reviewed.
Gascoyne Demersal Scalefish	Gascoyne Demersal Scalefish Managed Fishery	Annual: Level 2 Periodic: Level 5 Snapper – 2017	Sustainable: Recovering	Commercial: Snapper 51.4t (Q) Other demersals 227t (Q) Recreational: Not formal	Commercial: Snapper 39.7t Other demersals 167t Recreational: 82–110t (95% CI, boat only in 17/18, top 10 species) Charter: Snapper 5t	Acceptable Commercial: Acceptable Recreational:Acceptable Snapper spawning biomass close to limit level with additional management action undertaken in 2018 including TACC reduction.
Gascoyne Demersal Scalefish	Inner Shark Bay Demersal (Snapper)	Periodic: Level 5 2015	Sustainable: Adequate	Commercial: 3.8t Eastern Gulf (EG), 3.8t Denham Sound (DS), 1.2t Freycinet Estuary (FE) Recreational: 11.2t EG, 11.2t DS, 3.8t FE	Commercial: <0.5t Charter: <0.5t EG, 1.1t DS, 1t FE Recreational: 2.1t EG (95% CI 0.8–3.4t), 4.6t DS (95% CI 3.4-5.9t), 11.5t FE (95% CI 4.3-18.7t) (boat only, assumed same as in 2018)	Not Acceptable Commercial: NA Incidental catch. Recreational: Not Acceptable Catch in Freycinet above acceptable range.
North Coast Bioregion						
Northern Invertebrates	Onslow Prawn Managed Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 60–180t Recreational: NA	Commercial: <60t	Acceptable Commercial: Low effort in 2020.
Northern Invertebrates	Nickol Bay Prawn Managed Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 90–300t Recreational: NA	Commercial: 202t	Acceptable
Northern Invertebrates	Broome Prawn Managed Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 55–260t Recreational: NA	Negligible	NA Commercial: Minimal fishing occurred in 2020.
Northern Invertebrates	Kimberley Prawn Managed Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 240–500t Recreational: NA	Commercial: 253t	Acceptable
Northern Estuarine and Nearshore Scalefish and Invertebrates	Kimberley Gillnet and Barramundi Managed Fishery	Annual: Level 2	Sustainable: Adequate	Commercial: 33–44t (barramundi) Recreational: Not formal	Commercial: 34t (barramundi) 45t (total) Recreational: 15–26t (95% CI, boat only in 17/18, top 10 species)	Acceptable Commercial: Catch at the low end of range and the catch rate remains high. Recreational: Catch levels considered appropriate.

Resource	Fishery	Assessment level	Breeding stock assessment	Catch (and effort) range	Catch, effort and catch rate for season reported[1,2]	Catch (or effort or catch rate) level acceptable and explanation if needed
Northern Demersal Scalefish	Northern Demersal Scalefish Managed Fishery	Annual: Level 2 Periodic: Level 5 – 2018	Sustainable: Adequate	Commercial: 440–533t (goldband snapper) 121–154t (red emperor) Catch range review in progress Recreational: Not formal	Commercial: 1419t (total) 630t (goldband snapper – not including other jobfish) 144t (red emperor) Recreational: 63–88t (95% CI, boat only in 17/18, top 10 species)	Acceptable Commercial: Acceptable Recreational:Acceptable Catch levels are combined for Kimberley and Pilbara.
Northern Demersal Scalefish	Pilbara Fish Trawl (Interim) Managed Fishery	Annual: Level 2, 3 Periodic: Level 5 – Underway	Sustainable: Adequate	Commercial: 136-244t (red emperor, combined trawl, trap and line) Recreational: NA	Commercial: 2087t (all species, trawl) 216t (red emperor, combined trawl, trap and line)	Acceptable Commercial: Acceptable Combined trawl, trap and line commercial catch of indicator species red emperor within acceptable range.
Northern Demersal Scalefish	Pilbara Demersal Trap Managed Fishery and Pilbara Line Fishery	Annual: Level 2, 3 Periodic: Level 5 – Underway	Sustainable: Adequate	Commercial: 136-244t (red emperor, combined trawl, trap and line) Recreational: NA	Commercial: 584t (all species, trap) 167t (all species, line) 216t (red emperor, combined trawl, trap and line)	Acceptable Commercial: Acceptable Combined trawl, trap and line commercial catch of indicator species red emperor within acceptable range
Statewide Large Pelagic Scalefish	Mackerel Managed Fishery	Annual: Level 2	Sustainable: Adequate	Commercial: 246–430t (Q, Spanish Mackerel) Recreational: Not formal	Commercial: 290t Recreational: 87–121t (95% CI, boat only in 17/18, top 10 species)	Acceptable Commercial: Nominal catch rate increased but low in areas 2 and 3. Recreational: Catch levels remain appropriate. Recent charter/FTO catch very low due to COVID19.
Northern Shark	Northern Shark Fishery	No assessment	NA	<20t (sandbar)	0	NA No fishing since 2008/09.
Pearl Oyster (P. maxima)	Pearl Oyster Wildstock Fishery (MSC)	Annual: Level 4	Sustainable: Adequate	Commercial 786,170 oysters (Q) (14,071–20,551 dive hours) Recreational: NA	Commercial: 455,980 oysters (7,942 dive hours)	Acceptable Commercial: Catch below quota as COVID-19 issues reduced fishing. Catch rates increased from 2018 to 2020.
Statewide Hand Collection	Western Australian Sea Cucumber Fishery (MSC)	Annual: Level 2	Sustainable: Adequate	Commercial: Sandfish (Kimberley) 0–100t Sandfish (Pilbara) 0–80t Redfish 0–150t Recreational: NA	Commercial: Sandfish (Kimberley): 0t Sandfish (Pilbara): 0t Redfish:0t	Acceptable No fishing due to planned rotational harvest schedule by industry.
South Coast Bioregion						
South Coast and West Coast Crustacean	South Coast Crustacean Managed Fishery (includes old Windy Harbour, Augusta Fishery)	Annual: Level 2	Sustainable: Adequate	Commercial: 50–80t (southern rock lobster) Recreational: NA	Commercial: 19.4 t (southern rock lobster)	Not Acceptable Commercial: Catch below acceptable range. The stock status is currently being reviewed.

Resource	Fishery	Assessment level	Breeding stock assessment	Catch (and effort) range	Catch, effort and catch rate for season reported[1,2]	Catch (or effort or catch rate) level acceptable and explanation if needed
Statewide Abalone	Abalone (Greenlip/ Brownlip) Managed Fishery (MSC)	Annual: Level 3	Inadequate	Commercial: 54t (Q) (3440–5270 hours) Recreational: Not formal	Commercial: 36t (1421 hours) Recreational: 8t	Not Acceptable Commercial: Catch below TACC due to commercial industry decisions. TACC reduced to 49t and spatial closures added for the 2021 season. Recreational: Catch levels still not considered a risk to stocks.
South Coast Estuarine and Nearshore Scalefish and Invertebrates	South Coast Estuarine Managed Fishery South Coast Open Access Net Fishery South Coast Herring Trap (closed) South Coast Salmon Managed Fishery South Coast Oceanic Fish Trap Fishery (FBL Condition 74) King George Sound Fish Trap Fishery (Condition 192)	Annual: Levels 1 and 2. Periodic: Levels 3 and 4 Herring – 2017 Salmon – 2017 Cobbler – 2018	Sustainable: Recovering– Cobbler in Wilson Inlet, Herring (State) Sustainable: Adequate – Salmon (State)/ Mullets/ Bream/Whitings	Commercial: Under revision (South Coast Review) Recreational: Not formal	Commercial: 220t (South Coast estuaries fish cal year), 13.4t (South Coast estuaries crab fin year) 110tt (South Coast nearshore) Recreational: finfish 17–35t (95% CI, boat only in 17/18, top 10 species)	NA Commercial: Low Salmon catch due to low effort from limited market demand. Recreational: Catch levels are not considered a risk to stocks. Review of acceptable catch ranges is required.
Statewide Small Pelagic Scalefish (Purse Seine)	Albany/King George Sound Purse Seine	Annual: Level 1	Sustainable: Adequate	Commercial: 2683t (Q) Recreational: NA	Commercial: 818t	Acceptable
Statewide Small Pelagic Scalefish (Purse Seine)	Bremer Bay and Esperance Purse Seine	Annual: Level 1	Sustainable: Adequate	Commercial: 3000t (Q) Combined Recreational: NA	Commercial: 680t	Acceptable Commercial catch below conservatively set quota.
South Coast and West Coast Demersal Finfish	Temperate Demersal Gillnet and Demersal Longline Joint Authority Southern Demersal Gillnet and Demersal Longline Fishery	Annual: Level 1 Periodic: Gummy and whiskery: Level 5 – 2017 Dusky and sandbar: Level 4 – 2017	Sustainable: Adequate– Gummy and whiskery Sustainable: Recovering– Dusky and sandbar	Commercial: shark 725–1095t Recreational: NA	Commercial: 655t (key species only) 774t (total sharks and rays)	Acceptable Relative lower catches in 2019-20 attributed to a lower effort. Standardised catch rates remain stable for the key shark species.
South Coast and West Coast Demersal Finfish	South Coast Line and Trap	Annual: Level 1 Periodic: Level 3 – 2014	Sustainable: Adequate	Commercial: Under development Recreational: Not formal	Commercial: 201t Recreational: 59-77t (95% CI, boat only in 17/18, top 10 species)	Acceptable Current commercial and recreational catch levels are at acceptable levels.
Northern Inland Bioregion						
Northern Inland Freshwater Scalefish and Invertebrates	Lake Argyle Silver Cobbler Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 93–180t Recreational: NA	Commercial: Not reportable	Acceptable Commercial: Catch is below acceptable level due to reduced effort.

Resource	Fishery	Assessment level	Breeding stock assessment	Catch (and effort) range	Catch, effort and catch rate for season reported[1,2]	Catch (or effort or catch rate) level acceptable and explanation if needed
Southern Inland Bioregion						
South and West Coast Inland Freshwater Resource	South West Recreational Freshwater Angling Fishery Recreational Marron Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: NA Recreational: 50,000–100,000 (marron) 50,000–120,000 (fish)	55,668marron (± 3,696se) 104,319 fish (±10,125se)	Acceptable Catch within acceptable range since 2003. Review of acceptable catch ranges is required.

1. Commercial and recreational catch figures supplied for latest year/ season available.
2. Where there are three or less licences operating in the fishery annual catch levels are not reported due to confidentiality requirements.

WEST COAST BIOREGION

ABOUT THE BIOREGION

The marine environment of the West Coast Bioregion between Kalbarri and Augusta is predominantly a temperate oceanic zone. However, it is heavily influenced by the Leeuwin Current, which transports warm tropical water southward along the edge of the continental shelf. The Integrated Marine and Coastal Regionalisation for Australia (IMCRA V 4.0) scheme divides this Bioregion into three meso-scale regions: Abrolhos Islands, Central West Coast and Leeuwin-Naturaliste (West Coast Overview Figure 1).

Most of the fish stocks of the region are temperate, in keeping with the coastal water temperatures that range from 18° C to about 24° C. The Leeuwin Current is also responsible for the existence of the Abrolhos Islands coral reefs at latitude 29° S and the extended southward distribution of many tropical species along the West Coast and even into the South Coast. Some species have appeared to form self-sustaining populations in this Bioregion.

The Leeuwin Current system, which can be up to several hundred kilometres wide along the West Coast, flows most strongly in autumn/winter (April to August) and has its origins in ocean flows from the Pacific through the Indonesian archipelago. The current is variable in strength from year-to-year, typically flowing at speeds around 1 knot, but has been recorded at up to 3 knots on occasions. The annual variability in current strength is reflected in variations in Fremantle sea levels, and is related to *El Niño* or Southern Oscillation events in the Pacific Ocean.

Weaker counter-currents on the continental shelf (shoreward of the Leeuwin Current), such as the Capes Current that flows northward from Cape Leeuwin as far as Shark Bay, occur during summer and influence the distribution of many of the coastal finfish species.

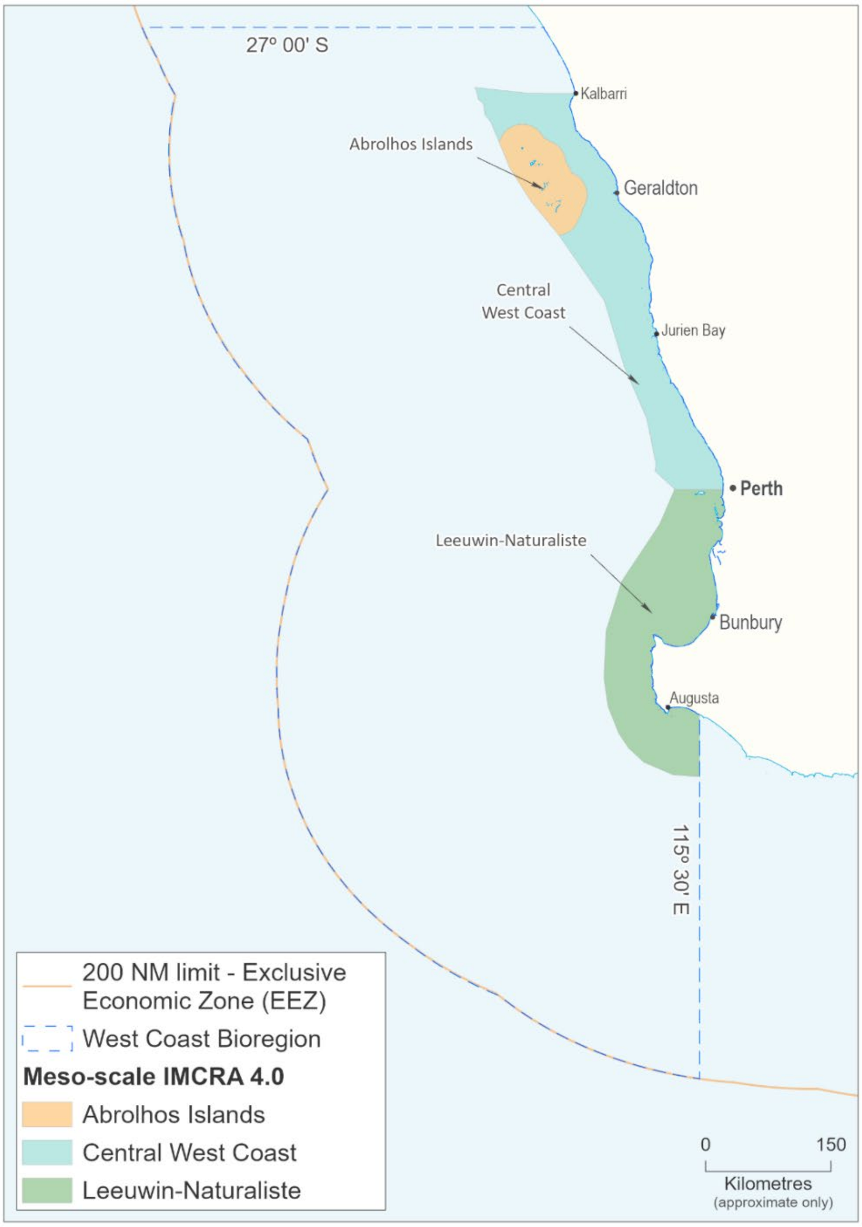
The most significant impact of the clear, warm, low-nutrient waters of the Leeuwin Current is on the growth and distribution of the temperate seagrasses. These form extensive meadows in protected coastal waters of the West Coast Bioregion, generally in depths of less than 20 m (but up to 30 m), and act as major nursery areas for many fish species and particularly for the western rock lobster stock.

The West Coast is characterised by exposed sandy beaches and a limestone reef system that creates surface reef lines, often about 5 kilometres off the coast. Further offshore, the continental shelf habitats are typically composed of coarse sand interspersed with low limestone reef associated with old shorelines. There are few areas of protected water along the west coast, the exceptions being within the Abrolhos Islands, the leeward sides of some small islands off the Midwest Coast, plus behind Rottnest and Garden Islands in the Perth metropolitan area.

The two significant marine embayments in the West Coast are Cockburn Sound and Geographe Bay. Along the West Coast, there are 4 significant estuarine systems – the Swan/Canning, Peel/Harvey and Leschenault estuaries and the Hardy Inlet (Blackwood estuary). All of these are permanently open to the sea and form an extension of the marine environment except when freshwater run-off displaces the oceanic water for a short period in winter and spring.

Southward of Cape Naturaliste, the coastline changes from limestone to predominantly granite and becomes more exposed to the influences of the Southern Ocean.

The ecosystem boundaries as defined by IMCRA (V 4.0) in the bioregion are depicted in West Coast Overview Figure 1. The potential threats and risks to these ecosystems are often similar. For simplicity, risk ratings were allocated by grouping the ecosystems into two broad groups, estuarine or marine. However, if a particular ecosystem is unique and/or is exposed to different or significant threats, risk was allocated to these ecosystems separately.



WEST COAST OVERVIEW FIGURE 1
Map showing the three main IMCRA (V4.0) ecosystems in the West Coast Bioregion: Abrolhos Islands; Central West Coast and the Leeuwin-Naturaliste.

SUMMARY OF ACTIVITIES POTENTIALLY IMPACTING THE BIOREGION

Climate Change

Some of the key environmental trends that may be affecting ecosystems in WA include:

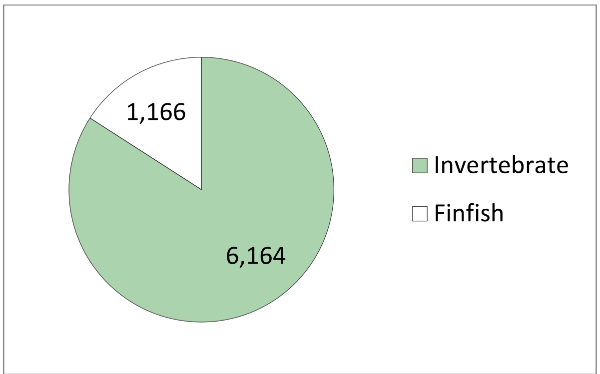
- Increasing frequency of El Niño/Southern Oscillation (ENSO) events;
- More years with a weaker Leeuwin Current;
- Increases in water temperature off the west coast of WA, particularly the lower west coast;
- Increase in salinity, which includes some large annual fluctuations;
- Change in the frequency and location of storms (and rainfall) affecting the lower west coast; and
- Change in the frequency of cyclones (and summer rainfall) affecting the west coast.

The West Coast Bioregion is predicted to be at enhanced risk from the effects of climate given that it spans a transitional zone between tropical and temperate regions. The variables expected to drive climate change impacts include changes in water temperature, ocean currents, winds, rainfall, sea level, ocean chemistry and extreme weather conditions.

It is apparent that climate change will impact the biological, economic, and social aspects of many fisheries, and both positive and negative impacts are expected. Climate change can influence biological systems by modifying the timing of spawning, range and distribution of species, composition and interactions within communities, exotic species invasions and impacts, and the structure and dynamics of communities, including changes in productivity. Species distribution shifts are the most commonly reported changes and are often the easiest to recognise and measure. Changes in the distribution of key species are monitored in a national citizen-science program (www.redmap.org.au) in which the Department is a collaborator.

Commercial Fishing

The commercial catch is dominated by invertebrates (see West Coast Overview Figure 2). The principal commercial fishery in this region is the western rock lobster fishery, which has historically been Australia's most valuable single-species wild capture fishery. There are also significant commercial fisheries for other invertebrates including scallops, abalone, blue swimmer crabs and octopus that use trawl, diving and potting methods. Commercial fishers also take a range of finfish species including sharks, West Australian dhufish, snapper, baldchin groper and emperors using demersal line and net methods. Beach-based methods such as beach seining and near-shore gillnetting, and hand-hauled nets are used to capture whitebait, mullet and whiting in a very restricted number of locations.

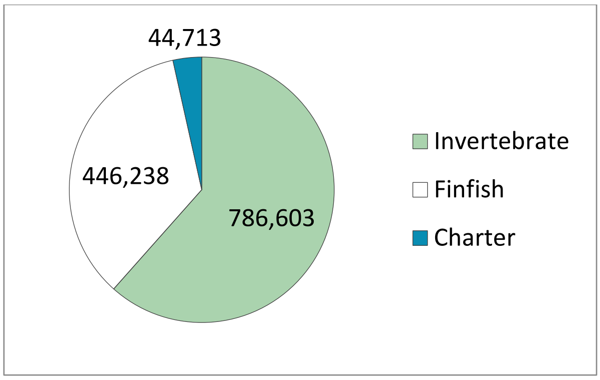


WEST COAST OVERVIEW FIGURE 2
Contribution of finfish and invertebrates to the total commercial wild fishery catch originating from the West Coast Bioregion. Numbers represent total catch (in tonnes) based on all major assessed fisheries identified in the Overview section of this report (see Overview Table 7).

Recreational Fishing

The West Coast Bioregion, which contains the state's major population centres, is the most heavily used bioregion for recreational fishing (including charter based fishing). The range of recreational fishing opportunities includes estuarine fishing (both shore- and boat-based), beach fishing and boat fishing either in embayments or offshore for demersal and pelagic/game species often around islands and out to the edge of the continental shelf. The recreational catch is dominated by invertebrates (West Coast Overview Figure 3).

Vessel retrievals from key boat ramps have been monitored using remote cameras for previous state-wide surveys[1], The typical seasonal pattern of vessel retrievals at Hillarys and Woodman Point was not observed during the early stages of COVID-19 restrictions from March to August 2020[2].



WEST COAST OVERVIEW FIGURE 3
Recreational catches (by number) in the West Coast Bioregion. Finfish and invertebrate catches were assessed in the statewide survey of boat-based recreational fishing in 2017/18[1]. Charter boat catch is for the same period. Estimates of shore based recreational catch are unavailable.

Aquaculture

The principal aquaculture development activities in the West Coast Bioregion is the emerging black pearl industry based on the production of *Pinctada margaritifera* at the Abrolhos Islands. Initiatives to expand the number of aquaculture sectors in this bioregion currently include those for rock oysters and finfish. Further, the Department has established a Mid-West Aquaculture Development Zone which aims to provide a platform to stimulate aquaculture investment and development in the bioregion. There has been small-scale production of yellowtail kingfish near Geraldton and some interest in offshore production in the Aquaculture Zone. Government supports establishment of a marine finfish nursery at Geraldton to underpin

1 Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia.

2 Ryan KL, Desfosses CJ, Denham AM, Taylor SM, Jackson, G. 2021. Initial insights on the impact of COVID-19 on boat-based recreational fishing in Western Australia. Marine Policy 132: 104646

growth of that sector. Planning for the nursery has been impacted by the COVID-19 pandemic with some aspects of the project requiring review.

Tourism

The State capital, Perth, is the principal gateway for more than two million visitors to Western Australia each year (normally) and a major international transit point for travellers arriving in Australia from Europe and Asia. The south-west of the state is also an important tourism destination for international and interstate visitors, as well as for Western Australian residents. However, tourism numbers were affected by COVID-19 restrictions in place during 2020. Beach-going is among the most popular leisure activities for tourists in the West Coast Bioregion. Surfing, fishing, SCUBA diving and snorkelling, windsurfing, whale watching and other marine wildlife experiences are also popular tourist activities.

Shipping and Maritime Activity

The West Coast Bioregion contains several major port facilities, including the State's busiest general cargo port (Fremantle), a potential land backed port (Westport) in Kwinana, as well as the Royal Australian Navy's largest base (HMAS Stirling) on Garden Island. In addition to handling most of Western Australia's container trade, significant quantities of non-containerised cargo pass through Fremantle, including: motor vehicles, steel and machinery imports, livestock exports and bulk commodities, such as petroleum, grain, alumina, iron ore, mineral sands, fertilisers and sulphur. Two other major commercial ports at Bunbury and Geraldton, primarily export iron ore, grain, mineral sands and alumina. Prior to COVID-19, international cruise ship visitations had increased and some cruise liners were home-based in Fremantle.

Major shipbuilding, repair, maintenance and offshore construction support industries are also located at Henderson in the north-eastern corner of Cockburn Sound. Collectively, these enterprises directly employ over 2,000 people, indirectly support thousands of more jobs and generate significant economic activity.

There are a number of smaller ports (e.g. Augusta, Busselton) and a large number of public boat ramps and marinas in the Bioregion.

The impacts from vessels and ships tend to be concentrated around ports and favoured anchorage areas. Impacts include physical damage to the habitat, small pollution incidents and the potential to introduce and spread marine pest species. The Department has surveillance in place for marine pests in key port areas to aid in the early detection of any unwanted aquatic species from other locations.

Other Activities

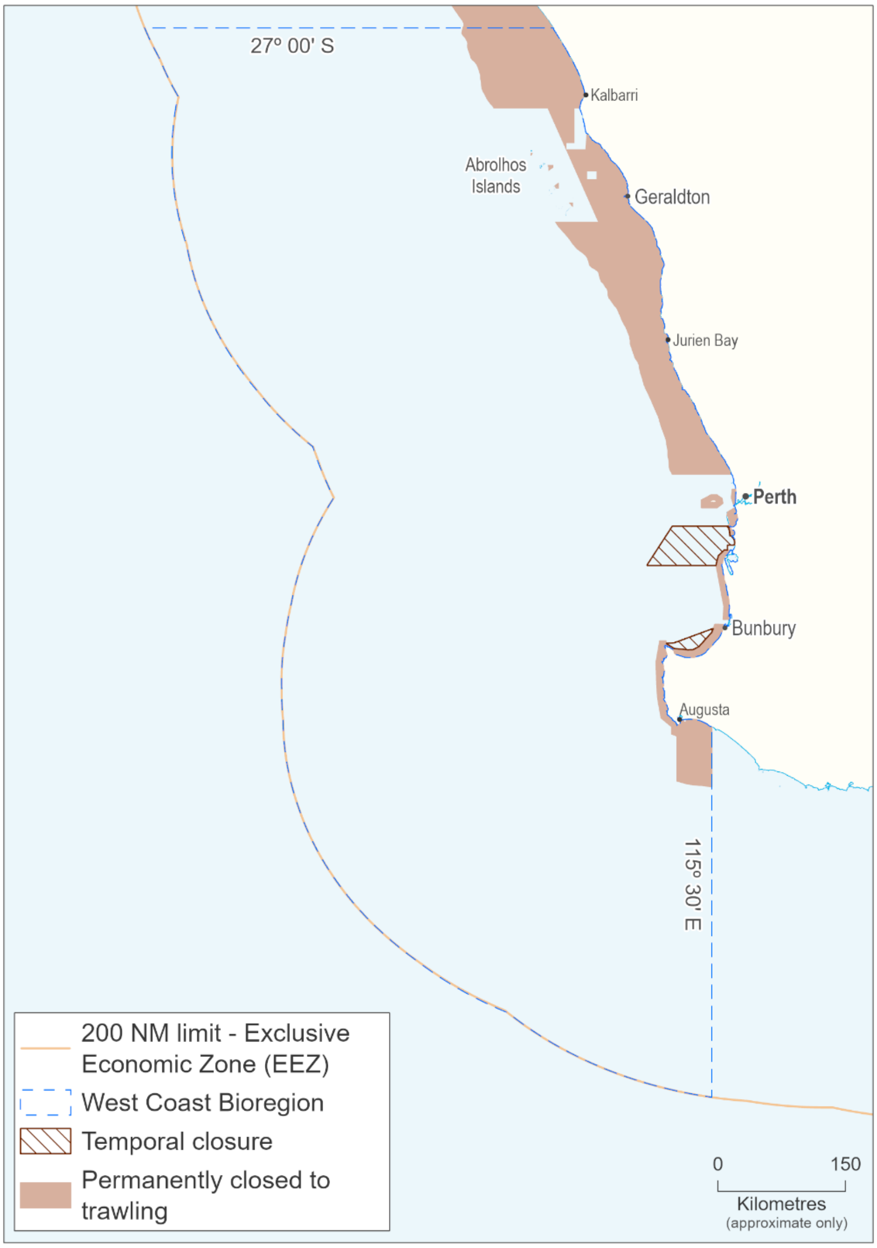
High rates of population growth and boat ownership in Western Australia have strained recreational boating facilities around major population centres, particularly in the Perth metropolitan region. New and upgraded marinas and boat launching facilities have been completed or are planned to accommodate this demand. In addition, major coastal infrastructure developments have been planned including the Westport Harbour in Kwinana and a deep-water port at Oakajee, 24 km north of Geraldton. Two large desalination plants at Kwinana and Binningup (22km North of Bunbury), which supply approximately half of Perth's freshwater requirements, also operate in the bioregion. Approval has been sought to develop two additional desalination plants in the metropolitan region, which may develop if the population grows and water demands increase.

BIOREGIONAL SPECIFIC ECOSYSTEM MANAGEMENT

Within each Bioregion there are a range of management measures that have been implemented to manage the potential impact of activities. Management measures specific to the West Coast Bioregion include:

Spatial Closures

The marine benthic habitats and their associated biodiversity along most of the West Coast are largely protected from any physical impact of commercial fishing due to the extensive closures to trawling. These closures inside 200 m depth were introduced in the 1970s and 1980s, in recognition of the significance of extensive areas of seagrass and reef as fish habitat (West Coast Overview Figure 4). Demersal gillnet and longline fishing was also prohibited from waters inside the 250 m isobath between 31^0 and 33^0 South from November 2007. The extent of these areas means that most of the West Coast Bioregion inside 200 m depth can be classified as one of the marine protected area International Union for the Conservation of Nature (IUCN) categories (West Coast Overview Table 1).



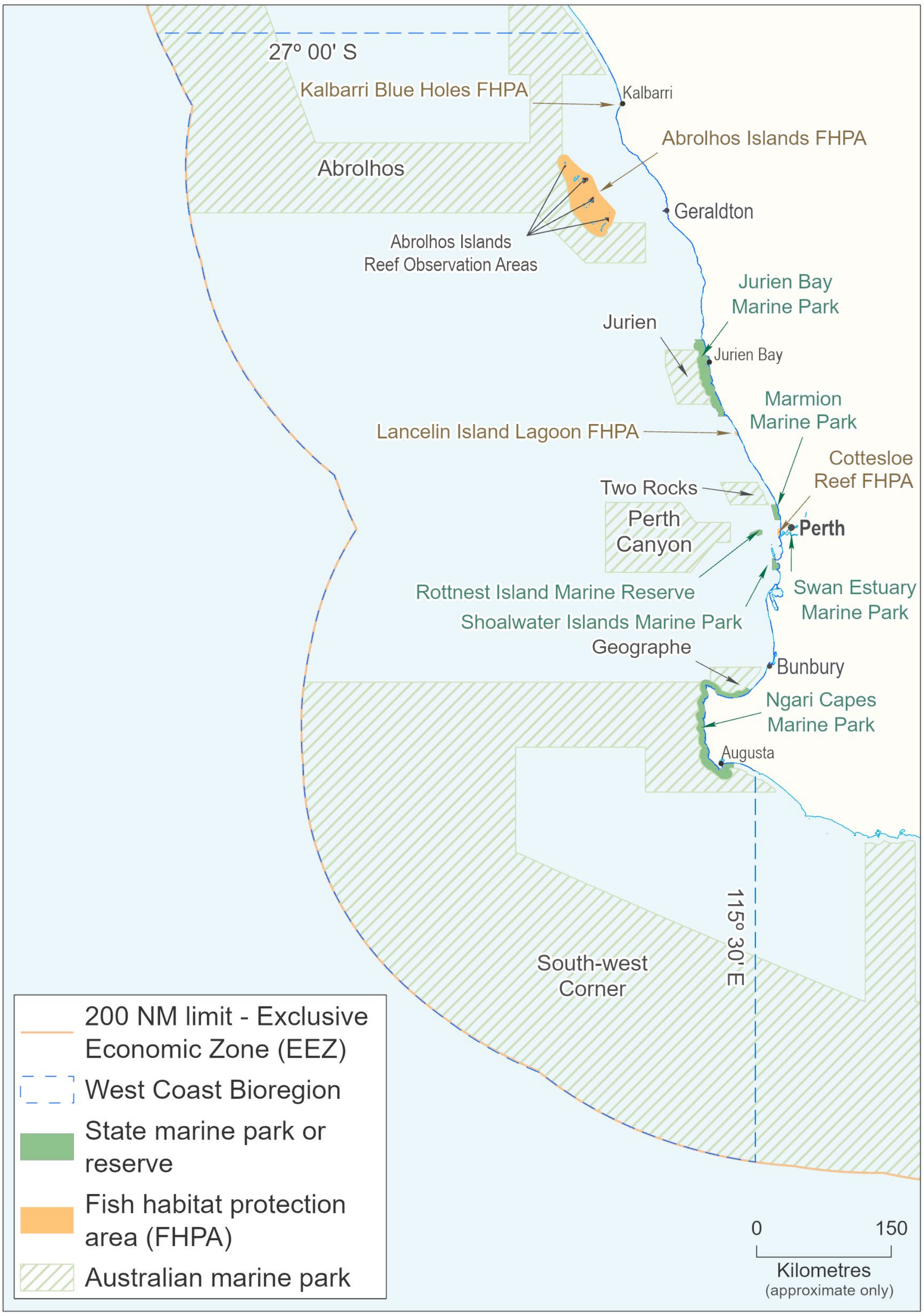
WEST COAST OVERVIEW FIGURE 4
Map showing areas of permanent and extended seasonal closures to trawl fishing in the West Coast Bioregion. The areas permanently closed are consistent with IUCN marine protected area category IV.

WEST COAST OVERVIEW TABLE 1
The areas and proportions of the West Coast Bioregion making up State Waters and all continental shelf waters, out to 200 m depth, which meet the IUCN criteria for classification as marine protected areas. This table does not yet include the closures that may be implemented by the Commonwealth as part of their marine planning zones (see next Figure).

IUCN category or equivalent	State Waters only ($10,088\ km^2$)				All Waters ($481,488\ km^2$ (including State Waters))			
	Fisheries		Existing MPA		Fisheries		Existing MPA	
	km^2	%	km^2	%	km^2	%	km^2	%
I	0	0	0	0	0	0	0	0
II	1	< 1	171	2	1	< 1	171	< 1
III	0	0	0	0	0	0	0	0
IV	4,500	44	1,900	19	33,600	7	1,900	< 1
V	0	0	0	0	0	0	0	0
VI	3,400	34	116	1	445,700	93	116	< 1

Protection of fish habitat and biodiversity is also provided by marine protected areas consistent with IUCN categories of I, II and III along the West Coast including: Fish Habitat Protection Areas (FHPAs) at the Abrolhos Islands, Lancelin Island Lagoon, Cottesloe Reef, and Kalbarri Blueholes; Reef Observation Areas within the Abrolhos Islands FHPA and closures to fishing under Section 43 of the *Fish Resources Management Act* 1994 at Yallingup Reef, Cowaramup Bay, the Busselton Underwater Observatory and around the wrecks of the *Saxon Ranger* (Shoalwater Bay), HMAS *Swan* (Geographe Bay) and *Lena* (Off Bunbury). In addition, marine conservation areas proclaimed under the *Conservation and Land Management Act* 1984 exist at Jurien Bay, Marmion, Swan Estuary, Shoalwater Islands, and Ngari Capes Marine Park between Cape Leeuwin and Cape Naturaliste and the Rottnest Island Marine Reserve. (West Coast Overview Figure 5).

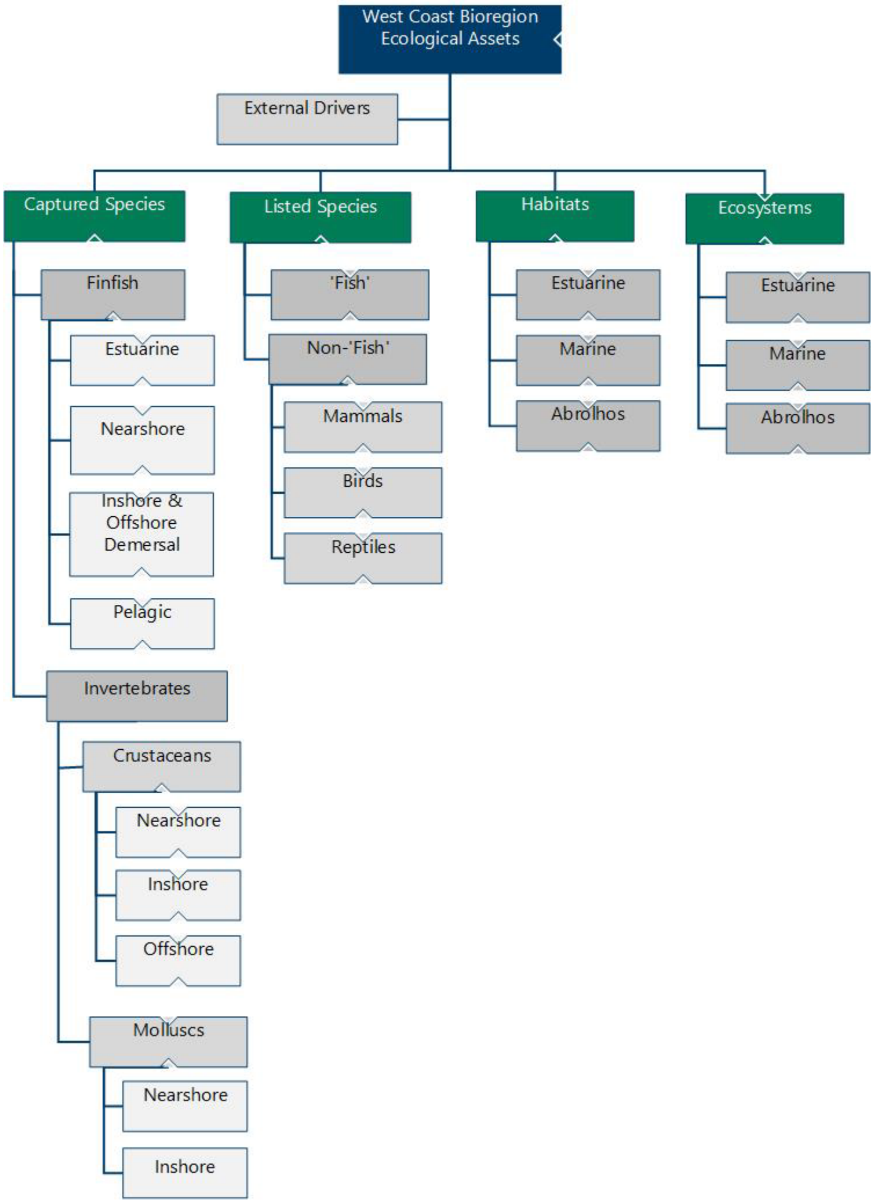
The Commonwealth Government has also implemented its Marine Bioregional Plans for Commonwealth waters between Kangaroo Island (South Australia) and Shark Bay, which includes a number of marine Protected Areas in the West Coast Bioregion (West Coast Overview Figure 5).



WEST COAST OVERVIEW FIGURE 5
Map showing current marine protected areas in the West Coast Bioregion.

ECOSYSTEM MONITORING AND STATUS

In order to assess the adequacy of management arrangements aimed at ensuring sustainability of the ecological assets within the West Coast Bioregion, the Department must identify and monitor trends in the condition of these resources. This is achieved through application of an Ecosystem Based Fisheries Management (EBFM) framework (see How to use this Volume for more information) to identify, in a hierarchical manner, the key ecological resources that require ongoing monitoring and assessment. These key ecological assets identified for the West Bioregion are identified in West Coast Overview Figure 6 and their current risk status reported on in the following sections.



WEST COAST OVERVIEW FIGURE 6
Component tree showing the ecological assets identified and separately assessed for the West Coast Bioregion.

External Drivers

External drivers include factors impacting at the bioregional-level that are likely to affect the ecosystem as a whole and may not fall within the direct control of Fishery legislation (e.g. climate change). An understanding of these factors, which are typically environmental (e.g. ocean currents), is necessary to fully assess the performance of the ecological resource. The main external drivers identified with potential to affect the West Coast Bioregion include climate and introduced pests and diseases.

Climate

External Drivers	Current Risk Status
Climate	HIGH (long term)

The south west of Western Australia is predicted to be heavily influenced by the impacts of climate change (e.g. increasing sea temperatures, declines in rainfall). Some climate change information has been taken into account in the rock lobster stock assessment process and the effect of the marine heat wave in 2010/11[1,2,3] on fisheries has been assessed but further information is required to examine potential impacts on this bioregion.

Captured Species

FINFISH

Estuarine

Captured Species	Aquatic zone	Ecological Risk
Finfish	Estuarine	HIGH (non-fishing)

Stock status is variable among species. There is concern for species within estuaries (e.g. Perth herring) in the West Coast Bioregion mainly due to external (non-fishing) factors (e.g. poor water quality, reduced water flows, water diversion, other environmental factors).

Peel-Harvey sea mullet holds MSC certification for the commercial fishery.

Nearshore

Captured Species	Aquatic zone	Ecological Risk
Finfish	Nearshore	HIGH

Concerns for status of a range of nearshore species including Australian herring, southern garfish and whitebait, have resulted in additional management actions being implimented, which remain in place.

Inshore and Offshore Demersal

Captured Species	Aquatic zone	Ecological Risk
Finfish	Inshore and Offshore Demersal	MEDIUM

Following assessments of inshore demersal indicator species (West Australian dhufish, pink snapper, baldchin groper), management actions were implemented to reduce both the commercial and recreational catch levels by 50% of their 2005/06 levels. Based on assessments of indicator stocks this resource is considered to be in a recovery phase. While the deep-water indicator species are vulnerable to overfishing, current catch levels are low and therefore the stocks are not at risk.

The risk rating for this asset is in part due to the high degree of social amenity these stocks provide for local recreational and commercial sectors, the resultant fishing pressure applied to them and the need for increased management action on the recreational catch for pink snapper and baldchin groper.

Pelagic

Captured species	Aquatic zone	Ecological Risk
Finfish	Pelagic	LOW

There is minimal capture of pelagic fish in this bioregion, with most emphasis focussed on Samsonfish by recreational anglers.

INVERTEBRATES

Crustaceans

Captured species	Aquatic zone	Ecological Risk
Crustaceans (Crabs)	Estuarine/ Nearshore	MEDIUM
Crustaceans (Lobsters)	Inshore	LOW

The stocks of crabs in Cockburn Sound are currently considered to be “Environmentally Limited”. Recruitment and breeding stock levels have improved in 2020, however they remain below the limit reference level of the harvest strategy and the fishery remains closed. It is unlikely that the stock will return to historical high levels, mainly as a result of changing environmental conditions (e.g. decline in nutrients and primary production).

Assessment of other crab stocks in this region (e.g. Peel Harvey) has been completed and all are considered to be in an adequate state and fishing levels are acceptable. Both the commercial and recreational sectors of the Peel-Harvey crab fishery are MSC certified. The stock levels of western rock lobster are currently at appropriate levels. Ongoing strong management that was applied to the rock lobster fishery has ensured that the lobster spawning stock is currently at near record high levels. The Western Rock Lobster fishery has maintained MSC certification since 2000.

1 Pearce, A., Lenanton, R., Jackson, G., Moore, J., Feng, M. and Gaughan, D. 2011. The “marine heat wave” off Western Australia during the summer of 2010/11. Fisheries Research Report No. 222. Department of Fisheries, Western Australia. 40pp;

2 Caputi, N., Jackson, G. and Pearce, A. 2014. The marine heat wave off Western Australia during the summer of 2010/11 – 2 years on. Fisheries Research Report No. 250. Department of Fisheries, Western Australia. 40pp.

3 Caputi, N., Feng, M., Pearce, A., Benthuysen, J., Denham, A., Hetzel, Y., Matear, R., Jackson, G., Molony, B., Joll, L. and Chandrapavan A. (2015). Management implications of climate change effect on fisheries in Western Australia, Part 1: Environmental change and risk assessment. FRDC Project No. 2010/535. Fisheries Research Report No. 260. Department of Fisheries, Western Australia. 180pp.

Molluscs

Captured species	Aquatic zone	Ecological Risk
Molluscs (Abalone)	Nearshore	MEDIUM
Molluscs (Scallops)	Inshore	MEDIUM

The stocks of abalone are conservatively managed with strong management controls on both commercial and recreational fishers. However, the marine heat wave in 2010/11 caused the almost total loss of Roes abalone in the Kalbarri region and that region has consequently been closed since 2011/12.

The stock of scallops is considered sustainable with pre-season surveys showing a further improvement in the distribution of scallop abundances over the historical fishing grounds.

Listed species

A variety of endangered, threatened and protected[1] (ETP) species can be found within the West Coast Bioregion, including cetaceans, pinnipeds, elasmobranchs, seahorses and pipefish and sea/shore birds. These species are protected by various international agreements and national and state legislation. Primary pieces of legislation include the *Commonwealth Environment Protection and Biodiversity Conservation Act* 1999, the *Western Australian Wildlife Conservation Act* 1950, and the *Fish Resources Management Act* 1994.

Fish

Listed species	Ecological Risk
Fish	MEDIUM

Grey nurse shark (*Carcharias taurus*) is protected under State and Commonwealth legislation throughout this and all bioregions. Blue groper (Rottnest Island) and baldchin groper (Abrolhos Islands FHPA between 1 November and 31 January) cannot be landed by commercial or recreational fishers in the particular areas and periods.

Non-Fish

Listed species	Ecological Risk
Mammals	LOW
Birds and Reptiles	HIGH

Fisher et al. (2020[2]), reported a high risk score for the migratory and threatened shorebird species that inhabit Peel-Harvey Estuary during the summer months, when there is potential for feeding and roosting birds to be disturbed by recreational scoop net fishers in key areas of overlap. As part of the MSC assessment process, the impacts of recreational crabbing in Peel Harvey Estuary on migratory ETP shorebirds is being assessed in more detail.

The West Coast Bioregion lies to the south of most marine turtles' distributions and, thus, there are minimal risks to turtles from fishing activities within this bioregion. The trawl fishery that operates around the Abrolhos Islands uses bycatch reduction devices, which are effective at minimising the capture of turtles.

Sea lion exclusion devices (SLEDs) have now been implemented for rock lobster pots near Australian sea lion breeding colonies. Demersal gillnet fishing effort in the West Coast Bioregion, which has historically been responsible for a very small number of reported sea lion captures, is now less than 10% of its peak level of the late 1980s.

Regulated modifications to rock lobster fishing gear configuration during humpback and southern right whales' northerly winter migration have successfully reduced entanglement rates by ~60% in recent years. Thus, risks to whales from fishing activities in the West Coast Bioregion have decreased in recent years but are not yet considered to be low due to the social value (and therefore risk) around whales.

Habitats and Ecosystems

Due to the counter-acting Leeuwin and Capes Currents, the West Coast Bioregion has the unique characteristic of containing tropical, sub-tropical and temperate ecosystems. The key habitats occurring in depths of less than 40 m (where the vast majority of relevant fisheries resources are located and fishing activities are undertaken in this bioregion) include:

Algae: Along the WCB, algae attach to intertidal and subtidal rocky substrata and in turn, are habitat to a variety of organisms. Algal assemblages contribute to marine nutrient and carbon cycling are also an important as a food source, nursery grounds and shelter for a variety of organisms. Along the WCB, there is a gradual transition from a subtropical flora of the Abrolhos Islands and north of Geraldton to a cold-temperate flora found along the southwest corner and south coast of WA. Macroalgae along the southwestern and southern coasts of Australia are very diverse, with a high level of endemism.

Sand: The majority of seabed of the WCB is composed of soft, unconsolidated sediments. These sediments provide an important habitat for microalgae and benthic infauna.

1 Note that listed species does not automatically indicate that a species is either threatened or endangered.

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

Seagrasses: In temperate WA, seagrasses occupy approx. 20 000 km^2 of shallow coastal waters and grow predominantly on sand from 1 – 35 m depth, but also on deep rock to over 50 m deep. Seagrasses provide habitat for many fish and crustacean species, stabilise coastal sediments and prevent coastal erosion. In addition, seagrasses are also important for primary production, CO_2 uptake and nutrient cycling. The diversity of seagrasses in temperate south-western Australia is the highest for any temperate region, with 17 species within WCB and SCB combined.

Corals: Due to the cool temperate waters corals are not common in the WCB with the exception of the Abrolhos Islands, which are located offshore and are more exposed to the warm Leeuwin Current. The Abrolhos Islands are well-known for their high species diversity, coral reefs and unique mixture of temperate and tropical species. Currently there are 184 known coral species at the Abrolhos. Elsewhere in the WCB corals occur in patches around offshore islands, usually comprised of only a few species.

Sponges: In southwestern Australia, sponges are found in areas where algae are less dominant, including shallow waters, areas deeper than 30 m, and caves. As they are sessile filter-feeders, sponges flourish in areas of high current, although large sponges are also found in calmer deeper waters. In areas with an absence of reef-building corals, sponges function as large epibenthos that form the three-dimensional structure of subtidal reefs providing shelter for other organisms, such as worms, crustaceans, echinoderms, molluscs and fish.

Habitats

Habitats	Aquatic zone	Current Risk Status
West Coast Habitat	Estuarine	HIGH (non-fishing)
West Coast Habitat	Marine	LOW
Abrolhos Islands	Marine	MEDIUM

The West Coast is a micro-tidal, relatively high-energy area, with clear water and few rivers. The coastline is characterised by long beaches with occasional limestone cliffs and headlands, with offshore limestone islands and reef complexes. There are numerous protected marine areas in the West Coast (West Coast Overview Figure 5). Spatial zoning restricts activities within these areas, including preventing trawling.

Peel-Harvey Estuary habitats are under pressure due to poor water quality as a result of farming, canal development and urbanisation in the surrounding catchment. Fisher et al. (2020[1]), assessed the impacts of fishing on the various habitats in Peel Harvey Estuary as being either negligable or low. Cockburn Sound, which contains large areas of seagrass, has been mined for shell sand since 1972. The permitted areas for mining have been increasingly restricted and regulated since the commencement of mining operations.

The main fisheries in the Central West Coast involve fishing gear which has minimal impacts to the benthic habitats. These include: western rock lobster which uses traps, Roes abalone which are hand collected and several finfish fisheries that mainly use lines.

Due to the unique diversity of tropical and temperate habitats, the Abrolhos Islands were gazetted as WA's first Fish Habitat Protection Area (FHPA) and have been placed on the National Estate Register. Due to this, the risks to Abrolhos Islands habitats are assessed separately to the bioregion as a whole.

The main activities at the Abrolhos are commercial rock lobster potting and line fishing and recreational fishing and diving. The Department has a long term coral reef monitoring program at the Abrolhos to detect potential impacts from human use and natural influences.

There are 45 public moorings installed at the Abrolhos Islands, distributed around the different island groups, to minimise impacts of anchoring to the benthic habitats. The commercial scallop fishery also operates away from coral reef habitats, predominately in areas of sand. Projected development of the tourism industry in the area may have effects on the habitats and will be monitored.

Ecosystems

Ecosystem	Aquatic zone	Current Risk Status
West Coast	Estuarine	HIGH (non-fishing)
West Coast	Marine	MEDIUM
Abrolhos Islands	Marine	MEDIUM

The estuarine ecosystems within this bioregion have been identified as being at significant risk, due to external factors (water quality issues due to high nutrient runoff from surrounding catchment, reduced rainfall) which have the potential to affect fish and other communities. Fish mortality events have been periodically reported from within the Peel–Harvey and Swan–Canning estuaries and in Cockburn Sound.

An assessment of the community structure and trophic level of all commercially caught fish species over the past 30 years found no evidence of systematic changes that could be evidence of an unacceptable impact on this ecosystem (Hall and Wise, 2011)[2]. Continued monitoring of a deep water closed area will allow evaluation of potential

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

2 Hall NG, and Wise BS. 2011. Development of an ecosystem approach to the monitoring and management of Western Australian fisheries. FRDC Report – Project 2005/063. Fisheries Research Report, No. 215. Department of Fisheries, Western Australia. 112 pp.

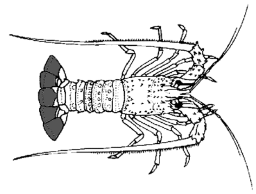
ecosystem impacts of lobster fishing in deeper water ecosystems.

The Abrolhos Islands are protected within a ‘Fish Habitat Protection Area’, and are not considered to be at unacceptable risk from fisheries related activities. A significant coral bleaching event was observed during the marine heat wave event in 2011 (Abdo *et al*. 2012)[1]. The impact of this event is being monitored as part of an ongoing monitoring program run by the Department. The program also includes monitoring of the community structure of finfish within and outside of non-fishing areas.

1 Abdo DA, Bellchambers LM, Evans SN. 2012. Turning up the Heat: Increasing Temperature and Coral Bleaching at the High Latitude Coral Reefs of the Houtman Abrolhos Islands. PLoS ONE 7(8): e43878.

FISHERIES

WEST COAST ROCK LOBSTER RESOURCE STATUS REPORT 2021



S. de Lestang, M. Rossbach, Laura Orme and Graeme Baudains.

OVERVIEW

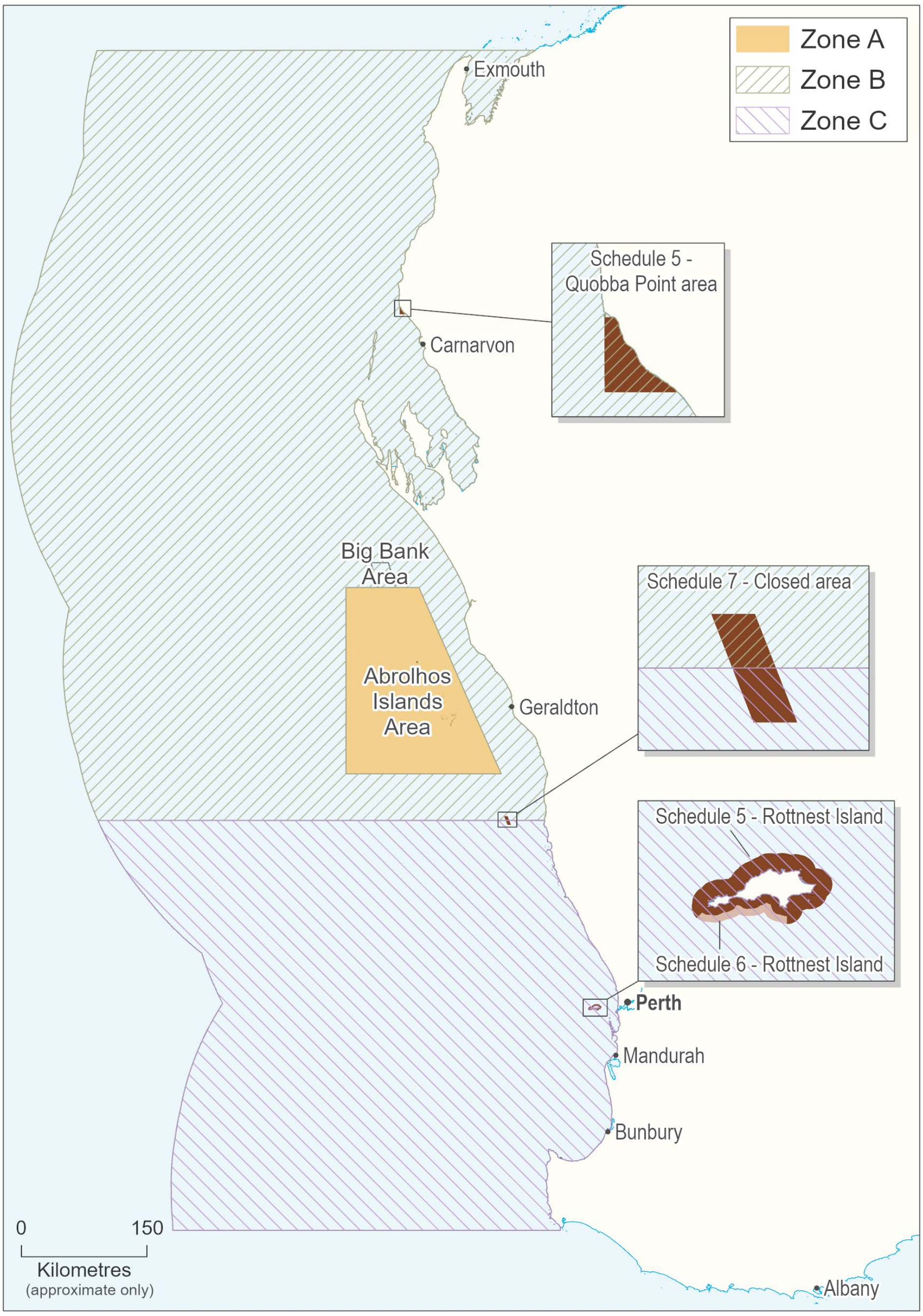
The West Coast Rock Lobster Managed Fishery (WCRLMF) targets the western rock lobster (*Panulirus cygnus*), on the west coast of Western Australia between Shark Bay and Cape Leeuwin. Lobsters are taken throughout their range by both the commercial and recreational sector and each sector operates to formal resource allocations.

The WCRLMF was one of the first limited entry fisheries in the world and for over 20 years utilised an Individual Transferable Effort system based on the number of allowable baited pots. In 2010/11 the WCRLMF began the transition to an Individually Transferable Quota (ITQ) fishery and now has a harvest strategy that uses maximum economic yield as its management target (DoF, 2014). The WCRLMF has historically been Australia's most valuable single species wild capture fishery and, in 2000, became the first fishery in the world to achieve Marine Stewardship Council (MSC) Certification. In 2017 it was the first fishery globally to be certified by MSC for the fourth time, (see de Lestang *et al*., 2016 for further details on the assessment and management of this fishery; www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_9.pdf).

The commercial fishing season begins on 15 January each year and runs for 12 months, however due to Covid-19 related logistics and marketing issues, the 2020/21 season was extended to 18 months, from 15 January 2020 to 30 June 2021. The recreational fishery still ran for 12 months state-wide and is nominally considered to span February to the following January (in an attempt to align it with the standard commercial season). Licenced recreational fishers are allowed to take lobsters using a maximum of two baited pots or by hand collection when diving to collect legal sized lobsters up to legislated bag and/or boat limits.

SUMMARY FEATURES

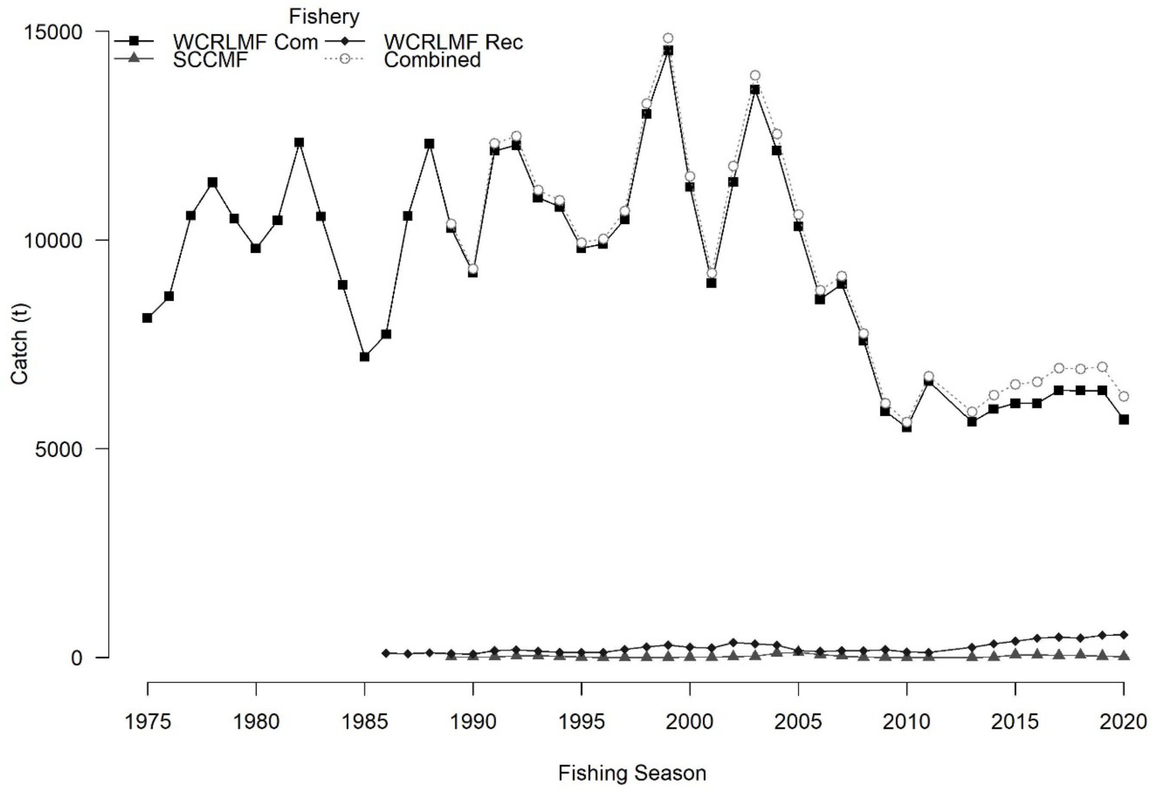
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (9,000 + 1.5% t)	Total Catch Jan 2020/Jun 21: 9,132 t	Acceptable
Recreational fishery (533 t)	Total Catch Feb 2020/Jan 21: 542 t	Acceptable
EBFM		
Indicator species		
Western Rock Lobster	Low Risk: Above biomass threshold	Adequate
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Negligible Risk	Adequate
Habitat	Low Risk	Adequate
Ecosystem	Low Risk	Adequate
Economic 2020/21 Financial year (GVP $225 m)	Moderate Risk	Acceptable
Social (high amenity)	Moderate Risk	Acceptable
Governance	Low Risk	Acceptable
External Drivers	High Risk (climate, market)	Acceptable



WESTERN ROCK LOBSTER FIGURE 1.
Map showing boundaries of the West Coast Rock Lobster Managed Fishery.

CATCH AND LANDINGS

The total commercial landings of western rock lobster in the 18-month season 2020/21 from the WCRLMF were 9,132 t. The total allowable commercial catch (TACC) was 9,135 t (9,000 t plus a 1.5% drip loss factor). Over the traditional 12-month season (15 Jan 2020 – 14 Jan 2021) commercial landings were 5,696 t. The median estimate of the recreational catch was 526 t (range: 460 - 592 t) and the charter catch was 16 t, compared to the Total Allowable Recreational Catch (TARC) of 533 t (Western Rock Lobster Figure 2).



WESTERN ROCK LOBSTER FIGURE 2.
Total landings by fishery including the South Coast Crustacean fishery (SCCMF) (and combined) for western rock lobster. Note for comparison with the other sectors, catches for the WCRLMF have been displayed for only the historic 12-month fishing season (15 Jan – 14 Jan).

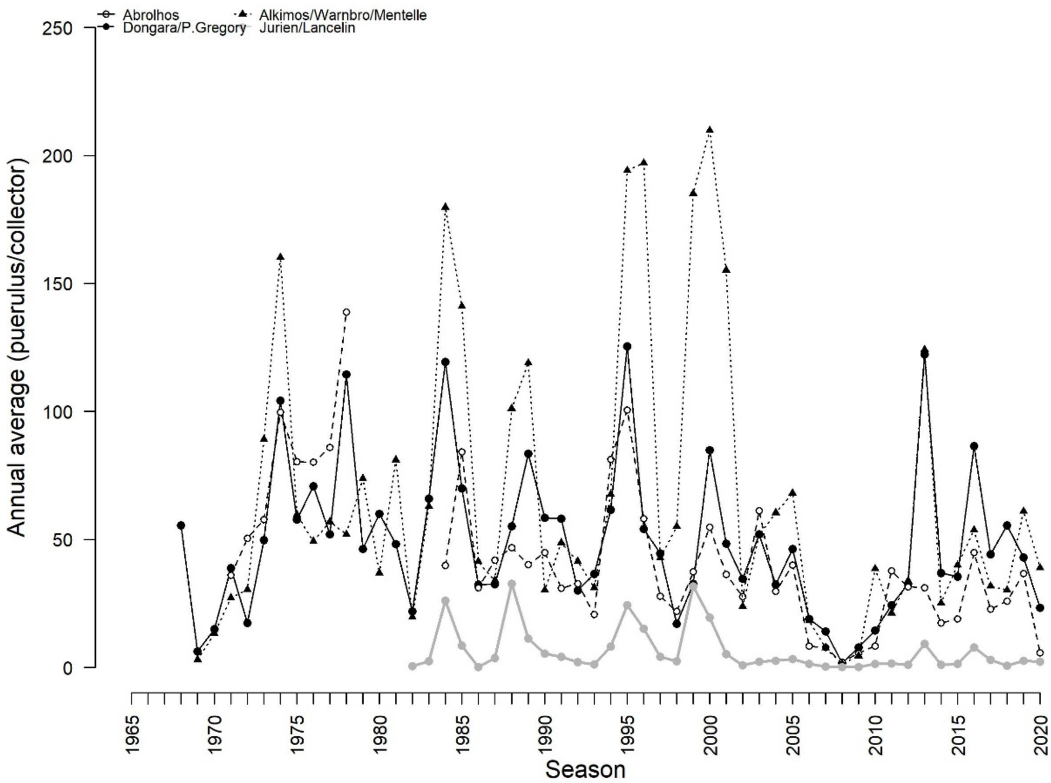
INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Western rock lobster - (Sustainable-Adequate)

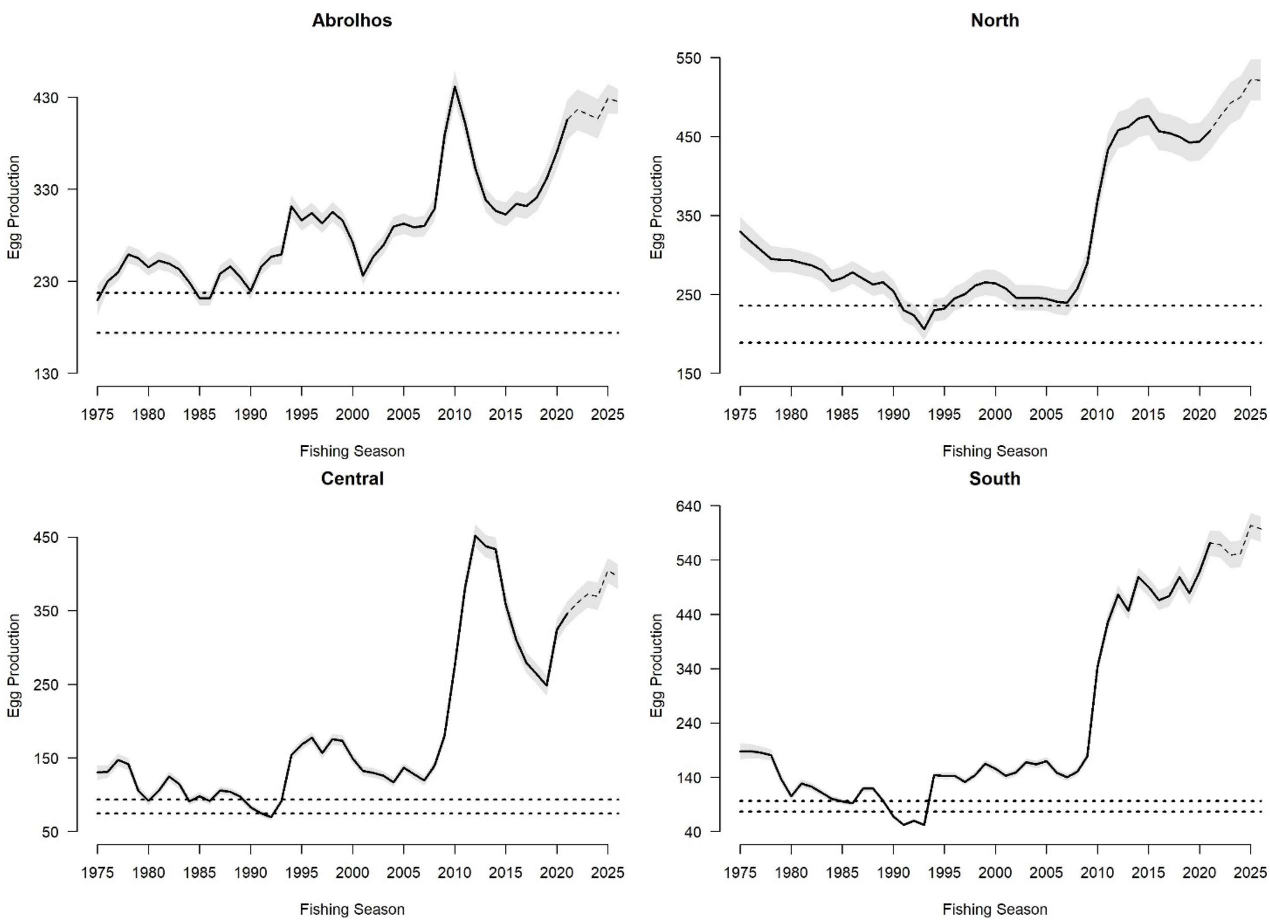
Commercial and recreational catch rates have been maintained near their record-high levels. Fishery-independent egg production indices at all sites are well above both threshold and long-term levels indicating that the biomass and egg production in all locations of the WCRLMF are at record-high levels since surveys began in the mid-1990s. The breeding stock is therefore considered **sustainable-adequate**.

Fishery-independent recruitment (puerulus) monitoring indicates that the puerulus settlement was slightly below average in all areas during 2020/21 except at the Abrolhos Islands, which was well below average (Western Rock Lobster Figure 3).

The integrated population model indicates that a continuation of fishing at similar or slightly higher TACCs (e.g. 6,000 t over 12 months) over the coming five-year period will result in similar legal and spawning biomass, catch rates and harvest rates (see de Lestang *et al*. (2016), section 9.3.14 and Western Rock Lobster Figure 4).



WESTERN ROCK LOBSTER FIGURE 3.
Levels of puerulus settlement in four regions of the WCRLMF from 1968.



WESTERN ROCK LOBSTER FIGURE 4.
Modelled estimates (black) and projections (dotted line) of egg production for the four breeding stock management areas based on a TACC of 6,500 t. The 75% CI is denoted in grey. Horizontal lines represent the threshold (upper grey dotted) and limit (lower grey dashed) reference points for breeding stock levels in each breeding stock management area.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

The main bycatch species landed in the WCRLMF are octopus, champagne crabs (CC) and baldchin grouper (BG). Octopus contributed most to the total bycatch landings with 12.7 t in 2020/21 and only incidental landings of the other species being recorded (2.1 t and 3.1 t for CC and BG, respectively). See Octopus, Deep Sea Crab and West Coast Demersal Scalefish reports for further information.

Protected species

The WCRLMF may interact with a number of protected species with substantial improvements having been achieved during the past decade (see Bellchambers *et al*. (2017) section 4).

To mitigate the risk to juvenile Australian sea lions (ASL) all pots fished within designated sea lion areas are now fitted with devices to stop the accidental drowning of ASL. Since their implementation there have been no records of any drowned ASL.

During the whale migration season (May – October inclusive) all pots must comply with mitigation measures aimed at reducing the entanglement of migrating whales (see Bellchambers *et al*. (2017) section 4). This has resulted in a significant (~60%) reduction in reported whale entanglements. There were eight entanglements in lobster gear reported in the 2020 migration.

Turtles can also get caught in the float rigs of lobster pots. In 2020 no turtles were reported to have been entangled in lobster fishing gear.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

While WRL may use a range of habitats throughout their life-cycle, including shallow water reefs and adjacent seagrass beds as juveniles, or un-vegetated areas during their migratory phase (‘whites’), the algal covered limestone reefs form the habitat for the majority of the population.

Ecosystem

WRL are an omnivorous generalist feeder, with a diet that consists of a variety of invertebrate, algae, carrion and bait. Results from monitoring in areas closed and open to WRL fishing, established to examine the potential ecosystem effects of WRL removal, suggest that lobsters do not play a keystone role in ecosystem functioning (see section 6.2 in Bellchambers *et al*. (2017)).

SOCIAL AND ECONOMIC OUTCOMES

Social

The WCRLMF is important for regional employment with 239 commercial vessels operating in 2020 with most of the catch handled by four main processing establishments. The rock lobster fishery is also a major recreational activity and provides a significant social benefit to the Western Australian community with over 55,000 recreational fishers holding rock lobster licences in 2020. At current high stock levels there is a **moderate risk** to this valuable social amenity, however as the recreational catch is very close to its TARC, there may be the requirment for an adjustment in the near future.

In November 2019, a three-year trial commenced to provide increased tourism opportunities for charter operators undertaking pot-based rock lobster fishing tours and experiences for local, interstate and international visitors. Despite limited international tourism as a result of COVID-19, the outcomes of the trial to date have been positive and indicate potential for growth in the charter sector.

Economic

The estimated average price across all processors and all zones of the WCRLMF received by commercial fishers for western rock lobster in the 2020/21 financial year was $33.93/kg. This was down from that paid in the 2019/20 financial year ($65.23/kg). The lower financial year beach price with similar landings resulted in the overall value of the WCRLMF dropping markedly to $225 million (12 month). The drop in beach price is strongly related to limitations in exporting live lobster into the Chinese market. Since this is the main market for Western Rock Lobster it is considered to be a **high risk**.

GOVERNANCE SYSTEM

Harvest Strategy

The Harvest Strategy and Control Rules 2014-2019 (HSCR; DoF, 2014) was used to set catch limits for both the commercial and recreational sectors on an annual basis. The HSCR have a primary sustainability objective to maintain egg production at sustainable levels and a secondary economic objective to maximise the profitability of the WCRLMF, i.e. to target Maximum Economic Yield (MEY) levels. The upper limit of the MEY assessment is currently used to determine the upper limit of the annual Total Allowable Catch (TAC) as this is the basis of setting the TARC.

Modelled future projections of the WCRLMF and MEY analysis indicates that a small (5 %) increase in TACC will move the WCRLMF

towards MEY and maintain healthy levels of egg production.

Allowable Catch Tolerance Levels

The landed commercial catch of 9,132 t was close to the TACC of 9,135 t (including 1.5% for water loss) and therefore the catch level was **acceptable**. The harvest control rules surrounding recreational catch are based on a five-year moving average (FYMA). The FYMA recreational catch in 2020/21 was 498 t and was below the FYMA TARC of 503 t. The recreational catch was therefore considered **acceptable**.

Compliance

For the recreational sector, compliance efforts focus on bag limits, size limits and retention of totally protected fish through routine landing inspections. In addition, targeted compliance operations are utilised to detect serious offences such as gear interference and the unlawful sale of recreationally caught rock lobster.

For the commercial sector, the majority of enforcement effort is applied to ensure that fishers' catches are within their quota entitlement. There is also at-sea compliance to check that rock lobster gear is compliant with ASL and whale mitigation devices/measures.

Consultation

Consultation occurs between the Department and the commercial sector either through the Western Rock Lobster Council or the Annual Management Meetings convened by the Department through the Western Australian Fishing Industry Council. Consultation with Recfishwest and other interested stakeholders is conducted through specific meetings and the Department's website.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

In September 2020 a series of amendments were made to the management settings for the commercial fishery. After consultation with industry, a COVID-19 response was implemented in order to minimise the economic impact of the pandemic on the fishery, given the significant reduction in demand for lobster in China in early 2020. The management response included extending the 2020/21 commercial season by 5.5 months, to end 30 June 2021; adjustment to the catch associated with the extended season (TACC of 9000 t plus 1.5% for water loss), and introduction of a new mechanism for fishers to undertake 'back-of-boat sales'.

In May 2021, noting continuing economic impacts as a result of COVID-19, amendments were made to the management arrangements to provide for an 18.5 month season extending from 1 July 2021 to 14 January 2023 (2021-23 season). The TACC was retained at 9000 t (plus 1.5% for water loss) for the extended season.

Following implementation of the back-of-boat sales program, approximaly 48 t of WRL was sold direct to the public between September 2020 and June 2021. The program will continue for the 2021-23 season with an aim to increase community engagement through supply of WRL to the public.

During the first year of the rock lobster charter trial (November 2019 – November 2020), 1,492 trips were undertaken with 13,420 paying passengers. This resulted in approximately 14.9 t of rock lobster. The trial will continue for the 2020/21 season.

EXTERNAL DRIVERS

The variations in WRL recruitment to the fishery are largely a result of variable levels of puerulus settlement 3-4 years previously. Catches are also dependent upon the environmental conditions at the time of fishing.

In 2011 and to some extent 2012 and 2013, abnormally warm water temperatures were recorded throughout the northern half of the western rock lobster fishery. Preliminary analysis indicates that this event negatively impacted the puerulus to juvenile relationship in the northern region of the fishery (e.g. Kalbarri). There are now strong signs that this area may have recovered from this imapct and returned to its historical relationship.

At a longer time scale, WRL have been rated a **high risk** to the effects of climate change as many aspects of its life history are highly sensitive to environmental conditions (Caputi *et al*. 2010).

The economic performance of the WCRLMF is strongly affected by the value of the Australian dollar (affecting the price of lobsters), fuel and labour costs and the status of the Chinese economy as China has recently imported nearly all of the WRL.

REFERENCES

Bellchambers LM, How J, Evans SN, Pember MB, de Lestang S and Caputi N. 2017. Ecological Assessment Report: Western Rock Lobster Resource of Western Australia Fisheries Research Report No. 279, Department of Fisheries, Western Australia. 92p.

Caputi N, Melville-Smith R, de Lestang S, Pearce AF, and Feng M. 2010. The effect of climate change on the western rock *lobster (Panulirus cygnus)* fishery of Western Australia. Canadian Journal of Fish and Aquatic Sciences 6: 85-96.

de Lestang S, Caputi N, and How J. 2016. Western Australian Marine Stewardship Council Report Series No. 9: Resource Assessment Report: Western Rock Lobster Resource of Western Australia. Department of Fisheries, Western Australia. www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_9.pdf

de Lestang, S., How, J., Caputi, N., Tuffley, E-J. and Rossbach, M. 2019. Summary of the West Coast Rock Lobster Managed Fishery science and modelling review. Fisheries Research Report No. 295. Department of Primary Industries and Regional Development, Western Australia. 60p.

Department of Fisheries. 2014. West Coast Rock Lobster Harvest Strategy and Control Rules 2014 – 2019. Fisheries Management Paper No. 264. Department of Fisheries, Western Australia.

Rogers P, de Lestang S, How J, Caputi N, McLeod P, Harrison N and McMath J. 2017. Establishing a low risk incremental approach for setting TACCs (changing quotas) in the Western Rock Lobster Fishery, taking into account maximum economic yield and other objectives. FRDC Project No 2015-236.

Thompson AP, Hanley JR and Johnson MS. 1996. Genetic structure of the western rock lobster, *Panulirus cygnus*, with the benefit of hindsight. Marine and Freshwater Research 47: 889–896.

WEST COAST ROE'S ABALONE RESOURCE STATUS REPORT 2021

L. Strain, J. Brown and R. Jones

OVERVIEW

The Roe's abalone (*Haliotis roei*) resource is accessed by both the commercial and recreational sectors, and is a dive and wade fishery operating in shallow coastal waters along WA's western and southern coasts. The commercial Roe's abalone fishery is managed primarily through Total Allowable Commercial Catches (TACCs), which are set annually for each of the six management areas (Roe's Abalone Figure 1) and allocated as Individually Transferable Quotas (ITQs).

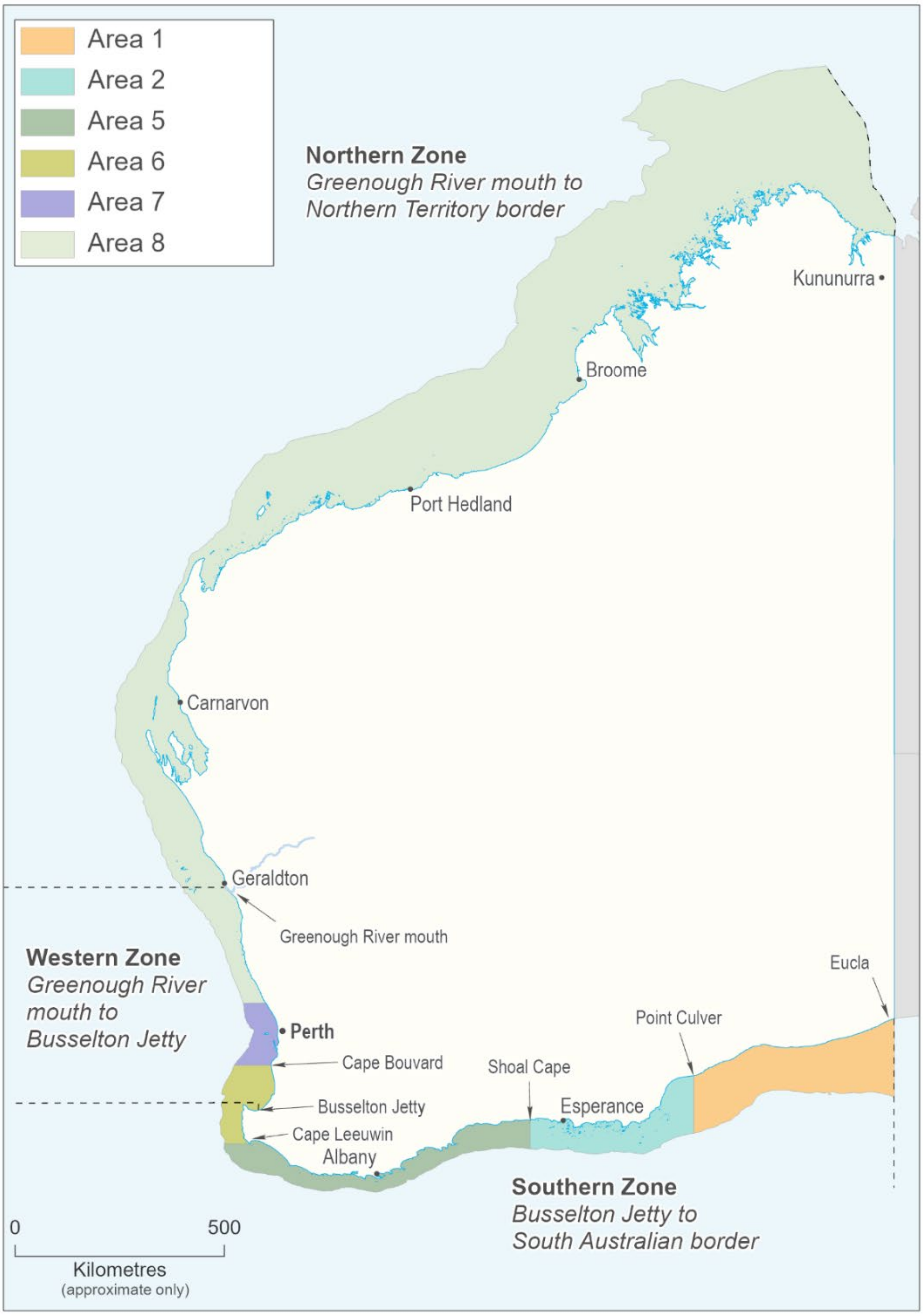
The recreational fishery is divided into three zones (Roe's Abalone Figure 1): Zone 1 (Western Zone - including Perth metropolitan area), Zone 2 (Northern Zone) and Zone 3 (Southern Zone).

Management arrangements include a specific abalone recreational fishing licence, size limits, daily bag and possession limits, temporal and spatial closures, and a Total Allowable Recreational Catch (TARC) in the Western Zone.

Further information on the fishery can be sourced from Hart *et al*. (2017) and Strain *et al.* (2021) at www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_8.pdf. and http://www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_8_addendum_4.pdf.

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (73.5 t)	Total Catch 2020: 18.2 t	Acceptable
Recreational fishery (28–32 t Perth Metro Fishery)	Total Catch 2020: 29–33 t Perth Metro Fishery; 14 t Other	Acceptable
EBFM		
Indicator species		
Roe's abalone (*Haliotis roei*)	Above Target (excluding closed Area 8/Northern Zone)	Adequate
Ecological		
Bycatch	Negligible risk	Adequate
Listed Species	Negligible risk	Adequate
Habitat	Negligible risk	Adequate
Ecosystem	Negligible risk	Adequate
Economic (GVP $0.5 m)	High risk	Acceptable
Social (Amenity - Significant)	High risk	Acceptable
Governance	Low risk	Acceptable
External Drivers	Significant risk	Management Action



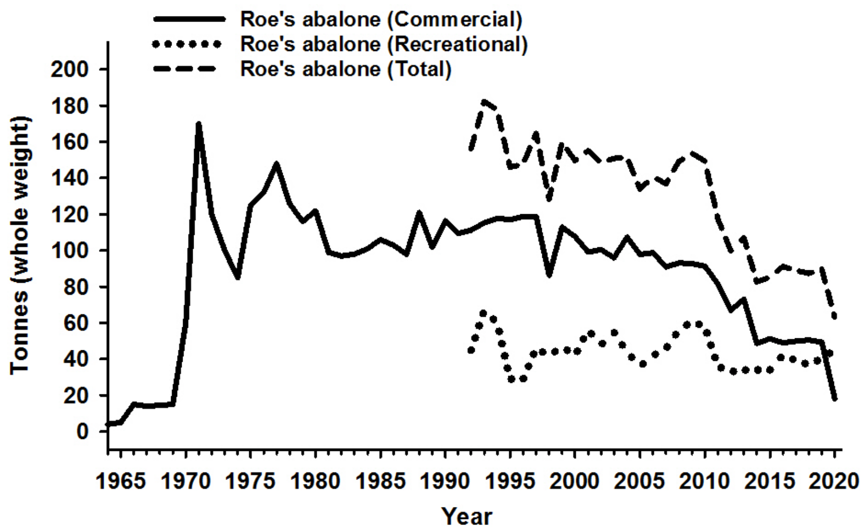
ROE'S ABALONE FIGURE 1.
Map showing the boundaries of the management areas for Roe's Abalone in the commercial Abalone Managed Fishery in Western Australia. Also showing the boundaries of the three zones within the Western Australian Recreational Abalone Fishery; the Western Zone, the Northern Zone and the Southern Zone.

CATCH AND LANDINGS

In 2020 the total commercial catch was 18.2 t whole weight, which was a reduction of over 60% from last season and only 25% of the 73.5 t whole weight TACC (Roe's Abalone Figure 2). The commercial catch was less than the TACC in Area 1 (0% caught), Area 2 (39% caught), Area 5 (3% caught), Area 6 (0% caught) and Area 7 (39% caught). Commercial viability of Roe's abalone fishing in regional areas has suffered over recent years due to economic influences (low value of catch and few viable markets), high cost of accessing these areas and prevailing weather conditions (Area 6).

The TACC was increased in Area 7 (by 6.3 t) given the recovery of the Perth abalone stocks from historically low levels post the 2011 marine heatwave. The potential impacts of the Ocean Reef Marina development on the fishery (loss of access), resulted in the TACC increase being restricted by 5.3 t (increase of 11.6 t). In Area 7, only 39% of the TACC was caught, which was only the second season the full TACC hasn't been caught since an individual management area quota was introduced in 1999. The commercial industry has attributed the reduction in catch in Area 7 during 2020 to the economic impacts of COVID-19 on overseas markets.

The recreational catch of Roe's abalone in 2020 was 45.2 t whole weight, which represents 71% of the total Roe's abalone catch (Roe's Abalone Figure 2). The recreational catch includes 29–33 t (31.2 t) from the Perth metropolitan stocks, and an estimate of 14 t for the rest of the state (Western Zone excluding the Perth metropolitan stocks and Southern Zone) derived from a 2007 phone diary survey. The TARC for the Perth metropolitan stocks was reduced by 4.7 t to account for the potential impacts of the Ocean Reef Marina development.



ROE'S ABALONE FIGURE 2.
Roe's abalone commercial and recreational catch (t, whole weight) by season as recorded against the nearest calendar year.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Roe's abalone (Sustainable – Adequate)

The stock status is assessed using commercial and recreational catch and effort statistics, and fishery-independent sampling. Trends in stock indicators were used to determine the 2020 TACC for each management area, and the TARC for Zone 1 of the recreational fishery.

Area 1 (near WA/SA border): There was no catch taken in 2020 of the 5 t TACC. This area is a marginal part of the fishery in a remote location making it economically difficult for fishers given current market conditions.

Area 2 (Esperance): The catch in 2020 was 5.1 t whole weight of the 13.2 t TACC. The SCPUE declined between 2010 and 2015, increased in 2016 and has declined slightly since, but is still above the target reference level.

Area 5 (Albany): The catch in 2020 was 0.4 t whole weight of the 15 t TACC. The SCPUE has been slightly lower than the historical average between 2013 and 2019, but remained stable during this period and above the target reference level. In 2020, the low catch has resulted in a high degree of uncertainty around the SCPUE estimate.

Area 6 (Capes): There was no catch taken in 2020 of the 7.5 t TACC. The SCPUE in 2019 was above the target reference level and within the historical range.

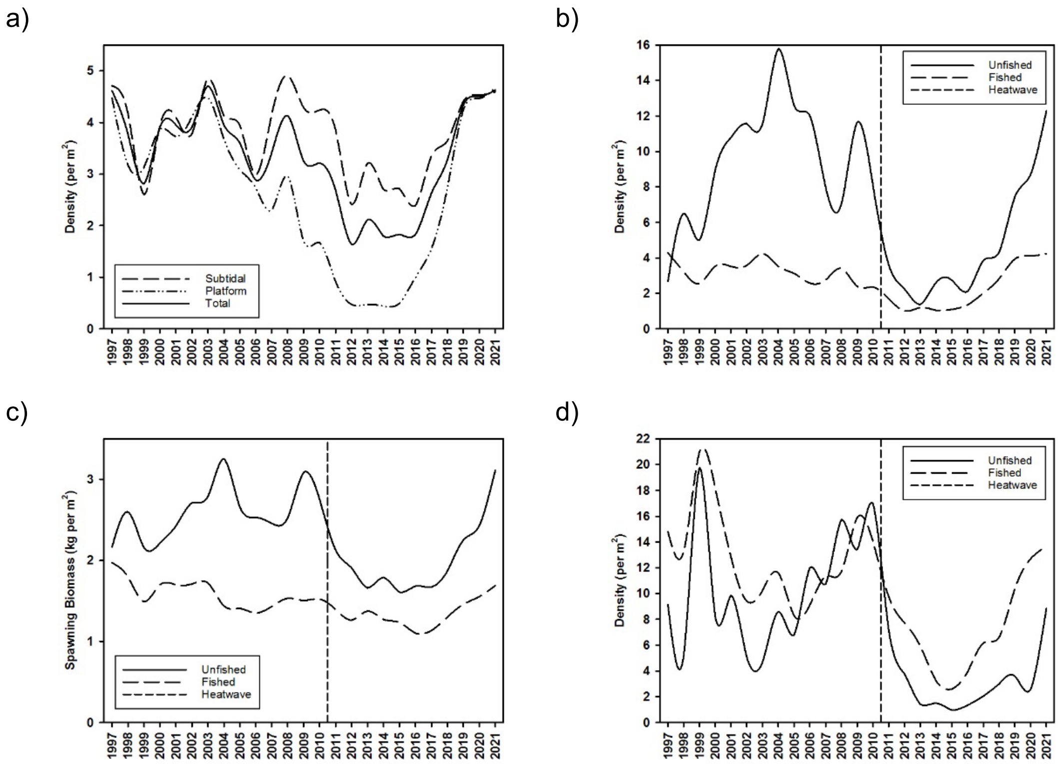
Area 8 (Kalbarri): Closed since the 2011/12 season due to catastrophic mortality following the 2011 marine heatwave. With no evidence of natural recovery, a restocking project has been successful on a trial-scale, but it has yet to be implemented on a commercial scale to determined if restocking would recover the entire stock in the longer term (Strain *et al.* 2019).

Perth Metropolitan Roe's Abalone Fishery (Area 7 / Zone 1): The commercial catch in 2020 was 12.7 t of the 32.8 t TACC. The SCPUE in Area 7 in 2020 was similar to last season and follows a continual increase over the previous 5 seasons, since a steady decline occured between 2005 and 2014. The SCPUE is above the target reference level and the TACC was set using the stock prediction model based on the juvenile abundance and an environmental factor. The recreational catch estimate was 29–33 t (31.2 t) whole weight and within the TARC range of 28–32 t.

Fishery-independent surveys indicate that the density of harvest-sized Roe's abalone in both the subtidal and platform habitats, and across both fished and unfished areas experienced substantial declines between 2003 and 2012 (Roe's Abalone Figure 3a and b). Density of harvest-sized animals then increased from record-low levels during 2012-2016, and in 2021 are nearing record-high levels in the subtidal and at record-high levels in the platform habitat (Roe's Abalone Figure 3a). Importantly, this increase in density has continued

in unfished stocks with the fished stock density equal to record-high levels (Roe's Abalone Figure 3b). Spawning biomass also increased in 2021 with both fished and unfished areas having reached pre-marine heatwave levels and are now approaching record-high levels (Roe's Abalone Figure 3c). Age 1+ (17 – 32 mm) animals have also shown an increase in density over the last six years, after the juvenile recruitment density declined by 80% between 2010 and 2013 (post marine heatwave), with 2015 being the lowest year on record (Roe's Abalone Figure 3d).

Recovery of the Perth Metropolitan Roe's Abalone Fishery from historically low levels is considered complete. Stock indicators (harvest-size animals, spawning biomass and recruitment) have returned to pre-marine heatwave levels with some indicators at or nearing record-high levels since surveys began. The recovery of these indicators has been aided by a marine cold spell occuring during 2016-2019.



ROE'S ABALONE FIGURE 3.
Density and spawning biomass of Roe's abalone in the Perth Metropolitan Fishery (Area 7/Zone 1) from fishery-independent surveys. a) Density of harvest-size Roe's abalone (71 mm+) in fished areas within the subtidal and platform habitats, b) Density of Roe's abalone (71 mm+) in the fished and unfished areas, c) Spawning biomass (kg per m^2 of <40 mm abalone) of Roe's abalone in the fished and unfished areas, d) Density of Age 1+ Roe's abalone (17 – 32 mm) in the fished and unfished areas.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Divers have the ability to target abalone of choice (species, sizes and quality of abalone) and do not inadvertently harvest bycatch in their normal fishing activities. The only potential listed species interaction is with the white shark (*Carcharodon carcharias*), with some divers adopting the 'shark shield' technology. **Negligible** risk.

HABITAT AND ECOSYSTEM INTERACTIONS

The fishing activity makes minimal contact with the habitat, which typically consists of hard rock surfaces in a high wave energy environment. As abalone feed on drift algae, their removal is unlikely to result in any changes to the algal growth cover in fished areas, and hence it is considered unlikely that the fishery has any significant effect on the food chain in the region. **Negligible** risk.

SOCIAL AND ECONOMIC OUTCOMES

Social

There are 24 vessels registered to operate in the commercial Roe's Abalone Fishery, but given the economic impacts outlined only a small number of divers fished during 2020. The dispersed nature of the Roe's abalone fishery means that small coastal towns from Perth to Eucla receive income from the activity of divers. The recreational fishery

provides a major social benefit to those members of the community that appreciate the abalone as a delicacy, and 18,328 licences were issued that would have allowed fishers to participate in the recreational abalone fishery. **High** risk.

Economic

Estimated annual value (to commercial fishers) for 2020 was $0.5 million, based on the estimated average price for Roe's abalone of $27.23/kg whole weight. The price of Roe's abalone has dropped by 50% since 2000, when it was $55/kg whole weight. This is due to the value of the Australian dollar and wild caught Roe's abalone being in direct market competition with aquaculture produced abalone. **High** risk.

GOVERNANCE SYSTEM

Harvest Strategy (Formal)

The harvest strategy (DoF 2017) uses SCPUE as a proxy for biomass and the 3-year mean of SCPUE as the key performance indicator, which is assessed against specified biological reference levels for each management area. The Perth Metropolitan Fishery (Area 7 / Zone 1) is managed using a stock prediction model with an environment factor (DoF 2017). The predicted harvest-sized density is used to set the Total Allowable Catch (TAC), with the habitat biomass and sectoral patterns of usage separating the TAC into TACC and TARC. The TACCs (whole weight) have been set for the 2021/22 season, they are 5 t in Area 1, 13.2 t in Area 2, 15 t in Area 5, 7.5 t in Area 6, 32.8 t in Area 7 and 0 t in Area 8, totalling 73.5 t. The Area 7 TACC and Western Zone TARC may be varied following a mid-year review.

Annual Catch Tolerance Levels

Commercial – Acceptable: 73.5 t (TACC) (530 - 640 fishing days)

Recreational – Acceptable: 28–32 t (TARC) Perth metropolitan fishery only (Zone 1).

Commercial catch was below the TACC due to the economic impacts of COVID-19 on overseas markets. The commercial fishing effort (133 days) was also below the expected range. Area 8 is still closed due to the catastrophic mortality following a marine heatwave. The recreational catch range in the Perth Metropolitan Fishery was within the TARC range.

Compliance

The Department conducts regular inspections of commercial catch at both the point of landing and processing facilities to ensure the commercial industry is adhering to governing legislation. The recreational fishery, particularly the Perth Metropolitan Fishery, has a high level of enforcement given its high participation rate combined with restrictive TARC, season length and bag limit.

Consultation

The Department undertakes consultation directly with the Abalone Industry Association of Western Australia (AIAWA), West Coast Abalone Divers Association (WCADA), the Southern Seafood Producers Association WA (SSPA) and licensees on operational issues. The Department convenes Annual Management Meetings through the Industry Consultation Unit at the Western Australian Fishing Industry Council (WAFIC), who are also responsible for undertaking statutory management plan consultation under a Service Level Agreement. Recreational consultation processes are facilitated by Recfishwest under a Service Level Agreement, although the Department undertakes direct consultation with the community on specific issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

In 2020, the Department continued the management arrangements for the Western Zone (Zone 1) of the recreational abalone fishery that were reviewed and implemented in 2017 to improve fisher safety and stock sustainability. Given the increase in the TARC range following the recovery of the Perth abalone stocks, the number of fishing sessions in the Western Zone was increased from 4 to 5 for 2020/21.

The commercial Roe's abalone fishery has undergone full MSC assessment and achieved certification in 2017, with the 3rd surveillance audit completed during 2020 (https://fisheries.msc.org/en/fisheries/western-australia-abalone-fishery/@@view).

The Department has reviewed the Harvest Strategy for the Western Australian Abalone Resource and is currently finalising consultation and approvals.

EXTERNAL DRIVERS

During the summer of 2010/11, the West Coast experienced a marine heatwave such that in the area north of Kalbarri (Area 8) mortalities of Roe's abalone were estimated at 99.9% (Strain *et al.* 2019). A complete closure of the commercial and recreational fisheries was then implemented. The heatwave also affected the Perth metropolitan stock but to a lesser extent (Hart *et al.* 2018). The recovery of the stock has been assisted by a marine cold spell during 2016-2019. Roe's abalone has been assessed as a significant risk to climate change effects.

Weather conditions during the time of fishing have a significant effect on catch rates and total catch of recreational fishers.

The small size of Roe's abalone results in its direct competition with aquaculture-produced abalone and therefore, there has been a decline in the beach price and overall economic value during the last decade.There has also been other economic impacts on overseas markets, which subsequently reduced Roe's abalone catches and consequently GVP of the fishery in 2020.

The Ocean Reef Marina development located within the Perth Metropolitan Fishery poses a significant risk to the Roe's abalone stock and subsequently the commercial and recreational fishery's. **Significant** risk.

REFERENCES

Department of Fisheries. 2017. Abalone Resource of Western Australia Harvest Strategy 2016 - 2021. Fisheries Management Paper No. 283. Department of Fisheries, Western Australia, 36p.

Hart A, Strain L, Hesp A, Fisher E, Webster F, Brand-Gardner S and Walters S. 2017. Marine Stewardship Council Full Assessment Report Western Australian Abalone Managed Fishery. Department of Fisheries, Western Australia. 288p.

Hart AM, Strain LWS and Brown J. 2018. Regulation dynamics of exploited and protected populations of Haliotis roei, and their response to a marine heatwave. ICES Journal of Marine Science 75 (6): 1924–1939. doi:10.1093/icesjms/fsy064.

Strain LWS, Brown JM and Hart AM. 2019. Recovering a collapsed abalone stock through translocation. Seafood CRC Project No. 2011/762. Fisheries Research Report No. 292. Department of Fisheries, Western Australia. 90p.

Strain L, Hart A and Jones R. 2021. Western Australian Abalone Managed Fishery. Western Australian Marine Stewardship Council Report Series No. 8. Addendum 4. Department of Primary Industries and Regional Development, Western Australia. 28p.

WEST COAST BLUE SWIMMER CRAB RESOURCE STATUS REPORT 2021

D. Johnston, D. Harris, D. Yeoh and N. Blay

Overview

Blue swimmer crabs (*Portunus armatus*) are found in waters less than 50 m depth along the entire coast of Western Australia. The commercial crab fisheries within the West Coast Bioregion are: the Cockburn Sound Crab Managed Fishery; the Warnbro Sound Crab Managed Fishery; Area 1 (Swan-Canning Estuary), Area 2 (Peel-Harvey Estuary) and Area 3 (Hardy Inlet) of the West Coast Estuarine Managed Fishery; and Area 1 (Comet Bay) and Area 2 (Mandurah to Bunbury) of the Mandurah to Bunbury Developing Crab Fishery. Commercial crab fishers currently use purpose-designed crab traps and gill nets.

Blue swimmer crabs represent the most important recreationally-fished nearshore species in the southwest of WA in terms of participation rate (Ryan *et al.* 2019). Recreational crab fisheries are centred largely on the estuaries and coastal embayments from Geographe Bay to the Swan River and Cockburn Sound. Recreational fishers use either baited drop nets, scoop nets or diving.

Management arrangements for the commercial and recreational fisheries include minimum size limits, protection of breeding females and seasonal closures with effort controls in place for the commercial fishery.

For more detailed descriptions of blue swimmer crab biology and the West Coast crab fisheries see Johnston et al. (2020a, b).

www.fish.wa.gov.au/Documents/research_reports/frr307.pdf)

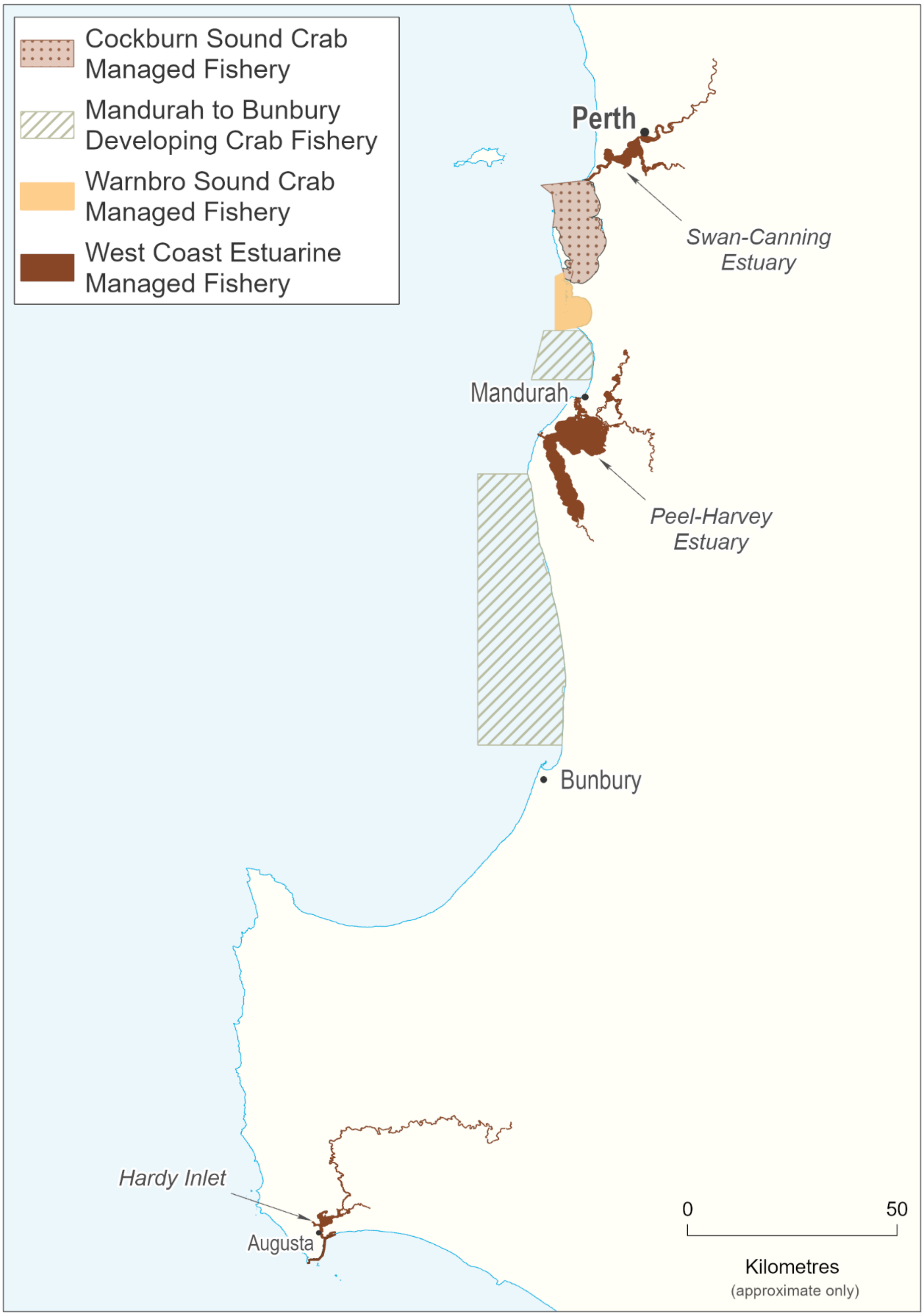
www.fish.wa.gov.au/Documents/research_reports/frr309.pdf)

Both the commercial and recreational Peel-Harvey crab fisheries attained Marine Stewardship Council (MSC) Certification in 2016 (see Johnston et al. (2015) for full details).

(www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_3.pdf

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2020: 80.8 t	Acceptable
Recreational fishery	Total Catch 2017/18: 61.1 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Cockburn Sound	Below limit	Environmentally limited
Peel-Harvey	Above threshold	Adequate
Other SW	Above threshold	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Negligible Risk	Adequate
Habitat (wading birds)	High Risk	Adequate
Ecosystem	Low Risk	Adequate
Economic (GVP <$1 m)	Moderate-High risk	Acceptable
Social (high amenity)	Moderate-High Risk	Acceptable
Governance	Moderate-High Risk	Acceptable
External Drivers	High Risk	

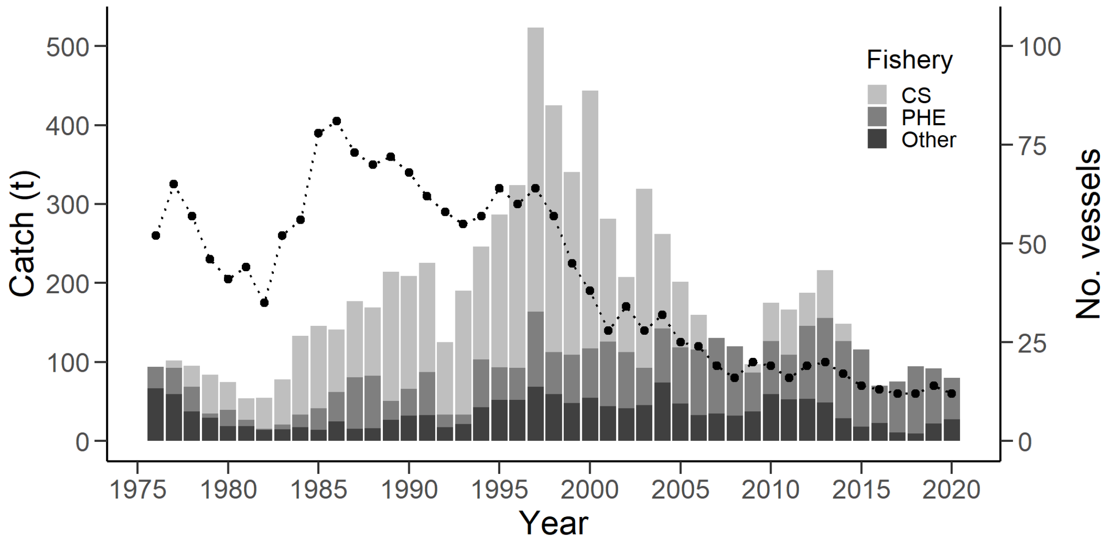


WEST COAST BLUE SWIMMER CRAB FIGURE 1.
Map showing the boundaries of the main commercial blue swimmer crab fisheries in the West Coast Bioregion:

CATCH AND LANDINGS

Commercial Sector

Total commercial catch of blue swimmer crabs in the West Coast Bioregion decreased from 91.9 t in 2019 to 80.8 t in 2020, primarily due to lower catches in the Peel-Harvey Estuary (West Coast Blue Swimmer Crab Figure 2). This level of catch is well below the historical levels of catches as Cockburn Sound remains closed. The West Coast catch accounted for approximately 11% of the State's total commercial blue swimmer crab catch of 714 t for 2020. The total State catch of blue swimmer crabs in 2020 was slightly higher to that landed in 2019 (660 t).



WEST COAST BLUE SWIMMER CRAB FIGURE 2.
West Coast bioregion commercial catch history for blue swimmer crabs in Western Australia since 1976 (by calendar year). The number of licensed fishing vessels retaining blue swimmer crabs each year is also shown (●). CS — Cockburn Sound, PHE — Peel-Harvey Estuary. Other fisheries include the Swan-Canning Estuary, Warnbro Sound, Mandurah to Bunbury (Area 1 and 2), Geographe Bay, Leschenault Estuary and Hardy Inlet. The Cockburn Sound Crab Managed fishery was closed from December 2006 – December 2009 and has been closed since April 2014.

Recreational Sector

The estimated retained harvest of blue swimmer crab by boat-based recreational fishers in Western Australia during 2017/18 was 61.1 t. The West Coast Bioregion boat-based recreational catch of blue swimmer crab represented 90% of the total statewide boat-based recreational catch (kept by numbers) in 2017/18. The estimated recreational harvest range for Blue Swimmer Crab in the West Coast was steady at 54 t (95% CI 45–63) in 2017/18 compared with 44 t (95% 37–51) in 2015/16 (Ryan et al. 2019). Recreational catch estimates for the Peel-Harvey Estuary account for the majority of the total boat-based recreational catch in the West Coast Bioregion, although significant recreational catches are recorded for the Swan Canning Estuary and Geographe Bay regions also (Ryan et al., 2019).

A previous (2008) survey of recreational fishing in Peel-Harvey covering fishing from boats, shore, canals and houseboats estimated the recreational catch to be between 107–193 t.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Cockburn Sound (Environmentally limited)

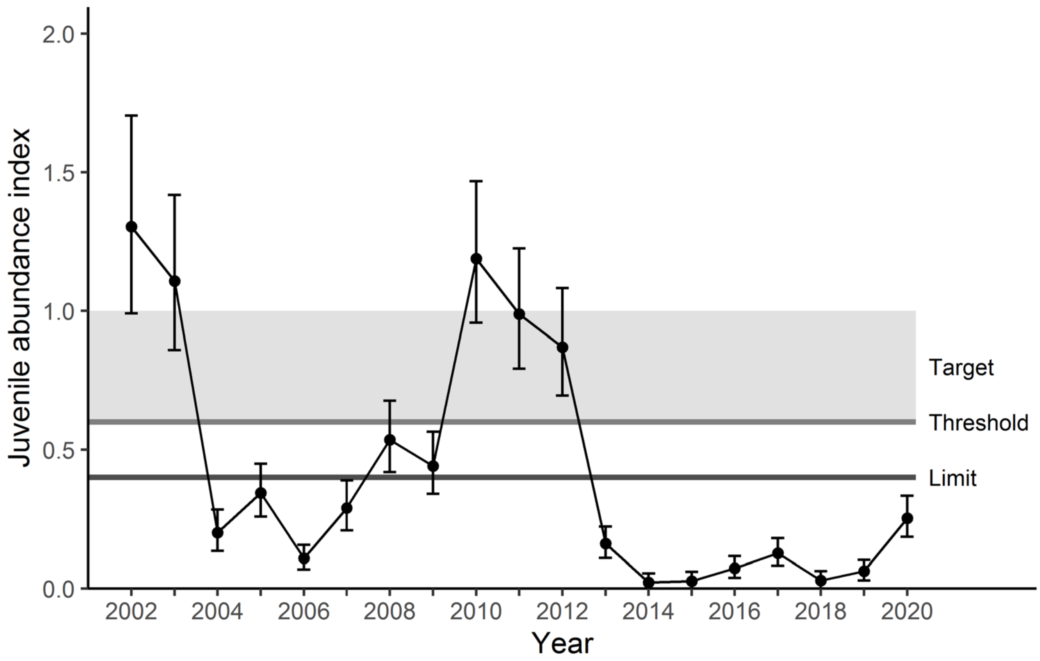
Since the fishery was closed in 2014, a harvest strategy has been determined for the Cockburn Sound Crab Fishery where the primary performance indicators are the juvenile abundance index and egg production index (Johnston et al. 2015; 2020a). A weight-of-evidence approach was used for the stock assessment where these indices, in addition to commercial catch rates and the proportion of females in the commercial catch, are taken into account to assess stock status.

Juvenile index**:** From 2014 to 2019 the abundance of juveniles in Cockburn Sound has remained very low (0.03–0.11 juveniles/100 m2 trawled). Despite a significant increase from 2019 (0.06 juveniles/100m2), the 2020 index of 0.25 juveniles/100 m2 remains substantially below the harvest strategy limit of 0.4 juveniles/100 m2 trawled, indicating that recruitment remains at unacceptable levels (West Coast Blue Swimmer Crab Figure 3).

Egg Production index: While the 2020 value of 6.1 $\times 10^6$ eggs/traplift was similar to that recorded in 2018 and 2019, it is still half the limit reference value of 12 x 10^6 eggs/traplift. This suggests that breeding stock levels continue to be unacceptable, and therefore the status of the stock has been classified as **environmentally limited.**

As the 2020 egg production and juvenile indices were below their respective limit levels, the fishery remained closed for the 2020/21 season. The outcomes of the research and management review of south-west crab stocks (DPIRD, 2018) will contribute to the future of this fishery.

Potential reasons for the stock decline include combined effects of reduced levels of primary productivity within Cockburn Sound, changes in water temperature, a low abundance of mature females and/or low proportion of berried females. The declines in abundance are believed to be substantially attributable to environmental changes, rather than fishing as the fishery has been closed for six years.

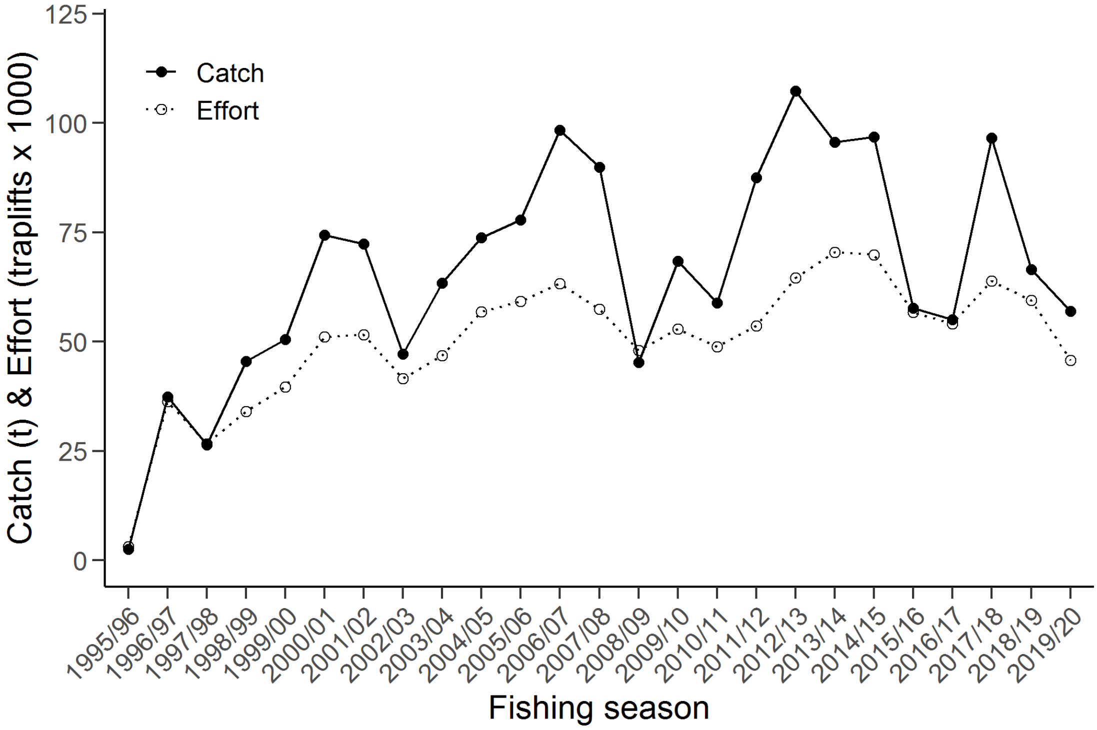


WEST COAST BLUE SWIMMER CRAB FIGURE 3.
Annual standardised index of juvenile (0+) blue swimmer crabs in Cockburn Sound calculated using data from juvenile research trawls conducted in April, May and June of each year. The index units are numbers of juveniles/100m^2 trawled. The associated reference points (target, threshold and limit) for the harvest strategy and the 95% confidence intervals are shown. The fishery was closed between December 2006 and December 2009, and has remained closed since April 2014.

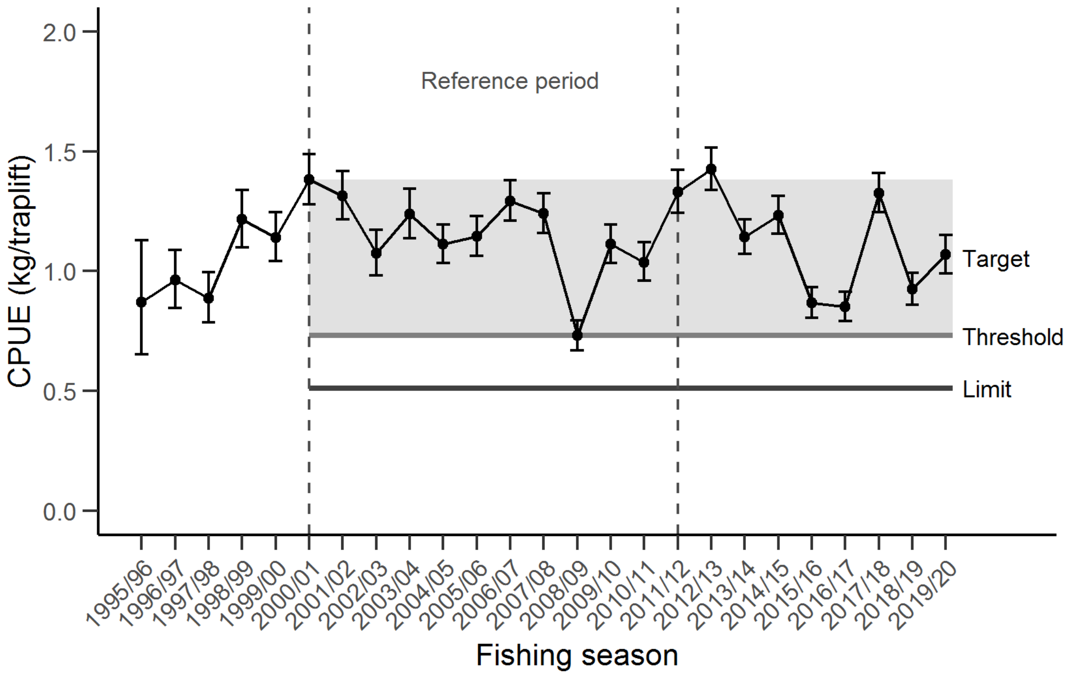
Peel-Harvey Estuary (Sustainable-Adequate)

The commercial catch and effort from the Peel-Harvey Estuary for the 2019/20 fishing season (December–August) was 57 t from 45,785 trap lifts, a decrease of ~10 t from the 2018/19 season (West Coast Blue Swimmer Crab Figure 4).

Since the conversion from nets to traps in 2000/01 annual standardised commercial catch rates have fluctuated between 0.8 and 1.4 kg/traplift, but have generally remained above 1 kg/traplift. The standardised catch rate of 1.07 kg/traplift for the 2019/20 fishing season represents an increase from 0.92 kg/traplift reported in 2018/19, and remains well above the harvest strategy threshold of 0.7 kg/traplift, indicating the stock is currently being fished at sustainable levels (West Coast Blue Swimmer Crab Figure 5). A weight-of-evidence approach was used for the stock assessment where information from fishery-independent surveys, commercial monitoring and environmental data are also taken into account to assess stock status. On the basis of this evidence, the crab stock in the Peel Harvey is classified as **Sustainable**.



WEST COAST BLUE SWIMMER CRAB FIGURE 4.
Blue swimmer crab commercial catch (t) and effort (traplifts x 1000) for the Peel-Harvey Estuary from 1995/96 to 2018/19. Fishing season prior to the 2019/20 season is defined as 1 November to 31 August; 2019/20 onwards is defined as 1 December to 31 August.



WEST COAST BLUE SWIMMER CRAB FIGURE 5.
Annual standardised commercial catch rate (kg/traplift) of blue swimmer crabs in the Peel-Harvey crab fishery, with 95% confidence limits, relative to the associated reference points (target, threshold and limit) for the harvest strategy. The reference period (2000/01 to 2011/12) was a period of relative stability when the fishery was considered to have been operating sustainably. The target range extends between the maximum and minimum values of the reference period, where the latter denotes the threshold level, a proxy for the stock level at which Maximum Sustainable Yield (MSY) can be achieved. The limit is set at 70% of the threshold value (0.7BMSY). Fishing season is defined as 1 November to 31 August between 1995/96 and 2018/19 but from 1 December to 31 August from 2019/20 onwards. Annual values have been standardised using a generalised linear model to account for effects of month and fisher.

BYCATCH and PROTECTED SPECIES INTERACTIONS

Bycatch

Crab traps are purpose-designed to minimise the capture of non-target species and are therefore an inefficient way to capture fish. The low number of fish caught and returned poses a **negligible** risk to these stocks.

Protected species interactions

The crab trap longline system is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities and are therefore considered a **low** risk.

HABITAT and ECOSYSTEM INTERACTIONS

Habitat

Retrieval of traps may result in minor dragging across the mostly sandy substrate. The small amount of living seagrass removed, results in minimal habitat damage and hence trapping poses a **low risk** to benthic habitats. However, a **high risk** score was given to the migratory and threatened shorebird species that inhabit the estuary during summer months when there is potential for feeding and roosting birds to be disturbed by recreational scoop net fishers (and other recreational activities) in key areas of overlap (Fisher et al., 2020).

Ecosystem interactions

As the commercial take of crabs represents a relatively small portion of the biomass, which is effectively renewed annually and subject to high levels of natural variation in abundance, secondary food chain effects are likely to be minimal. These crab fisheries are a **low risk** to the ecosystem.

SOCIAL and ECONOMIC OUTCOMES

Social

West Coast blue swimmer crab fisheries provide a **high social amenity** to recreational fishing and diving and to consumers via commercial crab supply to markets and restaurants. During 2020, approximately 18 people were directly employed as skippers and crew on vessels targeting blue swimmer crabs in the West Coast Bioregion. A voluntary fisheries adjustment scheme was implemented in the Peel-Harvey Estuary Crab Fishery during the 2019/20 season so this number declined to 16 by the end of the season. Blue swimmer crabs provide a highly popular recreational fishery, particularly in the Swan River, Cockburn Sound, Warnbro Sound, the Peel-Harvey Estuary and the Geographe Bay region, where they dominate the inshore recreational catch. They are the highest captured (by number) recreational species. **Moderate–High** risk.

Economic

The commercial blue swimmer crab catch in the West Coast Bioregion for 2020 had an estimated gross value of production (GVP) of approximately $0.65 million, a decrease on the $0.74 million reported in 2019 (level 1 <$1 million). Most of the catch from the West Coast Bioregion was sold through local markets. Price data was generated by collecting monthly returns recording prices paid to fishers by fish processors. A weighted average price is then calculated for the financial year from the monthly data and for 2019/20 was $8.10 per kg. **Moderate-High** risk. The reasons for this risk level is the closure for the Cockburn Sound crab fishery and subsequent uncertainty around the economic value of the south west crab fisheries.

GOVERNANCE SYSTEM

Harvest Strategy

Cockburn Sound: Closed

As the 2020 egg production index and juvenile index were below their respective limit levels, the fishery remained closed for the 2020/21 season.

Peel Harvey:

The primary performance indicator is the standardised annual commercial catch rate. As the indicator was above the threshold for 2019/20, no resultant management action was required. However, a three month closure (1 September to 30 November) to commercial and recreational crab fishing was implemented in 2019/20 as a result of the south-west crab management review. Previously there was a 2-month closure in September and October with the start of season commencing from 1 November.

Other West Coast fisheries:

The primary performance indicator is the standardised annual commercial catch rate. As the indicators were above the threshold in 2020 for all other fisheries in the West Coast Bioregion (Swan-Canning Estuary, Warnbro Sound, Comet Bay), a three month closure (1 September to 30 November) to commercial and recreational crab fishing was implemented.

Allowable Catch Tolerance Levels

Cockburn Sound:	Under review
Peel Harvey:	45–107 tonnes

Other West Coast fisheries: Under review

A catch range for Cockburn Sound crabs needs to be developed when the management arrangements and stock levels have stabilised. The acceptable catch range for Peel Harvey is based on the last 10 years of catch values. The other west coast crab fisheries are yet to develop a sufficiently stable catch history or set of management arrangements to develop a definitive catch range.

Compliance

Current risks to enforcement are **low** for West Coast crab fisheries. However, the Peel-Harvey Estuary has a high level of enforcement risk in the recreational fishery as it has the highest level of non-compliance in the State, particularly for undersize crabs being taken, and fishing activities during night-time periods.

Consultation

The Department undertakes consultation directly with licensees on operational issues and processes and is responsible for the statutory management plan consultation. Industry Annual Management Meetings are convened by the Western Australian Fishing Industry Council (WAFIC) and the Southern Seafood Producers Association (SSPA), who are also responsible for statutory management plan consultation under a Service Level Agreement with the Department.

Consultation processes are now facilitated by Recfishwest under a Service Level Agreement, although the Department undertakes direct consultation with the community on specific issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

A review of the south-west blue swimmer crab resource was initiated in late 2018. The aim of the review was to improve the level of protection to the breeding stock, in particular mated pre-spawn females, and to improve resilience of the resource as well as improving the efficiency and consistency of management arrangements across the entire resource. The review included the release of *Fisheries Management Paper 288 - Protecting breeding stock levels of the blue swimmer crab resource in the south west* for public comment. Having considered public submissions and consultation with peak sector bodies, in August 2019 the Minister for Fisheries announced his decision to implement:

- an annual 3-month closure (1 September through 30 November) across all south west crab fisheries (except for Geographe Bay);
- a reduced bag limit of 5 crabs in the Swan and Canning Rivers;
- a maximum of 5 female crabs (as part of the 10 bag limit) in Geographe Bay; and
- a process to buy back commercial fishing licences in the Cockburn Sound, Warnbro Sound and Mandurah to Bunbury Crab Fisheries prior to their permanent closure.

The Department is now implementing the Minister's decisions and is working with Recfishwest, WAFIC and the SSPA to consider other potential changes to the management of the south-west blue swimmer crab resource.

Separate to the Crab Review, as part of the Government's election commitment, $1.5 million was allocated for projects to ensure the continued health of the Peel-Harvey Estuary. This commitment includes a voluntary fisheries adjustment scheme (VFAS) to buy back some of the 11 existing commercial licences operating on the estuary. The VFAS was completed during 2020 and achieved it's obejctve by removing four commercial licences from the Peel-Harvey Estuary.

EXTERNAL DRIVERS

Levels of recruitment to many of the crab fisheries fluctuate considerably mainly due to environmental influences (e.g. water temperature) both on spawning success and larval survival through to recruitment. Temperature appears to be an important factor contributing to the initial decline (2006 closure) of the Cockburn Sound Crab Fishery. The level and timing of rainfall may also affect the Peel-Harvey and Swan River fisheries.

Potential reasons for the recent stock decline (2014 closure) and lack of recovery of crabs in Cockburn Sound include combined effects of reduced levels of primary productivity (Chlorophyll-a), changes in water temperature, and the negative effects of density-dependent growth which may have contributed to an observed decline in the proportion of berried females. The recent declines in abundance are believed to be substantially attributable to environmental changes, rather than fishing. It is unlikely that crab stock levels will recover to historical highs while productivity in the system remains low.

Although these temperature changes have also resulted in the increased abundance of blue swimmer crabs in the South Coast estuaries, on the West Coast this species is rated as having a high risk to climate change.

REFERENCES

Department of Primary Industries and Regional Development — DPIRD 2018. Protection of the blue swimmer crab resource in the south west. Fisheries Management Paper No. 288. Department of Primary Industries and Regional Development, Western Australia.

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

Harris, D.C., Johnston, D.J., Baker, J.D. and Foster, M. 2017. Adopting a Citizen Science approach to develop cost-efficient methods that will deliver annual information for managing small-scale recreational fisheries: The Southwest Recreational Crabbing Project. Fisheries Research Report No. 281. Department of Fisheries, Western Australia. 121p.

Johnston, D.J., Harris, D., Caputi, N. and Thomson, P. 2011. Decline of a blue swimmer crab (*Portunus pelagicus*) fishery in Western Australia – history, contributing factors and future management strategy. Fish. Res. 109: 119-130.

Johnston, D., Chandrapavan, A., Wise, B. and Caputi N. 2014. Assessment of blue swimmer crab recruitment and breeding stock levels in the Peel-Harvey Estuary and status of the Mandurah to Bunbury developing crab fishery. Fisheries Research Report No. 258. Department of Fisheries, Western Australia.148 p.

Johnston, DJ, Smith, KA, Brown, JI, Travaille, KL, Crowe, F, Oliver, RK & Fisher, EA. 2015. Western Australian Marine Stewardship Council Report Series No 3: West Coast Estuarine Managed Fishery (Area 2: Peel-Harvey) & Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery. Department of Fisheries, Western Australia. 284 p.

Johnston, D., Yeoh, D., Harris, D. and Fisher, E. 2020a. 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, Western Australia. 194 p.

Johnston, D., Harris, D. and Yeoh, D. 2020b. Blue Swimmer Crab (*Portunus armatus*) Resource in the West Coast Bioregion, Western Australia. Part 2: Warnbro Sound, Comet Bay, Mandurah to Bunbury, Leschenault Estuary, Geographe Bay and Hardy Inlet. Fisheries Research Report No. 309. Department of Primary Industries and Regional Development, Western Australia. 94 p.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS. 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297. Department of Primary Industries and Regional Development, Western Australia.

WEST COAST OCTOPUS RESOURCE STATUS REPORT 2021

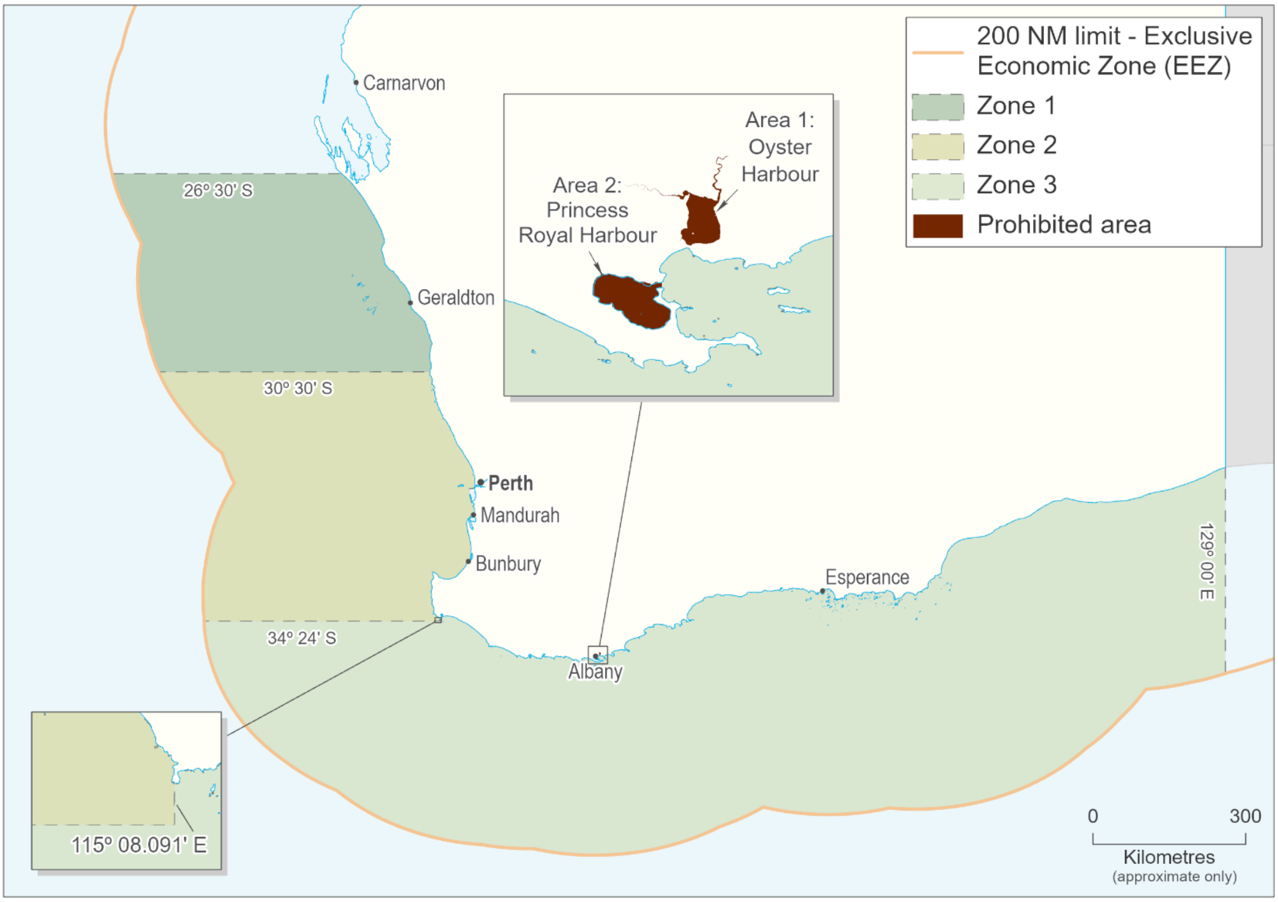
A. Hart, D. Murphy, and L.Wiberg

OVERVIEW

The octopus fishery in Western Australia targets *Octopus djinda*, which is closely related to *Octopus tetricus* found on the east coast of Australia and New Zealand (Amor and Hart, in press). Commercial octopus catch is harvested from three different fisheries with the majority of commercial catch coming from the Octopus Interim Managed Fishery (OIMF). The primary harvest method in the OIMF is a 'trigger trap'. Unbaited or passive (shelter) pots are also used mainly in the Cockburn Sound Line and Pot Managed Fishery (CSLPMF) and octopus are also caught as by-product in rock lobster pots. Commercial management arrangements include input controls on the total allowable number of pots/traps permitted in each spatial management zone. More details are available in the octopus Resource Assessment Report (Hart et al. 2018) available at http://www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_14.pdf.

SUMMARY FEATURES

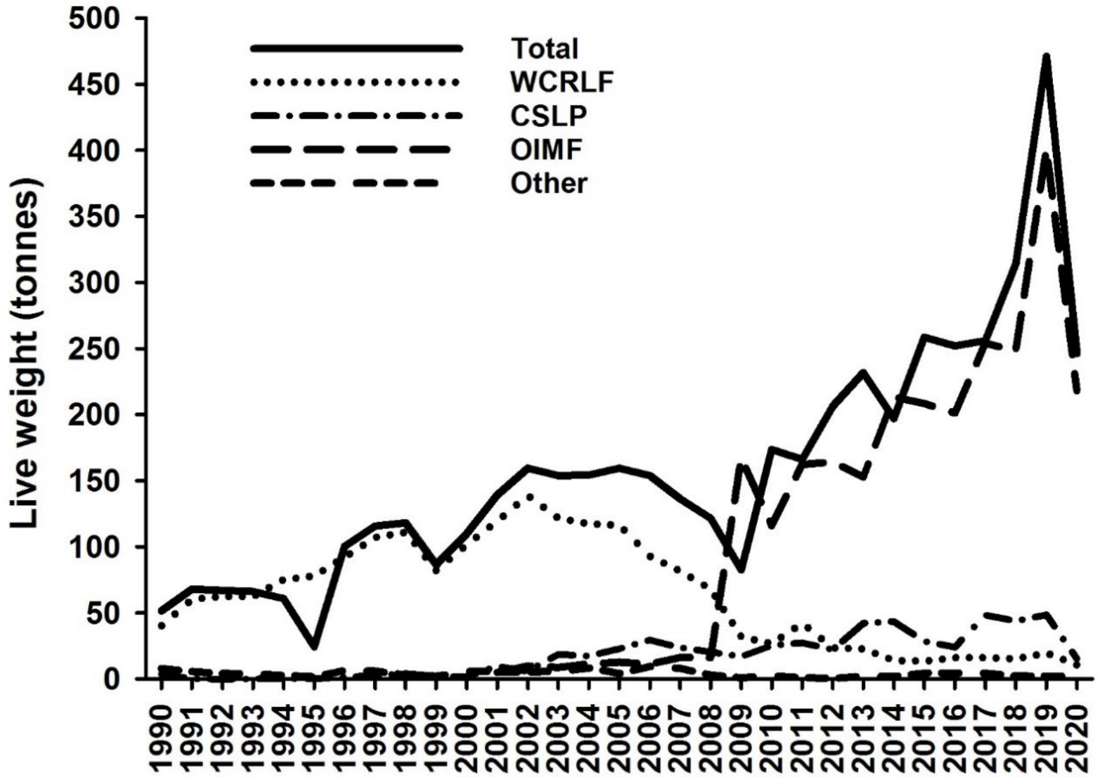
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2020: 254 t	Acceptable
Recreational fishery	Total Catch 2020: 1 t	Acceptable
EBFM		
Indicator species		
octopus (Octopus *djinda*)	Performance indicator above target	Adequate
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Low Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (GVP $3.3 m)	Low Risk	Acceptable
Social	Low Risk	Acceptable
Governance	Low Risk	Acceptable
External Drivers	Low Risk	Acceptable



OCTOPUS FIGURE 1.
Map of the three fishery management zones (Zone 1, Zone 2, Zone 3) for the Octopus Interim Managed Fishery of Western Australia. The octopus fishery is primarily managed by the number of octopus traps permitted to be fished in each of these zones.

CATCH AND LANDINGS

In 2020 the total commercial octopus catch was 254 t live weight, which was 45% lower than the 2019 catch (Octopus Figure 2). The decrease was due to COVID-19 related issues, with supply and trade route limitations interupting the harvest over a number of months. The recreational catch by boat-based fishers state-wide during 2019 was estimated at a total weight of approximately 1.0 tonne (with most taken in the West Coast Bioregion).



OCTOPUS FIGURE 2.
Commercial catch (t) of *Octopus djinda* in Western Australia since 1990. WCRLF (West Coast Rock Lobster Managed Fishery), CSLPMF, OIMF and Other, which is bycatch from trawl and miscellaneous pot fisheries.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Octopus (Sustainable – Adequate)

Octopus djinda (previously *Octopus* aff. *tetricus*) was subject to a recent comprehensive resource assessment which looked at the biology, fishing efficiency and stock abundance and distribution (Hart et al. 2018). The overall conclusion was that the stock is highly productive, with an average maximum age of 1.5 years, as well as being abundant and widely distributed along the West and South Coast of Western Australia. The estimated area of habitat fished in 2020 was 500 km^2, a substantial decrease from the 1500 km^2 fished in 2019. This area was a minor percentage (<5%) of the total estimated habitat area on the West Coast of 20,073 km^2 (Hart et al. 2019), where most of the fishing occurs. The current catch of 254 t is likely to be no more than 10% of the total biomass, at a conservative estimate. Consequently, the breeding stock is considered to be **adequate**.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

The selective method of fishing used results in a minimal level of bycatch of other species. In 2020 there was two reported entanglements with a whale in octopus fishing gear. Fishers have adopted gear changes to mitigate entanglements, which includes setting pots on longlines, and using weighted ropes that hang vertically in the water column. **Low** risk.

HABITAT AND ECOSYSTEM INTERACTIONS

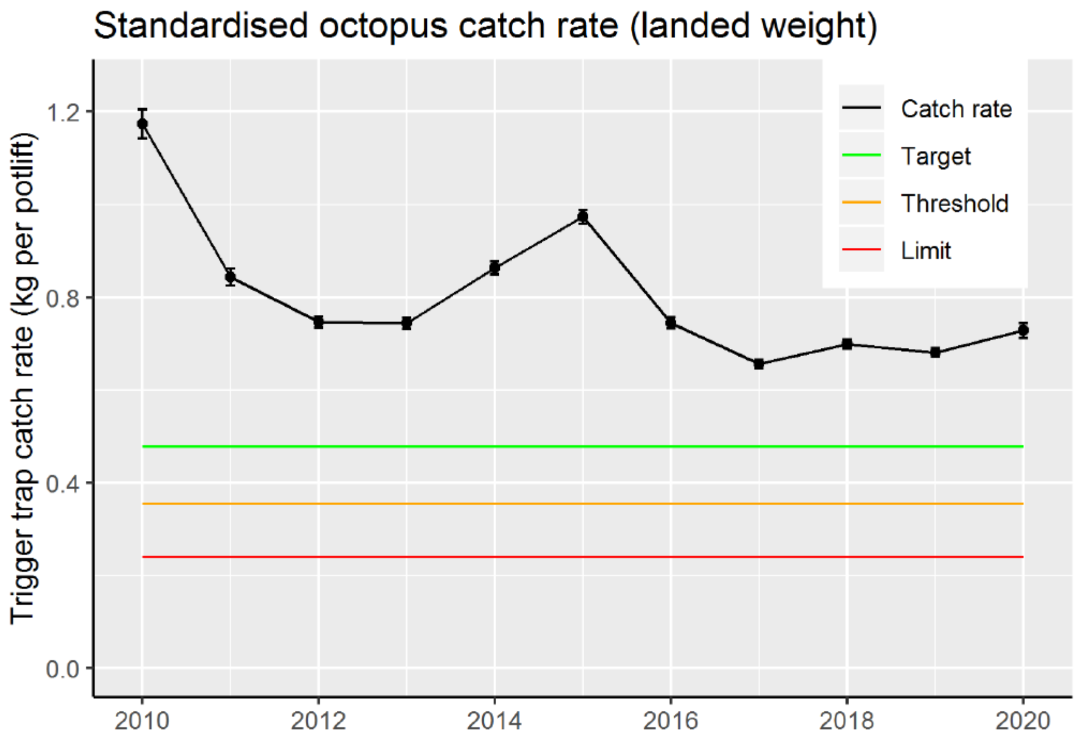
Habitat

In the CSLPMF and OIMF, octopus-specific pots are set in similar habitats to those fished in the WCRLMF, as well as sandy and seagrass areas, particularly in Cockburn Sound. These are not expected to impact on benthic habitats as the soak times are at long intervals, averaging 10

days in the OIMF and 15-20 days in the CSLPMF. Rock lobster potting in the WCRLMF occurs primarily on sand areas around robust limestone reef habitats covered with coralline and macro-algae, and these habitats are considered resistant to lobster potting due to the hard nature of the bottom substrate (see WCRLMF report for full details). **Low** Risk.

Ecosystem

This fishery harvests only a small amount of the octopus available in the ecosystems per annum. The effect from this harvesting on the rest of the ecosystem, given that the catch is spread over a wide region, is likely to incur a **Negligible** risk to the ecosystem.



OCTOPUS FIGURE 3.
Standardised catch per unit effort (SCPUE) (±95% CL) in kg / pot (landed weight) of *Octopus djinda*. Biological reference points (Target, Threshold, Limit) are also given (see Department of Primary Industries and Regional Development, 2018 for definition of BRPs).

SOCIAL AND ECONOMIC OUTCOMES

Social

Each dedicated octopus fishing vessel employs between 2 and 4 people. Within the octopus-specific fisheries, 4 vessels fished in the CSLP, and 25 vessels in the OIMF. More than 20 vessels landed octopus as a by-product in the WCRLMF. There is also a substantial processing and value-added component to the octopus catch with factories in Fremantle and Geraldton. **Low** Risk.

Economic

The estimated annual value for 2020 was $2.8 million based on the total catch of 254 t and an average product price of $10.85 per kg live weight. **Low** Risk.

GOVERNANCE SYSTEM

Annual Catch Tolerance Levels

Commercial – Acceptable

The target catch range for octopus is 200-500 t. The 2020 catch of 254 t was within the acceptable range.

Harvest Strategy (Formal)

The harvest strategy for the Octopus Resource of Western Australia (2018 – 2022) was published in April 2018 (DPIRD 2018). The main performance indicator in the harvest strategy is a standardised catch per unit effort (SCPUE) in kg/pot lift, which accounts for environmental and efficiency changes in the fishery. Target, Threshold, and Limit reference points have been set, and the fishery is currently above the target level (Octopus Figure 3).

Compliance

There are no significant issues.

Consultation

The Department undertakes consultation directly with the Southern Seafood Producers Association WA (SSPA) and licensees on operational issues. Industry Annual Management Meetings are convened by the Department through the Western Australian Fishing Industry Council (WAFIC), who are also responsible for undertaking statutory management plan consultation on behalf of the Department under a Service Level Agreement.

Consultation processes with the recreational sector are facilitated by Recfishwest under a Service Level Agreement with the Department. However, the Department also undertakes direct consultation with the community on specific issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

In 2020 the Department proposed management changes to formally incorporate the use of baited traps into the fishery, after scientific trials.

The Octopus Interim Managed Fishery successfully attained MSC certification in late 2019, and passed the 1st audit in 2020. A gap analyses was undertaken to include the baited trap trial in the MSC unit of certification in January 2020.

In 2020, the Department in collaboration with the Department of Biodiversity, Conservation and Attractions have been working with permit holders in the OIMF to further improve whale entanglement mitigation measures. Arrangements will be formalised by amendments to the OIMF Management Plan in 2021.

EXTERNAL DRIVERS

Cephalopods in general, including octopus, are known to be subject to large environmentally-driven fluctuations in abundance. Octopus was rated as a **low** risk to climate change.

The move of the rock lobster fishery from an effort-controlled fishery to a catch quota fishery, coupled with significant effort reductions, will ensure the octopus catch in the WCRLMF remains a low proportion of the overall catch.

REFERENCES

Amor MD, Hart AM. 2021. *Octopus djinda*, sp. nov. (Cephalopoda: Octopodidae): a new member of the *Octopus vulgaris* group from southwest Australia. *Zootaxa.*

Department of Fisheries 2018. Octopus resource of Western Australia harvest strategy, 2018 – 2022. Fisheries Management Paper No. 282. V1. Department of Primary Industries and Regional Development, Western Australia. http://www.fish.wa.gov.au/Documents/management_papers/fmp286.pdf

Hart, A.M., Murphy, D., Hesp, S.A., Leporati, S. 2019. Biomass estimates and harvest strategies for the Western Australian *Octopus* aff. *tetricus* fishery. ICES Journal of Marine Science 76 (7): 2205-2217.

Hart, A.M., Murphy, D.M., Harry, A.V. and Fisher, E.A. 2018. Western Australian Marine Stewardship Council Report Series No. 14: Resource Assessment Report Western Australian Octopus Resource. Department of Primary Industries and Regional Development, Western Australia. 114p. http://www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_14.pdf

Ryan KL, Hall NG, Lai EK, Smallwood CB, Taylor SM, Wise BS. 2017. Statewide survey of boat-based recreational fishing in Western Australia 2015/16. Fisheries Research Report No. 287. Department of Primary Industries and Regional Development, Western Australia.

WEST COAST NEARSHORE AND ESTUARINE FINFISH RESOURCE STATUS REPORT 2021

R. Duffy, N. Blay and S. Blazeski

OVERVIEW

The West Coast Nearshore and Estuarine Finfish Resource (WCENSR) encompasses 10 commercial fisheries (West Coast Estuarine Managed Fishery, West Coast (Beach Bait Fish Net) Managed Fishery, South West Coast Salmon Managed Fishery, Cockburn Sound (Fish Net) Managed Fishery, Cockburn Sound (Line and Pot) Managed Fishery, South West Coast Beach Net Fishery (Prohibition Order 43), Open Access fishing in the West Coast Bioregion using nets, and three FBL condition exemptions), as well as recreational and customary fishing that targets nearshore and estuarine species. The main commercial methods are haul, beach seine and gill netting. The main recreational method is line fishing from the beach or via a boat.

Four estuaries are open to commercial fishing (Swan-Canning Estuary, Peel-Harvey Estuary, Vasse-Wonnerup Estuary and Toby Inlet). The Peel-Harvey Estuary commercial fishery (Area 2 of the West Coast Estuarine Managed Fishery) received Marine Stewardship Council (MSC) certification for sea mullet in June 2016 (see Department of Fisheries 2015). Links to more detailed, online information are provided in the reference list.

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2020: 246.8 t	Acceptable
Recreational fishery	Total Catch 2017/18: 49–64 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Western Australian Salmon	Above Target	Adequate
Sea Mullet (WCB)	Above threshold	Adequate
Australian herring	Above threshold	Recovering
Yellowfin whiting	Above threshold	Adequate
Whitebait	Below limit	Inadequate
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Negligible risk	Adequate
Habitat	Negligible risk	Adequate
Ecosystem	Moderate risk	Adequate
Economic (GVP < $1 m)	Moderate risk	Acceptable
Social (high amenity)	Moderate risk	Acceptable
Governance	Moderate risk	Acceptable
External Drivers	High risk	

CATCH AND LANDINGS

In 2020, the total commercial catch within the West Coast Nearshore and Estuarine Finfish resource was 246.8 t. This catch is much lower (~150 t) than the catch reproted in 2019 (406.5 t), mostly due to an approximatley 130 t reduction in the catch of Western Australian Salmon. This reduction was a result of reduced demand related to COVID and large reductions in rock lobster fishing, which uses salmon as bait. The majority of the catch (~55%) was a single species, sea mullet (Nearshore and Estuarine Finfish Table 1), and nearly all of this was taken in a single fishery, the West Coast Estuarine Manged Fishery.

The top 10 nearshore and estuarine species (or species groupings) in the West Coast represented 95% of the boat-based recreational catch (kept by numbers) in 2017/18. The estimated harvest for these 10 species was steady at apprxoimately 56 t (95% CI 49–64 t) in 2017/18 compared with 65 t (95% CI 57–73) in 2015/16 (Ryan et al. 2019). The total recreational shore-based catch was not estimated but is believed to represent a significant proportion of the overall catches of nearshore and estuarine species.

NEARSHORE AND ESTUARINE FINFISH TABLE 1.
Total catches (tonnes) of the top 5 finfish (ordered by catch (t) in reporting year) in commercial fisheries within the West Coast Estuarine and Nearshore Scalefish Resources over the previous five years.

Common name	Scientific name	2016	2017	2018	2019	2020
Sea mullet	Mugil cephalus	138.4	127.1	140.9	114.3	138.9
Australian herring	Arripis georgianus	61.7	48.3	42.8	45.5	42.1
Yellowfin whiting	Sillago schombergkii	31.8	25.9	23.4	33.2	22.1
Western Australian salmon	Arripis truttaceus	98.0	103.8	139.5	147.8	16.6
Whitebait	Hyperlophus vittatus	16.3	15.1	40.2	24.2	10.9
Other finfish		35.3	32.8	41.3	41.5	16.2
All Species		381.5	353.0	428.1	406.5	246.8

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

The status of each stock is assessed using a weight-of-evidence approach that considers all available information about the stock. Use of the indicator species approach is currently under review.

Sea Mullet (Sustainable-Adequate)

The population structure of sea mullet in WA is unclear, due to uncertainty about the level of connectivity between Bioregions, and is therefore managed at the Bioregion level.

Recent commercial landings in the West Coast Bioregion (WCB) are low compared to historical levels due to reductions in fishing effort (Nearshore and Estuarine Finfish Figure 1). Since 2000, Landings have been relatively stable since 2000, ranging from 77 t (in 2011) to 143 t (in 2015). The 2020 WCB catch remained within this range, at 138.9 t (Table 1).

The boat-based recreational catch is estimated to be <1 t (Ryan et al. 2019) and, while the current recreational shore-based catch is not known, it is believed to be low.

In the WCB, approximately 60% of the commercial catch was taken in the Peel-Harvey Estuary where it forms the basis of an MSC certified fishery. A recent stock assesment (2021), indicated that sea mullet biomass has largely been maintained at a level above that estimated for MSY, with low levels of current fishing activity. Therefore, the current risk level for sea mullet is estimated to be MEDIUM, with current management measures considered to be maintaining the stock at an acceptable level (Duffy et al. in prep.).

On the basis of this evidence, the sea mullet stock in this region is classified as **sustainable-adequate**.

Australian herring (Sustainable-Recovering)

This species is caught by commercial and recreational fisheries in WA and South Australia, with negligible quantities also taken in Victoria (Smith et al. 2013a).

In 2020, the total commercial catch of Australian herring for the State was 79.3 t, with 42.1 t caught within the West Coast Nearshore and Estuarine Finfish resource (Nearshore and Estuarine Finfish Figure 2). Approximatley 80% of the resource

based catch was from two fisheries, the South West Coast Beach Net Fishery (Prohibition Order 43) (SWCBN) & Cockburn Sound (Fish Net) Managed Fishery (CSFN).

The estimated boat-based recreational harvest range for Australian herring in the West Coast was steady at 11 t (95% CI 8-14) in 2017/18 and 2015/16 (Ryan et al. 2019). The estimated shore-based recreational harvest range of Australian herring in the Perth metropolitan area from February – June was steady at 13 t (95% CI 5-21) in 2020 compared with 17 t (95% CI 10-24) in 2019.

A workshop to assess stock status of Australian herring was undertaken in 2017 (Wise and Molony 2018). The workshop was attended by DPIRD staff, South Australian scientists and managers, independent scientists and fishing industry representatives. Outcomes from the assessment determined there is currently a MEDIUM RISK to the stock, and stock biomass is projected to continue to increase under current management arrangements.

On this basis, the Australian herring stock is classified as **sustainable-recovering**.

Yellowfin whiting (Peel-Harvey) (Sustainable-Adequate)

In WA, yellowfin whiting range from Exmouth southwards, including relatively low densities of fish along the south coast. The population structure over this range is unclear and is currently under investiagation by a team in South Australia. As a result, Yellowfin whiting are currently managed as two separate stocks. The southern stock includes the West Coast Bioregion and the South Coast Bioregion (SCB).

The abundance of this species in both the WCB and SCB has been gradually increasing since the 1950s in response to ocean warming (Smith et al. 2019). This pattern was demonstrated by the catch rate trend in the Peel-Harvey Estuary, which exhibuited a rapid increase from 10 t caught in 2012 to the 30 t in landed in 2015 (Smith et al. 2019). The increase was due to a strong recruitment event (Department of Fisheries 2017), potentially reflected in catch trends for the Bioregion, which exhibited a peak in 2015 (Nearshore and Estuarine Finfish Figure 3). The total recreational catch is unknown due to a lack of information about the shore-based sector which is believed to take almost all recreational landings of this species (Brown et al. 2013). The boat-based recreational catch is estimated to be very low (<1 t) (Ryan et al. 2019).

The most recent level 3 assessment was based on age structure data collected in 2015 and 2016. 'Per recruit' modelling (SPR) suggested that the spawning biomass was above the threshold level (30%). A more recent assessment, based only on catch, provided further evidence of high biomass, and low fishing effort (Ferguson & Duffy 2021). Therefore this stock is considered to have a LOW risk.

On the basis of this evidence, the yellowfin whiting stock in this Bioregion is classified as **sustainable-adequate**.

Western Australian Salmon (Sustainable-Adequate)

The majority of the catch of Western Australian salmon has historically been taken on the South Coast. The catch of salmon on the West Coast has reflected these patterns, but to a lesser degree (Nearshore and Estuarine Finfish Figure 4).

Refer to South Coast Estuarine and Nearshore Scalefish and Invertebrate Resource chapter for information on the stock status in this region.

Other Species

The following species are not considered indicators, but are of relevance due to catches in the MSC certified Peel-Harvey Estuary sea mullet fishery, or have undergone management changes due to stock status concerns.

Estuarine cobbler (Peel-Harvey-Adequate)

In WA, cobbler occur in ocean and estuarine waters but are mainly caught by commercial fishers in estuaries. Landings by recreational fishers are believed to be negligible. Each estuary has a discrete stock of cobbler, which is genetically distinct to other estuarine populations and also distinct to cobbler populations in adjacent ocean waters. Catch in 2020 was 0.7 t, and has been somewhat stable in recent years, albeit at a level lower than historical catches (Fisher et al. 2020).

A Catch-MSY method of stock assessment has been undertaken, however, a core assumpiton of the method is a constant carrying capacity. Given the substantial human and environmental modifications of this system, violation of the assumption (Smith & Lenanton 2021) is considered to invalidate this approach for stock assessment. Given the low catch now taken in Peel-Harvey, stock status for cobbler is now assessed through an Ecological Risk Assessment (ERA) process that considers many data streams. The ERA determined cobbler in Peel-Harvey had a MEDIUM risk.

On this basis, the stock is classified as **sustainable-adequate**.

Perth herring (Environmentally Limited)

Perth herring is endemic to the WCB, where a single breeding stock is believed to occur. Stock level was assessed via commercial catch rate trends in the Swan-Canning Estuary until the

cessation of fishing for this species in 2007 (Smith 2006). Swan-Canning catch rates suggested a major decline in the stock after 1980, which is attributed to historical overfishing and environmental degradation in estuaries (Smith 2006). Fishery-independent evidence suggests stock abundance remains low compared to historical levels (Valesini et al. 2017). The Peel-Harvey Estuary is now the only area where this species is caught commercially, albeit in low quantities, with 0.8 t landed in 2020. Landings by recreational fishers are negligible.

Low spawning success due to environmental degradation in the upper reaches of the WCB estuaries and low rainfall is believed to be the main cause of ongoing low stock abundance. Risk status of Perth herring in Peel-Harvey is assessed through the ERA process as part of MSC certification. The risk for this species was determined to be HIGH. The stock is classified as **environmentally limited.**

Southern garfish (Perth metropolitan zone) (Inadequate)

Southern garfish ranges across southern Australia from WA (Lancelin) to New South Wales (Eden). The population structure is complex. Semi-discrete populations can arise over small distances (<60 km) due to the low rates of movement/dispersal by individual fish (Smith et al. 2017). In the WCB, the main fishing area was historically the Perth metropolitan zone, particularly Cockburn Sound. Garfish in this area are likely to have limited connectivity with populations further south (e.g. in Geographe Bay). In 2020, the total WA commercial catch was 14.3 t, and the catch from within this resource was 0.7 t.

The most recent level 3 assessment (Smith et al. 2017) indicated that spawning biomass in the Perth metropolitan zone was below the limit reference level (i.e. 20% of unfished level), and indicated the risk level was HIGH. In June 2017, this zone was closed to commercial and recreational fishing for southern garfish to aid stock recovery. Some recovery would be expected due to management action, therefore, risk rating and stock sustainability requires reassessment.

On the basis of the most recent assessment, the southern garfish stock in the Perth metropolitan zone is classified as **unsustainable-recovering.**

Tailor (Adequate)

In WA, tailor occur from Onslow to Esperance and is believed to constitute a single stock over this range (Smith et al. 2013b). The catch rate of tailor fluctuates in response to recruitment variations, which are linked to environmental factors (Smith et al. 2013b, Department of Fisheries 2017).

In 2020, the total commercial catch for the state was 15.1 t, with 3.8 t landed within the West Coast Nearshore and Estuarine Finfish resource. Peaks and declines in the catch of tailor within the West Coast Bioregion reflect those of the tailor catch of the whole state. State catch has declined substantially from the high numbers recorded around 2000, while the WCENSR catch in 2020 remains within the historic range of catches.

The estimated boat-based recreational harvest range for tailor in the West Coast was steady at 2 t (95% CI 1-3) in 2017/18 (Ryan et al. 2019). The estimated shore-based recreational harvest for tailor in the Perth metropolitan area from February – June was steady at 0.4 t (95% CI 0-1.3) in 2020 when compared to 0.1 t (95% CI 0-0.7) in 2019.

The most recent Catch-MSY based assessment of tailor, undertaken at a state level, determined that the stock is sustainable (Roelofs et al. 2021). Therefore the current risk level for tailor is MEDIUM.

On this basis, the stock is classified as **sustainable-adequate**.

Whitebait (Inadequate)

In WA, whitebait is restricted to coastal waters between Perth and Cape Naturaliste. Since 2003/04, virtually all commercial landings have been reported in the Bunbury area by the South West Beach Seine Fishery. Landings peaked during the 1990s and have declined ever since. Within this broader trend, is a highly cyclic trend of two to five year peaks and troughs existing in catch records (Nearshore and Estuarine Finfish Figure 5). A stock assessment undertaken in 2018 indicated a risk rating of SEVERE and attributed recent low catches to low stock abundance. In 2020, the total commercial catch for the state was 10.9 t, all of which was derived from a single fishery in the West Coast Bioregion, the SWBSN fishery, and is the lowest level of catch reported in recent years. Whitebait has a lifespan of only 3-4 years, and so catches are likely to be strongly driven by recruitment variability. Some recovery would be expected due to management action, therefore the risk rating requires reassessment.

The available evidence indicates that the stock is **unsustainable-inadequate**. The contracted distribution and apparent heatwave impacts also suggest environmental limitations.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

The small-scale commercial finfish fisheries in nearshore and estuarine waters mainly use gill, seine and haul nets that are deployed in a targeted manner. Few non-target species are taken. Mesh size regulations ensure that target species caught by these methods are within an

appropriate size range. Minimal discarding occurs because virtually all fish taken can be retained and marketed. Recreational fishers mainly use line-based methods in nearshore and estuarine waters. This method can result in the capture and release of non-target species and undersized fish. The risks associated with post-release mortality vary considerably among species. In general, fish in nearshore and estuarine waters are captured from shallow depths and have a lower risk of barotrauma-related injuries than deep water oceanic species and so bycatch species are at **low risk**.

Protected Species

Interactions with listed species by the fishing gear used in these commercial fisheries are negligible. Estuarine birds have been known to interact with fishing nets, but none have been reported in recent years and the risks to their populations are negligible. Commercial fishers are required to report all interactions with listed species.

Recreational fishers using line-fishing methods are unlikely to capture listed species and interactions are expected to be a **negligible risk**.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

The operation of gillnets and haul nets over predominantly sand and mud bottoms is unlikely to have any impact on these habitats in estuaries and nearshore waters. Similarly, line fishing methods used by recreational fishers have a negligible impact on the bottom substrates. Anchoring by recreational fishing vessels may have localised impacts on habitats such as seagrass and reefs. Hence there is a **negligible risk** to benthic habitats.

Ecosystem

Whitebait is a key prey item for little penguins (*Eudyptula minor*) and whitebait availability may affect their breeding success (Cannell et al. 2012). Little penguins from colonies at Penguin Island and Garden Island forage for whitebait and other baitfish between Cockburn Sound and Geographe Bay (Cannell 2016). Whitebait removals by fishing pose a **moderate** risk to these penguins when whitebait abundance is low.

SOCIAL AND ECONOMIC OUTCOMES

Social

The nearshore and estuarine recreational fisheries of the WCB provide a **high social amenity** for the WA community. This Bioregion hosts the main population centres and fishery resources are very accessible to shore-based and boat-based recreational fishers. There is currently a **moderate risk** to these values.

Economic

Estimated annual value (Gross Value of Production) to commercial fishers for 2020:

Level 1: <$1 million

This reflects the commercial beach price of landed product only and does not include economic flow-on values such as employment within the fishery, additional employment/value in distribution networks, retail fish sales sectors and spending on fuel and equipment.

The West Coast Bioregion is the most heavily used area in Western Australia for recreational fishing (including charter-based fishing). The estimated value of all recreational fishing in the area is $1.7 billion. This consists of $305.6 million in the South West, $217.2 million in the Peel region, $1.1 billion in the Metropolitan area and $42.9 million in the Wheatbelt (McLeod and Lindner 2018). A significant amount of this value is derived from boat and shore-based fishing in nearshore and estuarine areas of the WCB.

Due to the decline in whitebait and ongoing recovery of herring, the economic risk is considered **Moderate.**

GOVERNANCE SYSTEM

Harvest Strategy

This resource is harvested using a constant exploitation approach, where the annual catch taken is assumed to vary in proportion to stock abundance. Indicator species are used to determine the status of the resource. All indicator species are assessed annually based on catch and/or catch rate trends, where data is available (noting that recreational fishery catch data is limited for these stocks). Additionally, higher level assessments are periodically undertaken for some stocks. The previous formal harvest strategy for finfish captured commercially within the Peel-Harvey Estuary (Department of Fisheries 2015) was updated during 2020 (see Fisheries Management Paper No.303).

A separate harvest strategy will also be developed for Australian herring (*Arripis georgianus*) and West Australian salmon (*Arripis truttaceus*), the range of which extends across multiple jurisdictions.

Allowable Catch Tolerance Levels

West Coast Estuarine Managed Fishery (Peel-Harvey Estuary only):

Finfish caught commercially in the Peel-Harvey Estuary are managed according to a Harvest

Strategy which uses catches and catch rates as indicators of fishery performance (Department of Fisheries 2015). In 2020, the catch of sea mullet was within the acceptable catch tolerance level of <150 t identified in the harvest strategy (DPIRD 2020). The Department reviewed the current risk posed by this catch level and determined that it was **acceptable**.

Australian herring fisheries:

The commercial catch tolerance range is 50-179 tonnes. This range represents the minimum and maximum total annual catches by 'minor' herring fisheries (i.e. excluding the former G-trap net fishery) over the period from 2000-2014. The 2019 catch was 65.6 t, which was **acceptable**. The current catch tolerance range used to assess annual recreational fishery performance is based on boat-based recreational catches remaining below the 2013/14 estimated state-wide catch of herring, i.e. <16 t. The 2017/18 boat-based recreational catch was 14 t, which was **acceptable**.

Compliance

The Department undertakes regular compliance inspections to ensure fishing is being undertaken in accordance with the governing legislation and runs education programs with various stakeholder groups to increase the levels of voluntary compliance.

Consultation

The Department undertakes consultation directly with the Southern Seafood Producers Association and licensees on operational issues. Industry Management Meetings are convened by the Department through the Western Australian Fishing Industry Council (WAFIC), who also undertake statutory management plan consultation on behalf of the Department under a Service Level Agreement. Consultation with the recreational sector is undertaken via the peak representative body, Recfishwest, and/or the Department's website when documents are released for public comment.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

As part of the Government's election commitment to ensure the continued health of the Peel-Harvey Estuary, in 2018 a Voluntary Fishery Adjustment Scheme (VFAS) was initiated to remove three to five commercial licences from the Peel Harvey Estuary. At the completion of the scheme the amount of net that can be used by commercial fishers in the Peel-Harvey Estuary (Area 2 of the WCEMF) will be reduced in proportion to the number of licences that are removed. The VFAS also relates to the take of blue swimmer crabs in the estuary, see the West Coast Blue Swimmer Crab Report for further information on this.

To assist recovery of the whitebait stock, management arrangements to reduce fishing pressure were introduced in July 2019. These will reduce the commercial catch to approximately 50% of the historical average catch.

EXTERNAL DRIVERS

Annual variations in coastal currents (particularly the Leeuwin and Capes Currents) appear to influence the spawning and recruitment patterns of species such as whitebait, tailor, Australian herring and western Australian salmon (Lenanton *et al.* 2009).

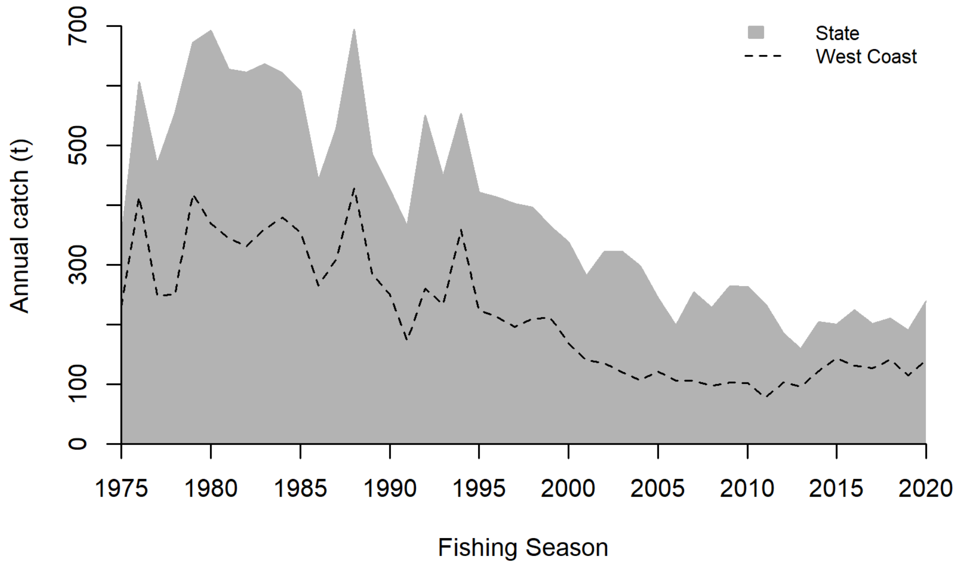
Changes in environmental variables due to climate change (such as ocean temperature, currents, winds, nutrient supply, rainfall, ocean chemistry and extreme weather conditions) are expected to have major impacts on marine ecosystems. These impacts are expected to create both difficulties and opportunities for fisheries.

In 2011, a 'heatwave' event in coastal waters of south-western WA altered the distribution (e.g. tropical species occurring in temperate waters) and behaviour (e.g. spawning activity, migration) of many nearshore finfish species, which appears to have affected the abundance of these species in 2011 and in subsequent years (Caputi et al. 2014).

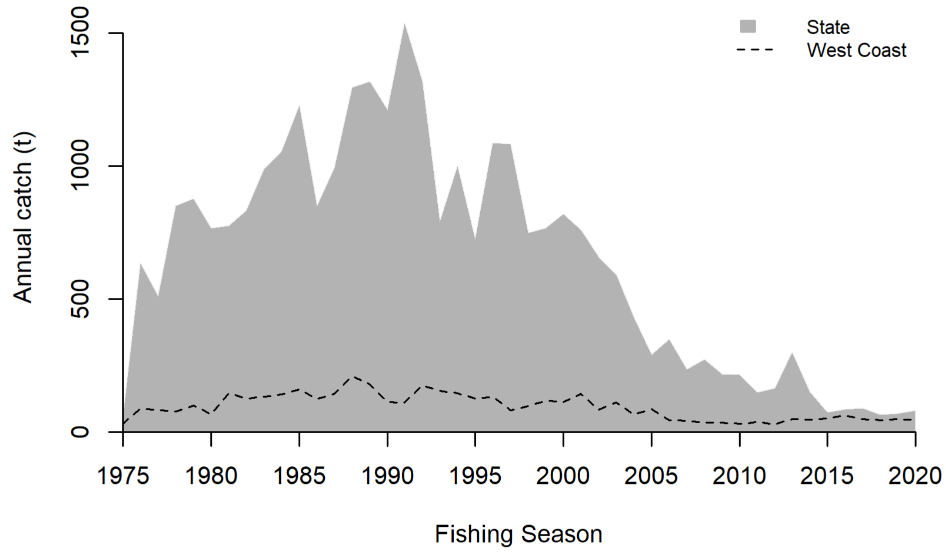
WCB estuaries are highly modified and often have degraded environments. As such, the impacts of environmental factors on estuarine fish are likely to be more important than fishing pressure. Impacts in estuaries are most pronounced among 'estuarine-dependent' species, i.e. those that rely on estuarine habitats for spawning, feeding and/or nursery areas (e.g. cobbler, Perth herring, black bream).

Fluctuating market demand is a significant factor affecting the annual commercial catch levels of many species.

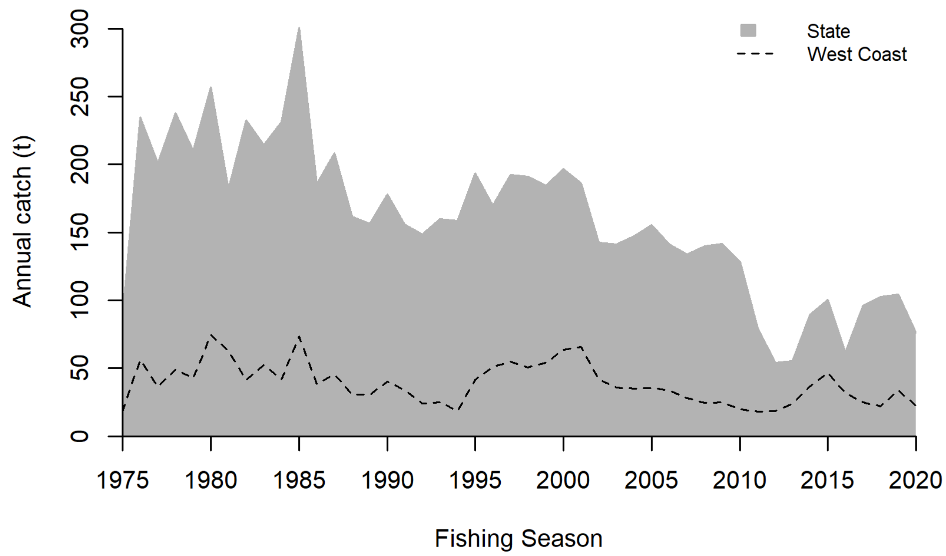
High risk.



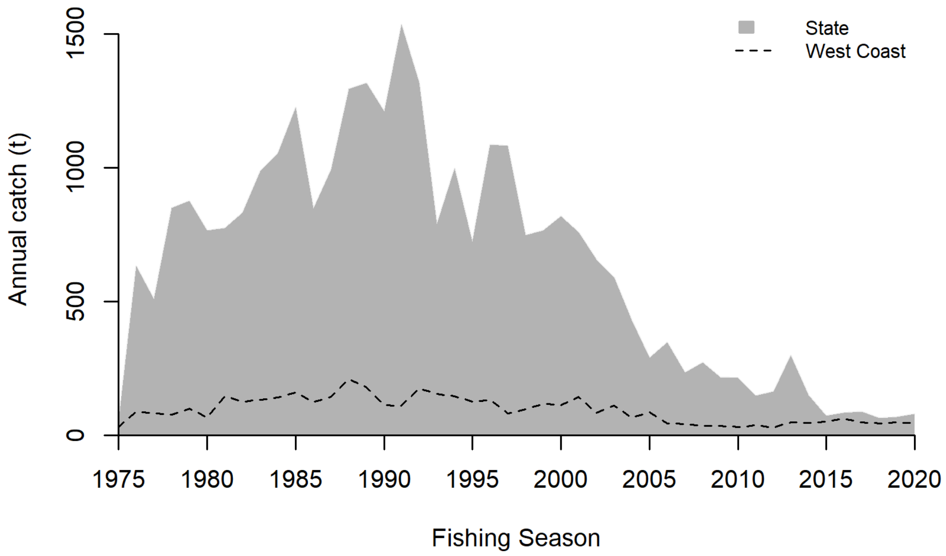
NEARSHORE AND ESTUARINE FINFISH FIGURE 1.
Annual commercial catch of sea mullet in the State and in the West Coast Bioregion since 1975.



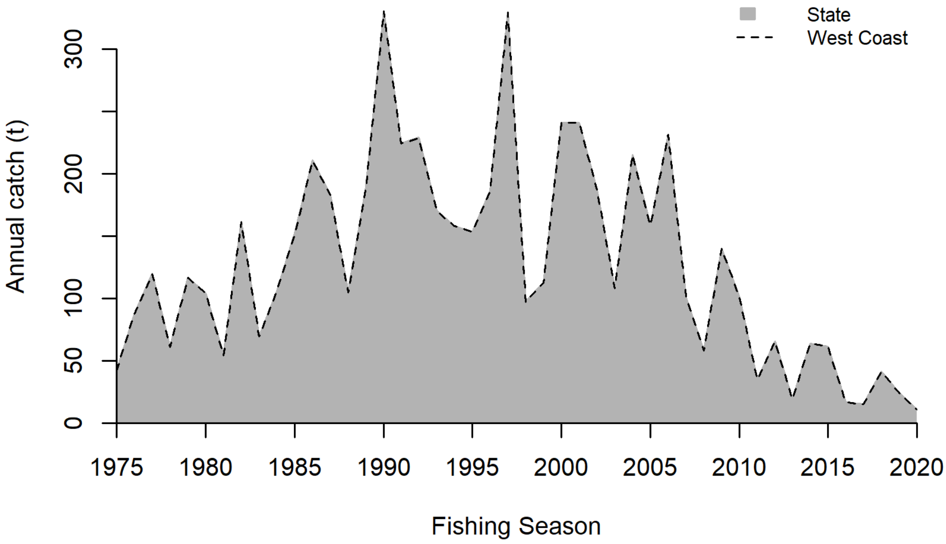
NEARSHORE AND ESTUARINE FINFISH FIGURE 2.
Annual commercial catch of Australian herring in the State and in the West Coast Bioregion since 1975.



NEARSHORE AND ESTUARINE FINFISH FIGURE 3.
Annual commercial catch of yellowfin whiting in the State and in the West Coast Bioregion since 1975.



NEARSHORE AND ESTUARINE FINFISH FIGURE 4.
Annual commercial catch of Western Australian salmon in the State and in the West Coast Bioregion since 1975.



NEARSHORE AND ESTUARINE FINFISH FIGURE 5.
Annual commercial catch of whitebait in the State and in the West Coast Bioregion since 1975.

REFERENCES

Brown J, Dowling C, Hesp A, Smith K, and Molony B. 2013. Status of nearshore finfish stocks in southwestern Western Australia. Part 3: Whiting (Sillaginidae). Fisheries Research Report No. 248. Department of Fisheries, Western Australia. 128p. http://www.fish.wa.gov.au/Documents/research_reports/frr248.pdf

Duffy R, Harris D, Fisher E, Smith K, Johnston D, Denham A, Hesp SA. In prep. Resource Assessment Report. South-West Estuarine and Nearshore Finfish Resource Part 1: Sea Mullet and Yellowfin Whiting. Department of Primary Industries and Regional Development, Western Australia.

Cannell BL, Chambers LE, Wooller RD, and Bradley JS. 2012. Poorer breeding by little penguins near Perth, Western Australia is correlated with above average sea surface temperatures and a stronger Leeuwin Current. Marine and Freshwater Research 63: 914-925.

Cannell B. 2016. How resilient are the Little Penguins and the coastal marine habitats they use? Report Year 3. Report for City of Rockingham, Fremantle Ports. Murdoch University. 40 p.

Caputi N, Jackson G, and Pearce A. 2014. The marine heatwave off Western Australia during the summer of 2010/11 – 2 years on. Fisheries Research Report No. 250. Department of Fisheries, Western Australia.

40p.

Department of Fisheries. 2015. Finfish Resources of the Peel-Harvey Estuary Harvest Strategy 2015 – 2020. Version 1.0. West Coast Estuarine Managed Fishery (Area 2). May 2015. Fisheries Management Paper No. 274. Department of Fisheries, Western Australia. 28p. http://www.fish.wa.gov.au/Documents/management_papers/fmp274.pdf

Department of Fisheries, 2017. Addendum to: Johnston DJ, Smith KA, Brown JI, Travaille KL, Crowe F, Oliver RK, Fisher EA. 2015. Western Australian Marine Stewardship Council Report Series No. 3: West Coast Estuarine Managed Fishery (Area 2: Peel-Harvey Estuary) and Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery. Department of Fisheries, Western Australia. 284p. http://www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_3_addendum.pdf

Department of Primary Industries and Regional Development. 2020. Fisheries Management Paper No. 303. Estuarine and Nearshore Finfish Resource of South-West Western Australia Harvest Strategy 2020-2025 Version 1.0. http://www.fish.wa.gov.au/Documents/management_papers/fmp303.pdf

Ferguson G, Duffy R, 2021. Yellowfin Whiting (2020) *Sillago schomburgkii*. In Toby Piddocke, Crispian Ashby, Klaas Hartmann, Alex Hesp, Patrick Hone, Joanne Klemke, Stephen Mayfield, Anthony Roelofs, Thor Saunders, John Stewart, Brent Wise and James Woodhams (eds) 2021, Status of Australian fish stocks reports 2020, Fisheries Research and Development Corporation, Canberra.

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

Fisher EA, Hesp SA, Hall NG, and Sulin EH. 2014. Predicting the impacts of shifting recreational fishing effort towards inshore species. FRDC Project No. 2010/001. Fisheries Research and Development Corporation.

Lenanton RC, Caputi N, Kangas M, and Craine M. 2009. The ongoing influence of the Leeuwin Current on economically important fish and invertebrates off temperate Western Australia – has it changed? Journal of the Royal Society of Western Australia 92: 111–127.

McLeod P and Lindner R. 2018. Economic dimension of recreational fishing in Western Australia. Research report for the Recreational Fishing Initiatives Fund. Final report. Economic Research Associates, Perth. https://recfishwest.org.au/wp-content/uploads/2019/03/Economic-Dimensions-of-Recreational-Fishing-in-Western-Australia-Report-2.pdf

Roelofs A, Stewart J, Duffy R, Conron S, 2021, Tailor 2020 - *Pomatomus saltatrix*. In Toby Piddocke, Crispian Ashby, Klaas Hartmann, Alex Hesp, Patrick Hone, Joanne Klemke, Stephen Mayfield, Anthony Roelofs, Thor Saunders, John Stewart, Brent Wise and James Woodhams (eds) 2021, Status of Australian fish stocks reports 2020, Fisheries Research and Development Corporation, Canberra.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS. 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297. Department of Primary Industries and Regional Development, Western Australia.

Smallwood CB, Pollock KH, Wise BS, Hall NG, and Gaughan DJ. 2012. Expanding Aerial–Roving Surveys to Include Counts of Shore-Based Recreational Fishers from Remotely Operated Cameras: Benefits, Limitations, and Cost Effectiveness. North American Journal of Fisheries Management 32: 1265-1276.

Smith KA. 2006. Review of fishery resources and status of key fishery stocks in the Swan-Canning Estuary. Fisheries Research Report No. 156. Department of Fisheries, Western Australia. 84p.

Smith K, Brown J, Lewis P, Dowling C, Howard A, Lenanton R, and Molony B. 2013a. Status of nearshore finfish stocks in south-western Western Australia, Part 1: Australian herring. Fisheries Research Report No. 246. Department of Fisheries, Western Australia. 200p. http://www.fish.wa.gov.au/Documents/research_reports/frr246.pdf

Smith, K.A. and Lenanton, R.C. 2021. Almost forgotten: Historical abundance of eel-tail catfish populations in south-western Australian estuaries and their decline due to habitat loss and historical overfishing. Regional Studies in Marine Science 41: 101605.

Smith K, Lewis P, Brown J, Dowling C, Howard A, Lenanton R, and Molony B. 2013b. Status of nearshore finfish stocks in south-western Western Australia, Part 2: Tailor. Fisheries Research Report No. 247. Department of Fisheries, Western Australia. 112p. http://www.fish.wa.gov.au/Documents/research_reports/frr247.pdf

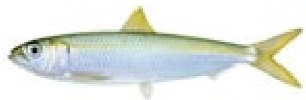
Smith K, Dowling C, Mountford S, Hesp A, Howard A, and Brown J. 2017. Status of southern garfish (*Hyporhamphus melanochir*) in Cockburn Sound, Western Australia. Fisheries Research Report No. 271. Department of Fisheries, Western Australia. 139p. http://www.fish.wa.gov.au/Documents/research_reports/frr271.pdf

Smith KA, Dowling C, and Brown J. 2019. Simmered then boiled: Multi-decadal poleward shift in distribution by a temperate fish accelerates during marine heatwave. Frontiers in Marine Science 6: 407.

Valesini FJ, Cottingham A, Hallett CS and Clarke KR. 2017. Interdecadal changes in the community, population and individual levels of the fish fauna of an extensively modified estuary. Journal of Fish Biology 90: 1734-1767.

Wise BS, and Molony BW. (Editors). 2018. Australian Herring and West Australian Salmon Scientific Workshop Report, October 2017. Fisheries Research Report No. 289. Department of Primary Industries and Regional Development, Western Australia. 158p. http://www.fish.wa.gov.au/Documents/research_reports/frr289.pdf

WEST COAST SMALL PELAGIC SCALEFISH RESOURCE STATUS REPORT 2021



J. Norriss and S. Blazeski

OVERVIEW

The five species comprising the west coast small pelagic scalefish resource are scaly mackerel (tropical sardine, *Sardinella lemuru*, pictured above), Australian sardine (pilchard, *Sardinops sagax*), Australian anchovy (*Engraulis australis*), yellowtail scad (*Trachurus novaezelandiae*) and maray (*Etrumeus jacksoniensis*). Scaly mackerel and Australian sardine are the indicator species and dominate the catch, which is taken predominantly by the West Coast Purse Seine Managed Fishery (WCPSMF) together with fishery developmental zone licence holders, using purse seine gear in waters between Geraldton and Cape Leeuwin. This region is split into three Zones - Northern Development Zone (all WA waters north of 31° 00’S, predominantly off Geraldton), Perth Metropolitan (31° 00’S to 33° 00’S, predominantly Cockburn Sound) and Southern Development Zone (33° 00’S to Cape Leeuwin, predominantly Geographe Bay). Licensees are also entitled to take Perth herring (*Nematalosa vlaminghi*), which forms part of the West Coast Nearshore and Estuarine Finfish Resource, but there have been no reported catches since 1997.

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery Commercial notional TACs: Perth Metropolitan and Southern Development Zone combined: 3,000 t (Australian sardine 2,328 t, other permitted sp. 672 t); Northern Development Zone: 2,700 t scaly mackerel.	Total Catch 2020: 493 t (all small pelagic species & zones combined)	Acceptable
Recreational fishery (not defined)	Total Catch 2017/18: <1 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Scaly mackerel	Above threshold	Adequate
Australian sardine	Above threshold	Adequate
Ecological		
Bycatch	Negligible Risk	Acceptable
Listed Species	Low Risk	Acceptable
Habitat	Negligible Risk	Acceptable
Ecosystem	Low Risk	Acceptable
Economic GVP <$1 m	Moderate risk	Acceptable
Social (Low amenity)	Negligible Risk	Acceptable
Governance	Stable	Acceptable
External Drivers	Low Risk	Acceptable

WEST COAST SMALL PELAGIC SCALEFISH FIGURE 1.
Map showing the boundaries of the West Coast Purse Seine Fishery and the Northern and Southern Development Zones, which comprise the large majority of the catch of the West Coast small pelagic scalefish resource.

CATCH AND LANDINGS

The total combined catch of the five west coast small pelagic scalefish species taken by the WCPSMF and developmental licensees in 2020 was 493 t, of which 68% was scaly mackerel and 29% Australian sardine (West Coast Small Pelagic Scalefish Figure 2). Scaly mackerel have dominated the catch since Australian sardine suffered mass mortality events in 1995 and 1998/99 caused by a herpesvirus.

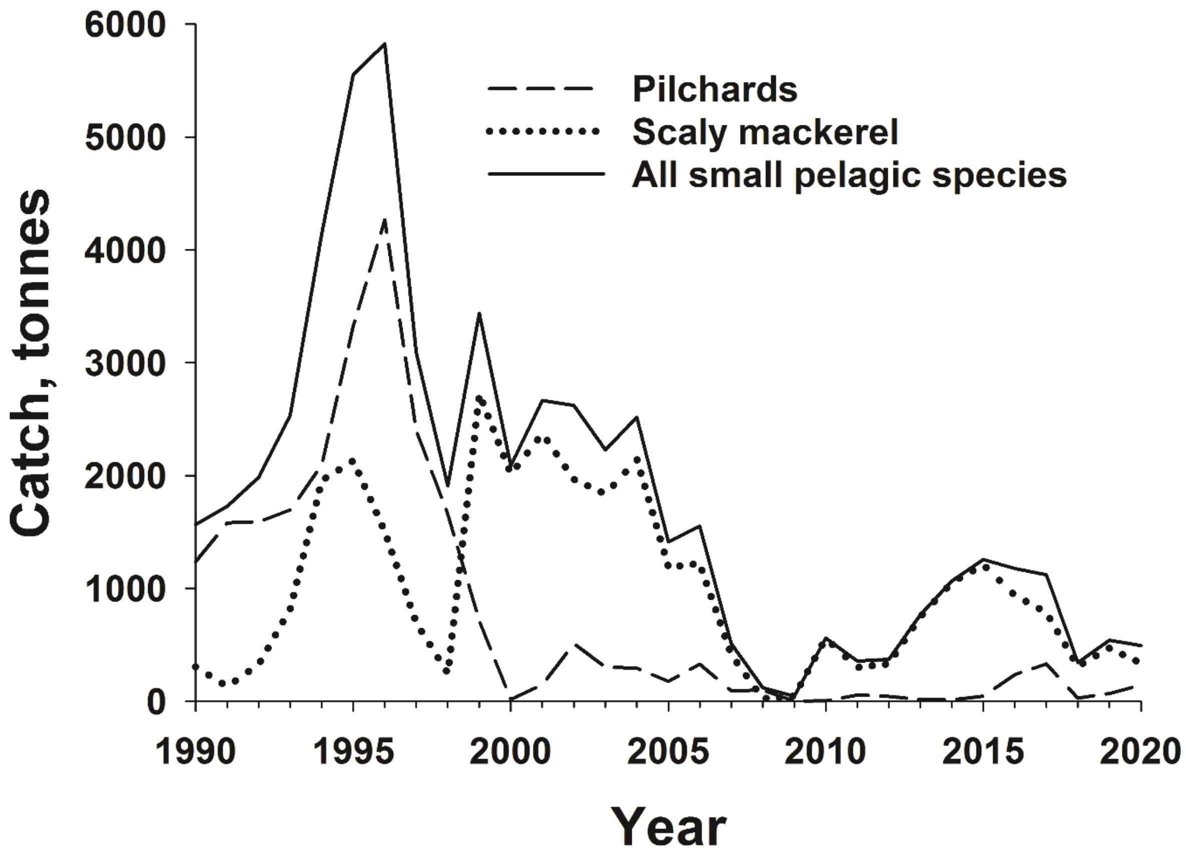
INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Scaly mackerel (Sustainable-Adequate)

Scaly mackerel are small, low trophic level pelagic species that feeds by filtering plankton. In WA longevity has been estimated to be up to 7 years of age, and a maximum fork length of 20 cm has been recorded.

The WCPSMF and developmental zone licensees operate at the southern limit of the scaly mackerel distribution in WA. Analysis of otolith chemistry showed no evidence for the existence of separate populations between Carnarvon and Fremantle (Gaughan and Mitchell 2000). They are a highly mobile species resulting in a patchy but widespread distribution.

The WCPSMF and developmental licensee catch of scaly mackerel in 2020 was 335 t, a 29% decrease from 2019 (West Coast Small Pelagic Scalefish Figure 2). Confidentiality requirements preclude disclosure of the spatial distribution of catch quantities. The limited spatial distribution of fishing effort, which has been at comparatively low levels in recent years, suggests that only a small proportion of a widespread stock is being targeted. Catches and biological stock status are therefore considered **sustainable-adequate**.



WEST COAST SMALL PELAGIC SCALEFISH FIGURE 2.
Time series of the total annual catch of all five west coast small pelagic scalefish species, scaly mackerel and Australian sardine by the WCPSMF and developmental licensees from 1990 to 2020.

Australian sardine (Sustainable-Adequate)

Australian sardine is a small, low trophic level pelagic species that feeds by filtering plankton. Longevity is estimated to be up to 9 years of age, and maximum size in the range of 200-250 mm SL.

The WCPSMF and developmental licensee catch of Australian sardine in 2020 was 145 t (West Coast Small Pelagic Scalefish Figure 2). Catches declined precipitously during the mid to late 1990s following two mass mortality events caused by a herpesvirus. While the stock had recovered by the mid-2000s (see below), catches have remained low. This is due to reduced effort and the fishery transitioning to primarily land scaly mackerel.

Population modelling, based on spawning biomass estimates (from egg surveys), catch-at-age and catch data, suggested the stock had recovered from the mass mortality events by the mid-2000s (Gaughan *et al.* 2008). By this time the annual exploitation rate was low: less than 5 per cent (around 400 t) of the estimated spawning biomass of approximately 25,000 t. Since then annual catches have remained below this level and so are unlikely to cause the stock to become recruitment overfished. Catches and biological stock status are therefore considered **sustainable-adequate**.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

The species available for capture in the WCPSMF and Development Zones are restricted by the West Coast Purse Seine Managed Fishery Management Plan 1989, a Prohibition on Fishing (Purse Seining) Order and an Instrument of Exemption issued under Sections 43 and 7(2)(e) respectively of the FRMA.

Bycatch

Small quantities of other finfish species are sometimes taken as bycatch, but this occurs infrequently and the majority are released from the net unharmed.

An ecological risk assessment (ERA) in 2021, assessed the impact of the WCPSMF and development zone activities on stocks of bycatch species as being **negligible** risk (Blazeski *et al.* 2021).

Protected species

Interactions with endangered, threatened and protected species (ETPs) must be reported to the Department on monthly statutory CAES returns. WCPSMF and development zone interactions are rare and usually result in the animal being released unharmed. No interactions were recorded by fishers in 2020.

The risk to protected species from WCPSMF and development zone activities was assessed as **negligible** (long nosed fur seal, Australian sea lion, syngnathids and other ETP species) and **low** (dolphins) in the 2021 ERA (Blazeski *et al.* 2021).

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

Purse seine nets are pelagic in nature, with little impact on benthic habitats during normal operations. On rare occasions nets may be deployed in shallow waters and come into contact with habitats such as seagrass beds. The light structure of the net is expected to cause minimal damage to benthic habitats when this occurs, and any impact is restricted to a small, localised area. The WCPSMF and Development Zones is therefore considered to be a **negligible** risk to these habitats (Blazeski *et al.* 2021).

Ecosystem

Australian sardine are a relatively short lived, low trophic level species important for ecosystem structure and function. Their abundance is subject to large natural variations in response to environmental conditions. Catch quotas are likely to be <10% of the spawning biomass, and trophic modelling by the much larger South Australian Australian sardine fishery (Goldsworthy *et al*. 2013) indicates minor impacts on top order predators. The ecosystem impact from fishing in the WCPSMF and Development Zones is considered **low** risk (Blazeski *et al.* 2021).

SOCIAL AND ECONOMIC OUTCOMES

Social

Small pelagic fish are not a major target for recreational fishers and catches are low: the only species detected in the catch of boat-based recreational fishers during 2017/18 was <1 t of yellowtail scad (Ryan *et al*. 2019). **Negligible** risk.

Economic

Local employment was provided by five active vessels as well as local processing factories. A small proportion of the catch is sold for human consumption while most is sold for bait or feed for aquaculture or pets. Product export was permitted by declaration of the WCPSMF and Development Zones as an approved Wildlife Trade Operation by the then Commonwealth Department of Environment and Energy in January 2020. The estimated gross value of production (GVP) for the WCPSMF in 2020 was <$1 million (Level 1). The economic risk is considered **Moderate**.

GOVERNANCE SYSTEM

Harvest Strategy

The WCPSMF is currently managed under a constant catch harvest strategy approach, with catches limited to notional Total Allowable Commercial Catches (TACCs).

Allowable Catch Tolerance Levels

Currently, a notional combined TACC, covering both the Perth metropolitan fishery and the Southern Development Zone, is set for Australian sardine and separately for other small pelagic species. For the 2020/21 licensing period (1 April 2020 – 31 March 2021) the notional TACC was 2,328 t for Australian sardine and 672 t for other small pelagic species and Perth herring combined. For the Northern Development Zone the notional TAC is 2,700 t for scaly mackerel. Reaching or exceeding the notional TACCs will trigger a management response.

Compliance

Compliance monitoring is via at-sea and on-land inspections.

Consultation

The Department undertakes consultation directly with the Southern Seafood Producers Association, WCPSMF and Development Zone licensees on operational issues on an as needs basis, and more formally via industry Management Meetings convened by the Western Australian Fishing Industry Council (WAFIC) pursuant to a Service Level Agreement with the Department. Consultation with the recreational sector is undertaken via the peak representative body, Recfishwest and/or the Department's website when documents are released for public comment.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives/Outlook Status

The West Coast Small Pelagic Scalefish Resource will continue to be monitored principally through Level 1 (catch based) assessments.

An Ecological Risk Assessment (ERA) in 2021 focussed on evaluating the impacts of WCPSMF and Development Zone activities on all relevant retained and bycatch species, endangered, threatened and protected species, habitats and the broader environment (Blazeski *et al.* 2021). The ERA involved a broad range of stakeholders including representatives of the commercial fishing sector, State and Australian Government agencies, Birdlife Australia, Conservation Council WA, the University of Western Australia, Murdoch University and the Marine Stewardship Council.

A formal harvest strategy for the Statewide Small Pelagic Scalefish Resource is yet to be developed, however, it is noted as a future management initiative.

EXTERNAL DRIVERS

Licensed operators in the Commonwealth Small Pelagic Fishery are permitted to take Australian sardine in waters adjacent to the West Australian coastline south of 31° 00’ S (near Lancelin) but no fishing in these waters was identified in 2019/20 (Marton and Steven 2020). Climate change is likely to be causing a gradual southward contraction in the natural distribution of Australian sardine (**moderate** risk) and facilitating a southward extension of the distribution for scaly mackerel (**negligible** risk).

REFERENCES

Gaughan D, Craine M, Stephenson P, Leary T, and Lewis P. 2008. Regrowth of pilchard (*Sardinops sagax*) stocks off southern WA following the mass mortality event of 1998/99. Final FRDC Report – Project 2000/135. Fisheries Research Report No. 176. Department of Fisheries, Western Australia. 82p.

Blazeski, S., Norriss, J.V., Smith, K.A. and Hourston, M. 2021. Ecological Risk Assessment for the State-Wide Small Pelagic Scalefish Resource. Fisheries Research Report. Department of Primary Industries and Regional Development, Western Australia. in prep.

Gaughan DJ, and Mitchell RWD. 2000. The biology and stock assessment of the tropical sardine, *Sardinella lemuru*, off the mid-west coast of Australia. Final Report, FRDC Project 95/037. Fisheries Research Report No. 119. Department of Fisheries, Western Australia. 136p.

Marton N. and Steven A.H. 2020. Small Pelagic Fishery. In: Patterson, H, Larcombe J, Woodhams, J, and Curtotti, R, *Fishery status reports 2020*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 4.0. https://doi.org/10.25814/5f447487e6749.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297. Department of Primary Industries and Regional Development, Western Australia.

WEST COAST DEMERSAL SCALEFISH RESOURCE STATUS REPORT 2021

D. Fairclough and S. Walters

OVERVIEW

The West Coast Demersal Scalefish Resource (WCDSR) comprises over 100 species in inshore (20-250 m deep) and offshore (>250 m) demersal habitats of the West Coast Bioregion (WCB) which are exploited by both commercial and recreational (including charter) boat-based line fishers. The indicator species for inshore waters include West Australian dhufish, Snapper and Baldchin groper, while the proposed indicators for offshore waters include Hapuku, Blue-eye trevalla and Eightbar grouper (DoF 2011).

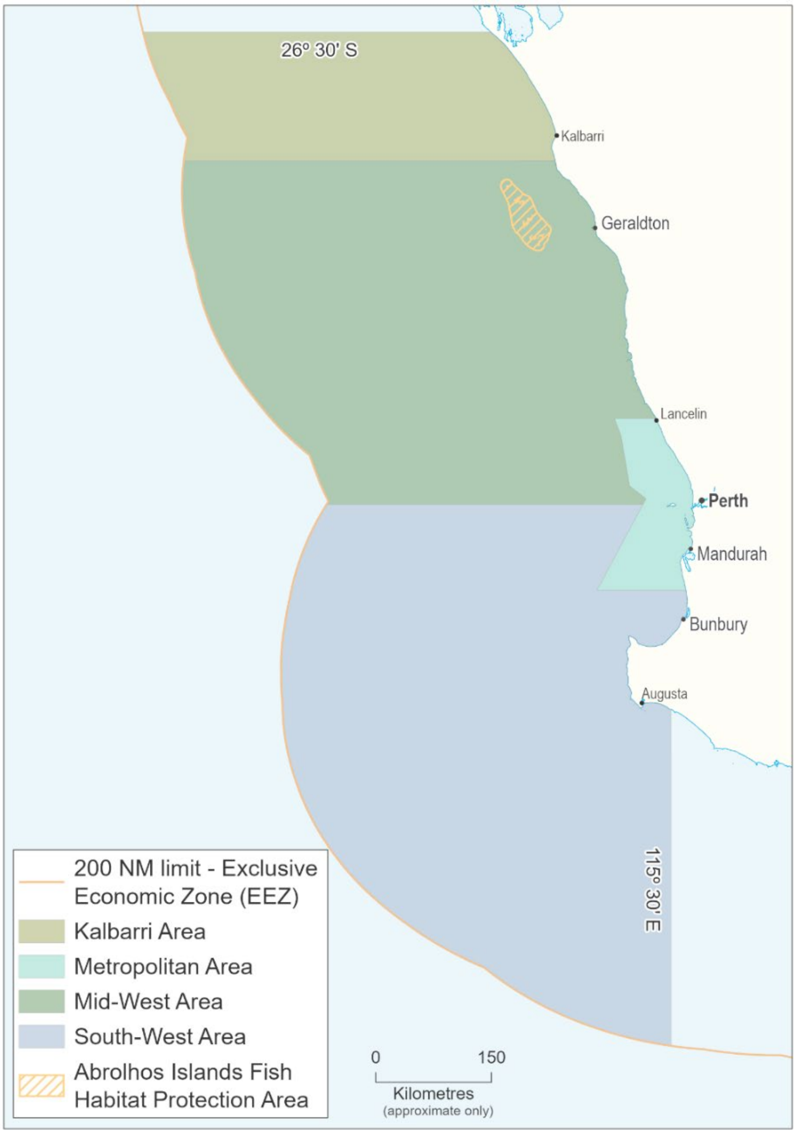
Following an assessment in 2007 that demonstrated overfishing of the indicators for the inshore demersal resource, management arrangements designed to recover the resource were progressively introduced between late 2007 and early 2010. The objective of these was to limit annual retained catches of demersal species by both the commercial and recreational sectors to no more than 50% of 2005/06 catch levels. These arrangements were implemented in order to reduce fishing mortality rates (*F*) of indicator species to below the threshold reference point and to manage the resource in accordance with a formal IFM sectoral allocation decision.

To achieve these management goals, each of the commercial fisheries authorised to land demersal scalefish in the WCB have individual management arrangements with access, gear, area (including metropolitan closure) and/or entitlement limitations. Similarly, boat-based recreational and charter fishers are licensed and managed by input and output controls, including a closed season.

SUMMARY FEATURES

Asset (Allowable catch)	Outcome	Status
[a]Commercial fisheries (450 t)	Total Catch 2019/20: 247 t	Acceptable
[b]Recreational fishery (250 t)	Total Catch Rec (top 15 species) 95% CLs 2017/18: 210-253 t; Charter 2017/18: 61 t (2019/20: 36 t)	Not acceptable (2017/18)
EBFM		
Indicator species		
West Australian dhufish	[c]2017: $F > F_{limit}$, $SPR_{limit} < SPR < SPR_{threshold}$	Recovering
Snapper	[c]2017: $F > F_{limit}$, $SPR \approx SPR_{limit}$	Recovering, increased management action required on recreational catch
Baldchin groper	[c]2014: $F > F_{limit}$, $SPR_{limit} < SPR < SPR_{threshold}$	Recovering, increased management action required on recreational catch
Ecological		
Bycatch	Low risk	Acceptable
Listed Species	Negligible risk	Acceptable
Habitat	Negligible risk	Acceptable
Ecosystem	Low risk	Acceptable
Economic (GVP $1-5 m)	Medium risk	Acceptable
Social (High amenity)	Medium risk	Acceptable
Governance	High risk	Acceptable
External Drivers	Medium risk	Acceptable

[a]demersal suite; [b]top 15 demersal species catch by the recreational sector comprises estimated retained catch by private boat-based fishers (Ryan et al., 2019) and retained catch by charter fishers in 2017/18; [c]date of last assessment.



WEST COAST DEMERSAL SCALEFISH RESOURCE FIGURE 1.
Map showing boundaries of the West Coast Demersal Scalefish Interim Managed Fishery. Note: the West Coast Bioregion and recreational sector in that bioregion begins at 27°S.

CATCH AND LANDINGS

The total landings of demersal species by commercial fisheries in the WCB in the most recent season (2019/20 or 2020) was 247 t and was below the stock recovery benchmark of 450 t (50% of 2005/06 catches), as they have been since 2008, when management commenced to recover stocks (West Coast Demersal Scalefish Resource Figure 2). The West Coast Demersal Scalefish Interim Managed Fishery (WCDSIMF) retained 213 t of demersal species (227 t of all fishes) in 2020, which was also below its stock recovery benchmark of 410 t. The Temperate Demersal Gillnet and Demersal Longline fisheries, the Cockburn Sound Line and Pot Managed Fishery, South-west Trawl Managed Fishery and West Coast Rock Lobster Managed Fishery landed 31 t, 1 t, 0 t and 2.6 t, respectively, in either 2019/20 or 2020.

Retained catches of demersal species by the WCDSIMF in 2020 in the Kalbarri Area (74 t) declined from 96 t in 2019, while they have increased in the Mid-west Area from 76 t in 2017 to 100 t in 2020. The higher catch in 2020 was due in part to an increase in effort and catch in the Mid-west in February, following Western rock lobster market changes as a result of the COVID-19 outbreak. In the South-west Area catches of demersal species declined from 55 t in 2019 to 38 t in 2020.

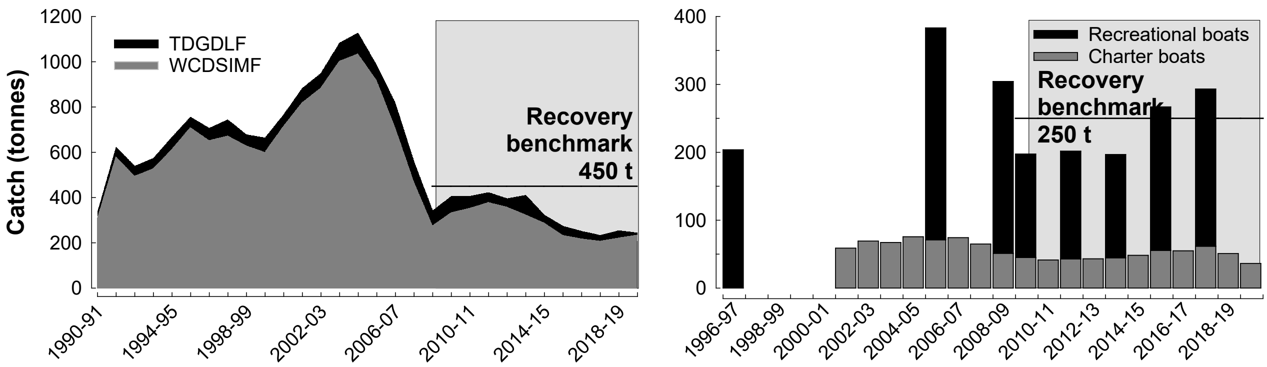
The WCDSIMF fished for ~8,440 hours in 2020, decreasing from ~9,160 in 2019. The majority of the effort in 2020 occurred in the Mid-west (~5,260 h), followed by the Kalbarri (2,100 h) and South-west areas (1,100 h). Since 2009, annual entitlement to fish (hours) consumed by the WCDSIMF in the Kalbarri, Mid-west and South-west areas has ranged from 68-77%, 53-69% and 36-51% of the maximum, respectively.

The estimated recreational harvest of the top 15 demersal species (or groupings) in the West

Coast derived from the last survey of private boat-based fishers in 2017/18 and reported catches of charter fishers in the same year was 271-314 t (comprising a catch range of 210–253 t (95% CI) by private fishers and 61 t by charter fishers). The estimated harvest range was thus above the stock recovery benchmark of 250 t (West Coast Demersal Scalefish Resource Figure 2).

The estimated recreational harvest (private boat-based) for the top 15 demersal species (or groupings) in the West Coast was steady at 231 t (95% CI 210–253 t) in 2017/18 compared with 213 t (95% CI 194–231 t) in 2015/16. The estimated charter catch in 2019/20 decreased to 36 t from 51 t in 2018/19, due in part by the effects of COVID-19 restrictions.

The annual estimated recreational fishing effort (private boat-based) in the West Coast Bioregion was steady in 2017/18 (311,495 boat days, 95% CI: 287,726-335,264) compared with 2015/16 (271,311 boat days, 95% CI: 249,688-292,934) (Ryan *et al*. 2019) and 2011/12 (293,112 boat days, 95% CI: 272,164–314,060), but was higher than 2013/14 (249,719 boat days, 95%CI: 229,016-270,423). The number of trips reported by charter fishers steadily increased since management changes were introduced to recover stocks, from about 1,400 in 2010/11 to 1,860 in 2017/18, but declined to 1,330 in 2019/20 as a result of COVID impacts on charter activities.



WEST COAST DEMERSAL SCALEFISH RESOURCE FIGURE 2.
Estimated retained catches of demersal species in the West Coast Bioregion for the commercial and recreational sectors. Stock recovery catch benchmarks were introduced between 2008 and 2010 (light grey shading). Estimated recreational sector retained catches combine data for financial year for charter (since logbooks were introduced in 2001/02) and survey year for recreational boats. Private boat-based recreational catches are estimates of the retained catch and do not show uncertainty (95% CIs), with 2011/12-2017/18 estimates derived from statewide phone diary surveys (Ryan et al., 2019) and prior estimates derived from boat ramp creel surveys. TDGDLF = Temperate Demersal Gill-net and Longline fisheries; WCDSIMF = West Coast Demersal (Interim) Managed Fishery.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Annual assessments are undertaken using catch levels. Periodic weight of evidence assessments of stock status of indicator species evaluate additional key performance indicators, including fishing mortality (*F*), spawning potential ratio (SPR) and relative biomass (Wise *et al*., 2007; Fairclough *et al*., 2014) and determine the extent of risk of further depletion within the next five years using ISO 31000-based risk assessment methods (Fletcher, 2015; Fletcher et al., 2011). The last assessment was conducted in 2017.

Inshore Demersal

West Australian dhufish (Recovering)

Retained catches of West Australian dhufish in the WCB by all commercial fisheries and the WCDSIMF have been around or below respective stock recovery benchmarks of 82 t and 72 t, since inception of the current management regime in 2008 to recover stocks. Fifty five tonnes of WA dhufish were landed by all commercial fisheries in 2019/20 and, of that, 48 t were landed by the WCDSIMF in 2020 (West Coast Demersal Scalefish Resource Figure 3). This represents increases from 53 and 44 t, respectively, from the previous season.

Retained catches of WA dhufish by the WCDSIMF in the Mid-west and South-west areas have remained around or below recovery benchmarks of 44 t and 19 t since 2008. Thirty five tonnes and 12 t were landed in those respective areas in 2020. Increased landings in recent years are mostly due to increases in the Mid-west Area. In 2020, this was related partly to increased effort, following Western Rock lobster market changes as a result of the COVID-19 outbreak. Catches of WA dhufish in the Kalbarri Area remain low (< 5 t).

The estimated retained catches of WA dhufish by the recreational sector (boat-based and charter fishers) of 135 t (116-154 t) in 2017/18 and 127 t

in 2015/16 (110-144 t) have increased since 2013/14 (81-108 t) and 2011/12 (76-101 t). The 2015/16 and 2017/18 point estimates were above the recovery benchmark of 126 t (West Coast Demersal Scalefish Resource Figure 3). However, in each case, the lower 95% CL was below the benchmark. The retained catch of WA dhufish by boat-based recreational fishers in 2017/18 was 123 t (95% CL: 105-141 t) and by charter fishers was 12 t. The retained catches of WA dhufish by charter fishers in 2019/20 declined to 8 t, at least in part as a result of restrictions on charter fishing due to COVID.

The numbers of WA dhufish retained represented 41% of the 63,068 (SE=5,842) caught (retained and released) by boat-based recreational fishers in 2017/18 (Ryan *et al.* 2019) and 61% of the 2,433 caught by charter fishers in 2019/20.

The 2017 weight of evidence assessment of the biological stock (bioregion level), which included age composition data from 2012/13-2014/15 (post management changes), demonstrated that *F* and *SPR* for WA dhufish had not reached acceptable levels at that time (i.e. the threshold). *F* estimates had not decreased either at the stock level or in the northern and southern parts of the bioregion. They were also greater in the northern than southern part of the bioregion, indicating greater depletion prior to management changes (West Coast Demersal Scalefish Resource Figure 4). There was preliminary evidence that year classes recruited to the fishery after management changes have experienced lower *F* than those that recruited prior to changes, indicating some reduction in recent fishing mortality. However, additional post-release mortality associated with high recreational sector release rates and unknown commercial release rates may impair the rate of stock recovery. This species was thus assessed as High Risk (C3 × L4).

The above evidence indicates that estimated levels of fishing pressure should allow the stock to recover from overfishing, if retained catches are maintained below the stock recovery benchmark and levels of post-release mortality are not significant. The biological stock is classified as recovering.

Snapper (Recovering)

Retained catches of Snapper in the WCB by all commercial fisheries and the WCDSIMF were above respective recovery benchmarks of 126 t and 120 t between 2010 and 2014. Reductions in effort entitlements to WCDSIMF fishers in the Kalbarri and Mid-west areas in 2015 contributed to reducing total commercial and WCDSIMF landings below benchmarks. Total landings of 79 t by all fisheries in 2019/20 and of 72 t by the WCDSIMF in 2020 increased slightly from recent years (West Coast Demersal Scalefish Resource Figure 3). Retained catches of snapper in 2020 in the Kalbarri Area remained low (32 t), while in the Mid-west Area they increased (38 t). However, catches in both areas remained below their respective benchmarks of 65 t and 43 t. In 2020, increased catches were related partly to increased effort, following Western Rock lobster market changes as a result of the COVID-19 outbreak. Catches of Snapper in the South-west Area have remained low since 2008 (< 5 t).

Estimated retained catches of Snapper by the recreational sector (boat-based and charter fishers) during the years of each of the four statewide surveys between 2011/12 and 2017/18 have been above the recovery benchmark of 37 t. For example, an estimated 70 t was landed by the recreational sector in 2017/18, comprising 22 t by charter fishers and 48 t (95% CLs 40-55 t) by boat-based fishers (West Coast Demersal Scalefish Resource Figure 3). Charter landings in 2019/20 decreased to 14 t, at least in part as a result of restrictions on charter fishing due to COVID.

The numbers of Snapper retained by private boat-based recreational fishers in 2017/18 represented 29% of 61,446 (SE=4,922) caught (retained and released) (Ryan *et al.* 2019) and 42% of the 12,168 caught by charter fishers in 2019/20.

The 2017 assessment of Snapper at the biological stock (bioregion) level, including age composition data collected from 2012/13-2014/15, demonstrated that although *F* had declined since 2009/10-10/11, *F* (and *SPR*) had not reached acceptable levels at that time (i.e. the threshold; West Coast Demersal Scalefish Resource Figure 4). In addition, high recreational catches, post-release mortality associated with high recreational sector release rates and unknown commercial release rates may impair the rate of stock recovery. Snapper is thus assessed as High Risk (C3 × L4). However, there is preliminary evidence that year classes recruited to the fishery after management changes have experienced lower *F* than those that recruited prior to changes, indicating reductions in fishing mortality.

The above evidence indicates that estimated levels of fishing pressure should allow the stock to recover from overfishing, if retained catches are maintained below the stock recovery benchmark and levels of post-release mortality are not significant. The biological stock is classified as recovering.

Baldchin groper (Recovering)

Landings of Baldchin groper in the WCB by all commercial fisheries (12 t, 2019/20) and the WCDSIMF (10 t, 2020) were below respective stock recovery benchmarks of 22 t and 17 t, as they have been since commencement of the current management regime (West Coast Demersal Scalefish Resource Figure 3). In 2020, increased catches were related partly to increased effort in the Mid-west Area, following Western Rock lobster market changes as a result of the COVID-19 outbreak.

Retained catches of Baldchin groper by the recreational sector have been above the benchmark of 33 t during three of the statewide surveys between 2011/12 and 2017/18, e.g. 43 t in 2017/18. Charter fishers landed 11 t in 2017/18, while boat-based recreational fishers landed 32 t (95% CL: 26-38 t) (Ryan et al., 2019; West Coast Demersal Scalefish Resource Figure 3). In 2019/20, charter fishers landed 8 t.

The numbers of Baldchin groper retained by private boat-based recreational fishers in 2017/18 represented 67% of 22,971 (SE=2,184) caught (retained and released) (Ryan et al. 2019) and 66% of the 4,208 caught by charter fishers in 2019/20.

The last assessment of Baldchin groper in 2014 demonstrated that rates of F at the biological stock level, using age composition data collected from 2008/09 to 2010/11 (i.e. during management changes) did not change from the previous assessment. F estimates were above the limit reference point of 1.5M (West Coast Demersal Scalefish Resource Figure 4; Fairclough et al., 2014). Similarly, little change was identified in SPR, with point estimates between 0.2 and 0.3. Expected high post-release mortality associated with recreational and commercial releases may impair the rate of stock recovery.

The above evidence indicates that estimated levels of fishing pressure should allow the stock to recover from overfishing, if retained catches are maintained below the stock recovery benchmark and levels of post-release mortality are not significant. The biological stock is classified as recovering.

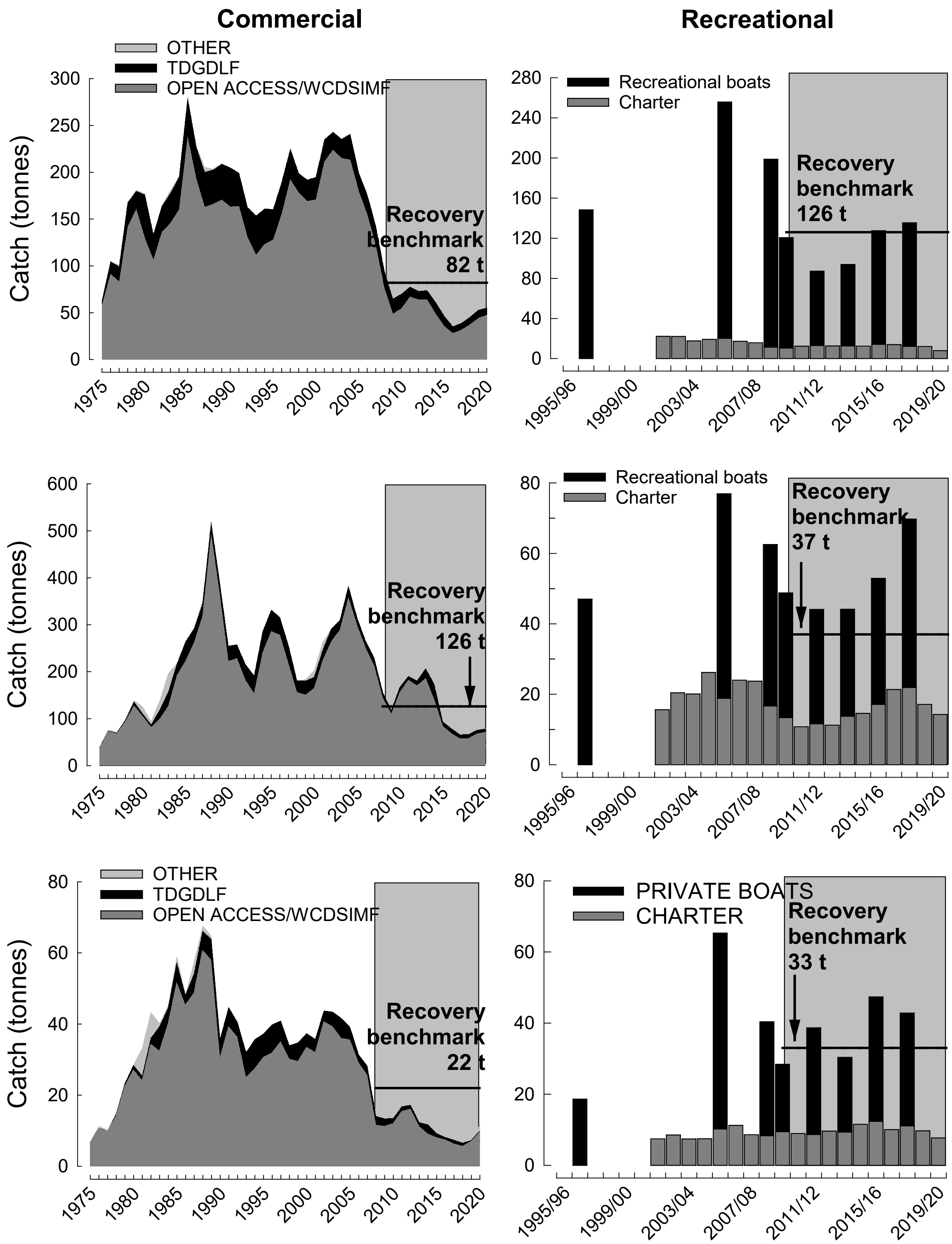
Offshore Demersal

Landings of the dominant offshore demersal species (Eightbar grouper, Bass groper, Hapuku, Blue-eye trevalla and Ruby snapper) by the WCDSIMF have remained below the nominal sustainable catch range for this suite (20-40 t) since the fishery commenced in 2008. Catches have been variable among years, ranging from 6-14 t between 2008 and 2013, increasing to 12-20 t per year between 2014 and 2019, before falling to 11 t in 2020. Following exploratory fishing in the early years of the WCDSIMF, the majority of the landings (≥76%) have occurred in the South-west Area since 2014, with Hapuku typically dominating the catch (≥61% since 2016).

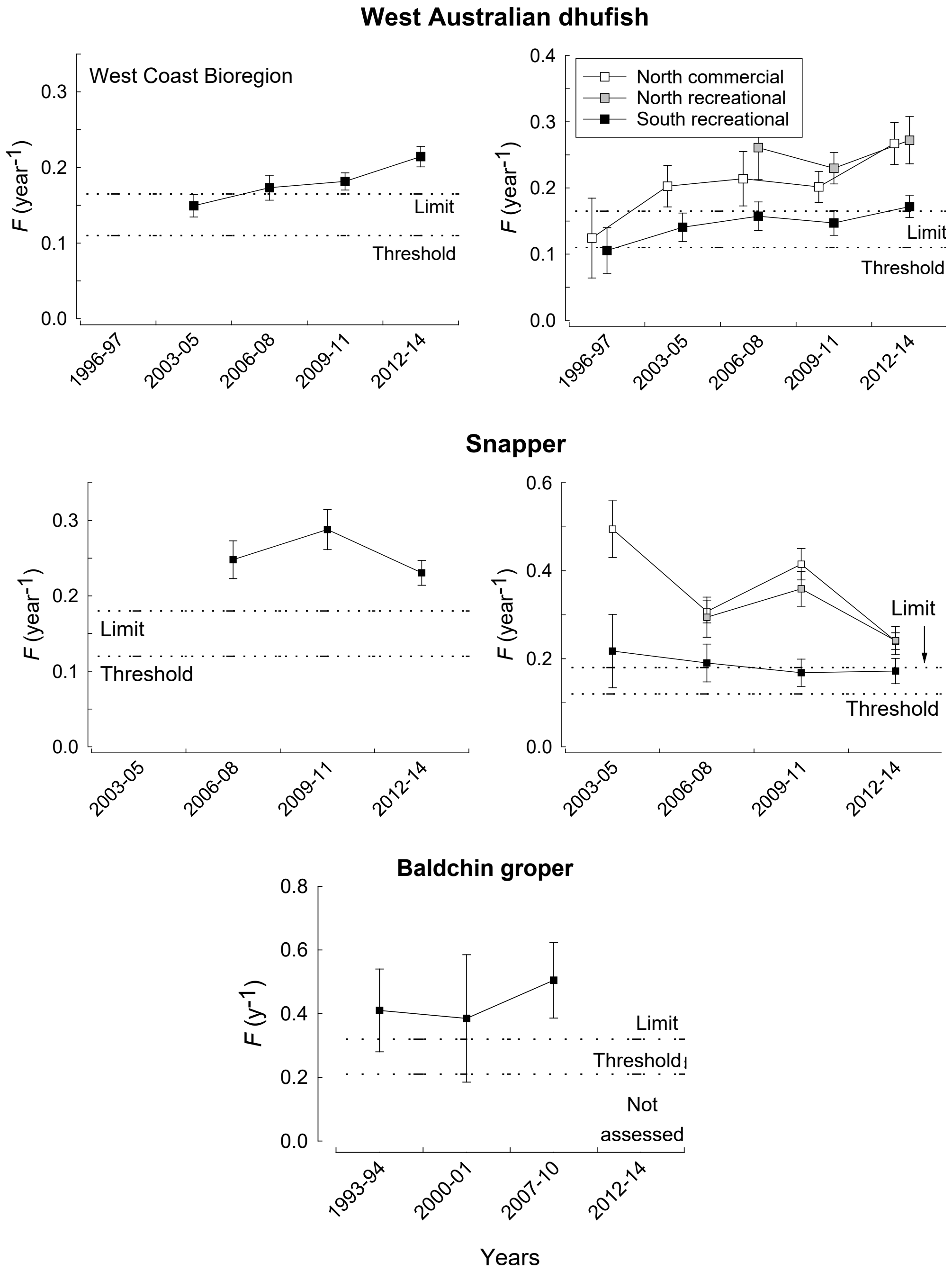
Offshore demersal species are sometimes also caught by the Commonwealth Western Deepwater Trawl Fishery. However, reported effort and estimated annual catches of offshore demersal species have remained very low in recent years (< 1 t) (http://data.gov.au/dataset/reported-retained-annual-catch-from-commonwealth-fisheries-logbooks).

Retained catches of the dominant offshore demersal species by the recreational sector comprised 8 t in 2017/18 by private boat-based fishers (Ryan et al., 2019) and 7 t by charter fishers (the highest level reported since 2001/02. Catches by charter fishers in 2019/20 were much lower (< 1 t), likely influenced by restrictions on fishing due to COVID impacts. Catches of offshore species by charter fishers occur predominantly in the Metropolitan Area.

The current level of fishing pressure is such that the biological stocks of offshore demersal species are considered sustainable.



WEST COAST DEMERSAL SCALEFISH RESOURCE FIGURE 3.
Commercial and recreational estimated retained catches of the indicator species West Australian dhufish, Snapper and Baldchin groper vs 50% of 2005/06 catch benchmarks for stock recovery. Private boat-based recreational catches are estimates of the retained catch and do not show uncertainty (95% CIs), with 2011/12-2017/18 estimates derived from statewide phone diary surveys (Ryan et al., 2019) and prior estimates derived from boat ramp creel surveys. TDGDLF = Temperate Demersal Gill-net and Longline fisheries; Open access and WCDSIMF [West Coast Demersal (Interim) Managed Fishery] are hand-line/drop-line fisheries.



WEST COAST DEMERSAL SCALEFISH RESOURCE FIGURE 4.
Estimated fishing mortality (±95% CIs) vs threshold and limit reference points for West Australian dhufish, Snapper and Baldchin groper at the stock level (West Coast Bioregion) and for WA dhufish and Snapper in the northern half (Kalbarri and Mid-west areas) and southern half (Metropolitan and South-west areas) of the bioregion, based on age composition data collected from the commercial and/or recreational sectors. Note Baldchin groper is only assessed in the northern half of the bioregion. Most recent assessment in 2017 was based on biological data from 2012/13 to 2014/15.

BYCATCH and PROTECTED SPECIES INTERACTIONS

Bycatch

Line fishing for demersal species using baited hooks is highly selective for fishes. While other fishes that are caught but not normally retained during demersal fishing activities (including inedible species, e.g. Silver Toadfish, and small species, such as wrasses) may not all survive, this still represents a minor impact to their stocks and therefore a low risk.

Protected Species

Commercial WCDSIMF and charter fishers are required to record listed species interactions in their statutory returns. Interactions with listed species by commercial, charter and recreational demersal fishers in the WCB are minimal. During 2020, eight Grey nurse sharks and eight White sharks were caught and released alive by WCDSIMF fishers. In 2019/20, charter fishers caught and released alive one gold-spotted

rockcod that were above the maximum size limit and two Grey nurse sharks. The level of interactions with listed species is therefore considered a negligible risk to their populations.

HABITAT and ECOSYSTEM INTERACTIONS

Habitat

Line fishing is the main fishing method used in the commercial and recreational fishery for demersal species which has little physical impact on the benthic environment and hence negligible risk to benthic habitats.

Ecosystem

Hall and Wise (2011) found that while the species composition in catches of commercial wetline, gillnet and longline fisheries in the WCB had changed over a 30-year timeline this may be a function of changes in targeting or differences in reporting methods. There was no evidence of a decline in the trophic level or mean size in catches and the fishery therefore represents a low risk to the ecosystem.

SOCIAL AND ECONOMIC OUTCOMES

Social

The WCDSR provides high social amenity to recreational fishing and diving and to consumers via commercial fish supply to markets and restaurants. There is currently a medium level of risk to these values.

The demersal resource in the WCB is highly accessible to boat fishers with 135,561 Recreational Fishing from Boat Licences held in WA from September 2017 to August 2018. The annual estimated boat-based recreational fishing effort in the West Coast Bioregion was steady in 2017/18 (311,495 boat days, SE=12,127) compared with 2015/16 (271,311, SE=11,032), and 2011/12 (293,112, SE=10,688), but higher than 2013/14 (249,719, SE=10,563) (Ryan *et al*. 2019).

Thirty three WCDSIMF vessels (LFBs) operated in 2020 and employed between zero and four crew excluding the skipper. Fifty-nine licensed charter operators fished in the WCB in 2019/20. The number of people employed in the charter industry has not been estimated.

Economic

The value of commercial fishing and aquaculture to the WA economy was recently estimated at $989 million (FRDC Project 2017-210). The estimated gross value of product (GVP) for the WCDSIMF in 2019 was $1-5 million (Level 2). There is currently a medium risk to this level of return.

The value of recreational fishing to the WA economy was recently estimated at $2.4 billion per year (McLeod and Lindner 2018) with recreational fishing in the Mid-West, Wheatbelt, Metro, Peel and South West regions estimated to be worth over $1.7 billion per year.

GOVERNANCE SYSTEM

Harvest Strategy

The WCDSR is currently managed using a constant catch strategy and a formal allocation of 64% of the catch to the commercial sector and 36% to the recreational sector. Although a formal harvest strategy is not yet in place for this resource, a stock rebuilding program is underway whereby retained catches are to remain below benchmark levels until fishing mortality rates and spawning potential ratios reach acceptable levels, i.e. the threshold reference point (see Fletcher *et al*., 2016).

Allowable Catch Tolerance Levels

Total catches of the demersal suite and indicator species (West Australian dhufish, Snapper, Baldchin groper) by the commercial sector in the most recent season were maintained below recovery catch benchmarks of 450, 82, 126 and 22 t, respectively. The retained catch levels of the commercial sector indicate that the fishery performance is considered acceptable.

Retained catch point estimates for the demersal suite and indicator species (West Australian dhufish, Snapper, Baldchin groper) by the recreational sector (boat-based recreational fishers from the most recent statewide survey and charter fishers in the same year, i.e. 2017/18) were each above the respective stock recovery benchmarks, i.e. 250 t, 126 t, 37 t and 33 t, respectively, and were thus not acceptable.

Compliance

The Department undertakes regular compliance inspections to ensure fishing is being undertaken in accordance with the governing legislation and runs education programs with various stakeholder groups to increase the levels of voluntary compliance.

Consultation

The Department undertakes consultation directly with licensees on operational issues. The Department convenes Annual Management Meetings through the West Australian Fishing Industry Council (WAFIC), who are also responsible for undertaking statutory management plan consultation for the Department under a Service Level Agreement. Recreational consultation processes are facilitated by

Recfishwest under a Service Level Agreement, although the Department undertakes direct consultation with the community on specific issues. Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

A formal harvest strategy recovery plan for the WCDSR will be developed in 2020/21. The next WCDSR stock assessment is due in early 2021. In 2021, a review will be undertaken to assess the current perfomance of the WCDSR against the harvest strategy and if it is recovering at an acceptable rate. Recent catches and the impact of post-release mortality will be considered through this review.

EXTERNAL DRIVERS

Recruitment success of demersal species, such as West Australian dhufish and Snapper vary annually and are influenced in part by environmental factors. Climate change may lead to a range of factors (e.g. increased water temperatures, changes in current strength) that could influence recruitment and the biology of demersal species (Caputi et al. 2014). Ongoing industrial development in Cockburn Sound may affect the spawning aggregation behaviour and survival of juvenile snapper in that area.

There is some overlap of species captured in the WCB by state fisheries and by the Commonwealth Western Deepwater Trawl Fishery and Great Australian Bight Trawl Sector of the Southern and Eastern Scalefish and Shark Fishery (>200 m). Published catches are currently small with no catches of demersal species in the WDWTF in 2016 and no data reported since then (data.gov.au). The Commonwealth's South-West Marine Bioregional Plan incorporates areas that will restrict access to fishing in parts of the WCB to the commercial and recreational sectors.

Moderate risk.

REFERENCES

Caputi N, Jackson G, and Pearce A. 2014. The marine heat wave off Western Australia during the summer of 2010/11 – 2 years on. Fisheries Research Report No. 250. Department of Fisheries, Western Australia. 40pp.

DPIRD. 2021. West Coast Demersal Scalefish Resource Harvest Strategy 2021-2025 Version 1.0. Fisheries Management Paper No. 305. Department of Primary Industries and Regional Development, Perth, Western Australia. 50p.

Fairclough DV, Molony BW, Crisafulli BM, Keay IS, Hesp SA, and Marriott RJ. 2014. Status of demersal finfish stocks on the west coast of Australia. Fisheries Research Report No. 253. Department of Fisheries, Western Australia. 96 p.

Fletcher WJ, Wise BS, Joll LM, Hall NG, Fisher EA, Harry AV, Fairclough DV, Gaughan DJ, Travaille K, Molony BW, and Kangas M. 2016. Refinements to harvest strategies to enable effective implementation of Ecosystem Based Fisheries Management for the multi-sector, multi-species fisheries of Western Australia. Fisheries Research 183: 594-608.

Hall NG, and Wise BS. 2011. Development of an ecosystem approach to the monitoring and management of Western Australian fisheries. FRDC Report – Project 2005/063. Fisheries Research Report No. 215. Department of Fisheries, Western Australia. 112 p.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, and Wise BS. 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297. Department of Primary Industries and Regional Development, Western Australia.

Wise BS, St John J, and Lenanton RC (eds). 2007. Spatial scales of exploitation among populations of demersal scalefish: implications for management. Part 1: Stock status of the key indicator species for the demersal scalefish fishery in the West Coast Bioregion. Final report to Fisheries Research and Development Corporation on Project No. 2003/052. Fisheries Research Report No. 163. Department of Fisheries, Western Australia.

GASCOYNE COAST BIOREGION

ABOUT THE BIOREGION

The marine environment of the Gascoyne Coast Bioregion (Gascoyne Overview Figure 1) represents a transition between the tropical waters of the North West Shelf of the North Coast Bioregion and the temperate waters of the West Coast Bioregion. Offshore ocean temperatures range from about 22°C to 28°C, while the inner areas of Shark Bay regularly fall to 15°C in winter. The major fish stocks are generally tropical in nature, with the exceptions of the temperate species, pink snapper, whiting and tailor, which are at the northern end of their distributions in Shark Bay.

The coastline is characterised by high cliffs in the southern half, changing to fringing coral reefs in the north. Coastal waters are generally high-energy in terms of wave action due to the strong trade wind system. The Exmouth Gulf section of the Gascoyne Coast Bioregion is seasonally influenced by extreme tropical summer cyclones, while the Shark Bay end of the Bioregion receives infrequent cyclones, but is affected at times by river outflows from inland cyclone-based summer rainfall. The limited local rainfall comes mostly from the northern edge of winter storm fronts.

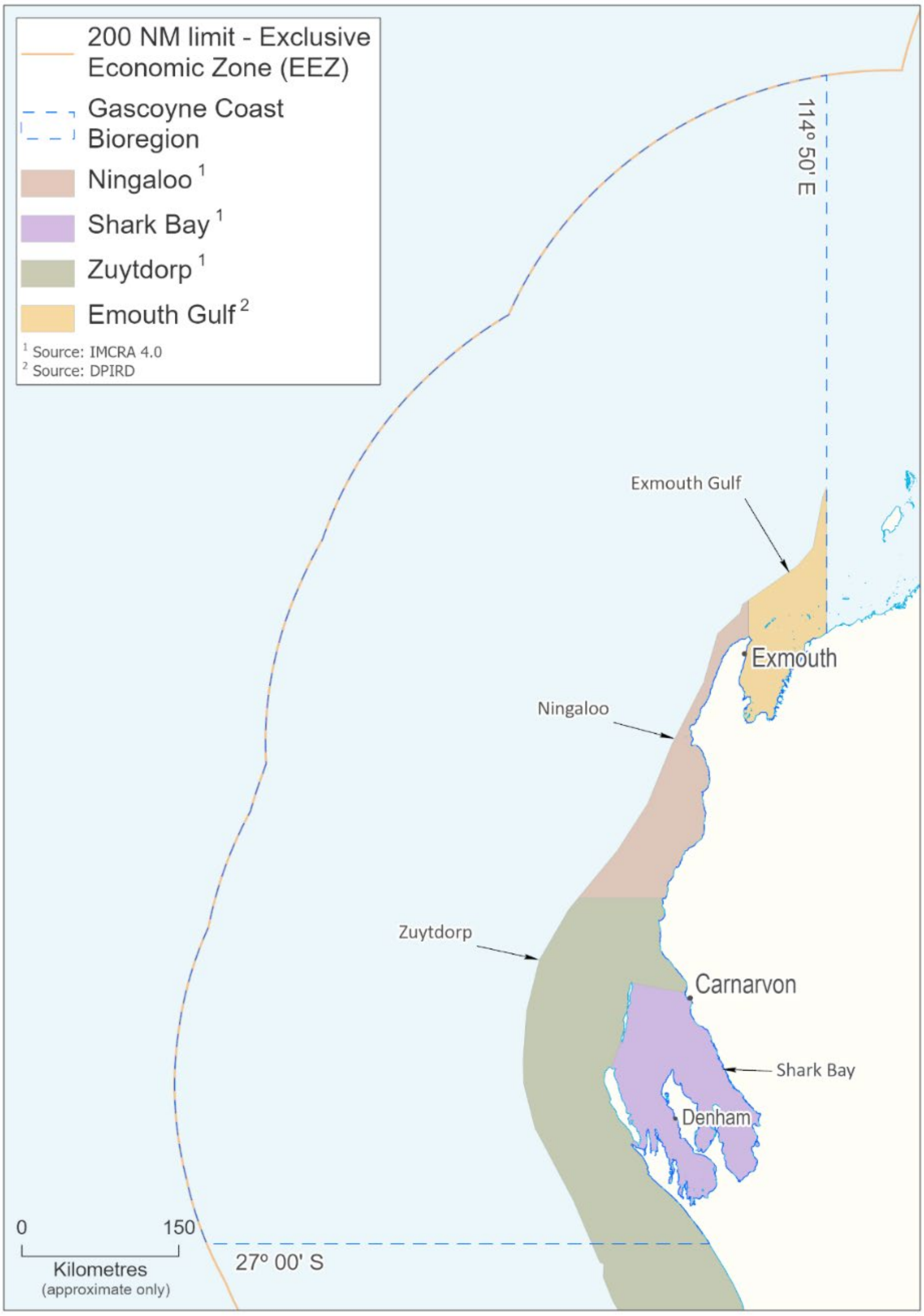
The waters off the Gascoyne Coast are also strongly influenced by the southward-flowing Leeuwin Current, generated by flow from the Pacific through the Indonesian archipelago. This tropical current becomes evident in the North West Cape area and flows along the edge of the narrow continental shelf where, coupled with low rainfall and run-off plus the north flowing Ningaloo Current, it supports the diverse Ningaloo Reef marine ecosystem.

The outer area of the large marine embayment of the World Heritage-listed Shark Bay is also influenced by the warm winter current. The inner waters of the embayment are hyper-saline, due to the high evaporation and low rainfall of the adjacent terrestrial desert areas. The sea floor of both Shark Bay and the continental shelf are typically sandy compared to Exmouth Gulf, which has more mud areas and greater turbidity.

The Gascoyne Coast Bioregion has been identified as one of 18 World ‘hotspots’ in terms of tropical reef endemism and the second most diverse marine environment in the world in terms of tropical reef species.

The Ningaloo reef in the north of the Bioregion is the largest continuous reef in WA and is one the most significant fringing reefs in Australia. The Bioregion also has areas of mangroves, mostly in Exmouth Gulf, while seagrass beds are located in a number of areas.

The ecosystem boundaries as defined by IMCRA (V 4.0) in the bioregion are depicted in Gascoyne Overview Figure 1. The potential threats and risks to these ecosystems are often similar. For simplicity, risk ratings were allocated by grouping the ecosystems into two broad groups, estuarine or marine. However, if a particular ecosystem is unique and/or is exposed to different or significant threats, risk was allocated to these ecosystems separately.



GASCOYNE OVERVIEW FIGURE 1
Map showing the Gascoyne Coast Bioregion and IMCRA (V 4.0) meso-scale regions: Zuytdorp, Shark Bay, Ningaloo and Exmouth Gulf.

SUMMARY OF ACTIVITIES POTENTIALLY IMPACTING THE BIOREGION

Climate Change

Some of the key environmental trends that may be affecting ecosystems in WA include:

- Increasing frequency of *El Niño*/Southern Oscillation (ENSO) events;
- More years with a weaker Leeuwin Current;
- Increases in water temperature off the west coast of WA, particularly the lower west coast;
- Increase in salinity, which includes some large annual fluctuations;
- Change in the frequency and location of storms (and rainfall) affecting the lower west coast; and
- Change in the frequency of cyclones (and summer rainfall) affecting the north-west coast.

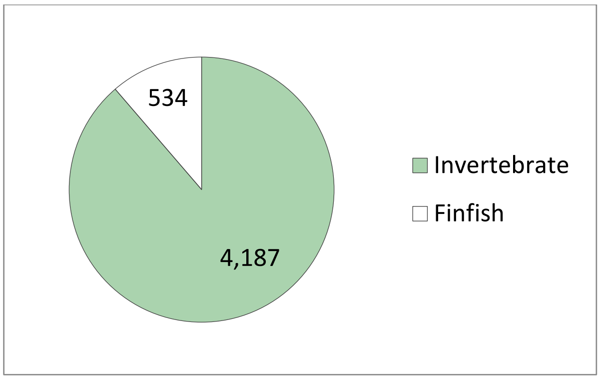
The Gascoyne Coast Bioregion is predicted to be at enhanced risk from the effects of climate given that it spans a transitional zone between tropical and temperate regions. The variables expected to drive climate change impacts include changes in water temperature, ocean currents, winds, rainfall, sea level, ocean chemistry and extreme weather conditions.

It is apparent that climate change will impact the biological, economic, and social aspects of many fisheries, and both positive and negative impacts are expected. Climate change can influence biological systems by modifying the timing of spawning, range and distribution of species, composition and interactions within communities, exotic species invasions and impacts, and the structure and dynamics of communities, including changes in productivity. Species distribution shifts are the most commonly reported changes and are often the easiest to recognise and measure. Changes in the distribution of key species are monitored in a national citizen-science program (www.redmap.org.au) in which the Department is a collaborator.

Commercial Fishing

Commercial fishing is a significant industry in the region, with catch dominated by invertebrate resources (Gascoyne Coast Overview Figure 2), including the State's more valuable fisheries – the Shark Bay Prawn, Exmouth Gulf Prawn and Shark Bay Scallop fisheries – landing combined catches valued in the range of $40 – $50 million annually. These trawl based fisheries have operated sustainably in the region since the mid-1960s and are internationally recognised as 'best practice' in terms of both management and research. Both prawn fisheries as well as the west coast deep sea crab fishery have achieved Marine Stewardship Council (MSC) certification. Only a relatively small number of the approximately 1,400 species of fish inhabiting this bioregion are targeted by commercial fishing activity.

The Gascoyne Demersal Scalefish Fishery (GDSF) and Shark Bay Beach Seine and Mesh Net Fishery have operated in the bioregion since the 1960s, and provide a significant proportion of the snapper and whiting catch for the State. The GDSF originally only targeted pink snapper but has developed over the past decade into a broader fishing sector taking other demersal finfish species including emperors, cods and deeper water species such as goldband snapper. The Gascoyne includes part of the Mackerel Managed Fishery (which extends to the NT border and is reported in the North Coast Bioregion chapter) with this area having lower annual catches compared to more northern areas. The region also includes some other small commercial fishing activities including the marine aquarium fishery which collects small numbers of a wide variety of species but is not permitted within some areas of the Ningaloo Marine Park, Shark Bay Marine Park or any waters closed to fishing. There is also a small beach seining fishery within Exmouth Gulf.



GASCOYNE COAST OVERVIEW FIGURE 2
Contribution of finfish and invertebrates to the total commercial wild fishery catch originating from the Gascoyne Coast Bioregion. Numbers represent total catch (in tonnes) based on all major assessed fisheries identified in the Overview section of this report (Gascoyne Coast Overview Table 1).

The main invertebrate species captured by fisheries in the Gascoyne Bioregion include a number of penaeid prawns, scallops, and blue swimmer crabs within the two main embayments of Shark Bay and Exmouth Gulf, plus deep sea crabs in the offshore region. The fishery for blue swimmer crabs which operates throughout the waters of Shark Bay has grown in the last decade to be the largest Australian crab fishery until recently affected by environmental issues. However, it is now recovering quite well. Other minor commercial fishing activities for invertebrates operating in the bioregion include collecting silver lipped pearl oyster which is used in pearl culture, though most effort is focused in the North Coast Bioregion, and some fishing for cockles.

Recreational Fishing

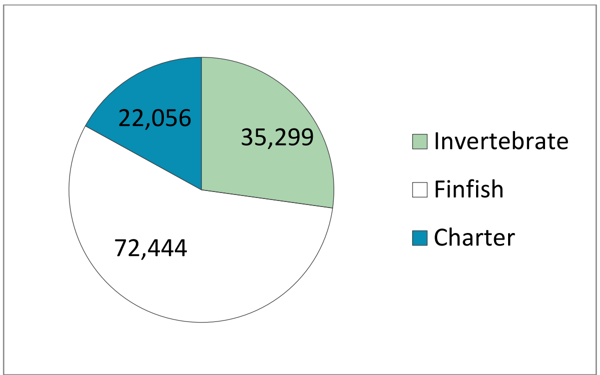
The special features of the Gascoyne Coast Bioregion, coupled with the warm, dry winter climate and accessible fish stocks, have made it a focal point for winter recreation by the Western Australian community. Fishing during this season is a key component of many tourist visits (Gascoyne Coast Overview Figure 3). A full range of angling activities is available, including beach and cliff fishing (e.g. Steep Point and Quobba), embayment and shallow-water boat angling (e.g. Shark Bay, Exmouth Gulf and Ningaloo lagoons), and offshore boat angling for demersal and larger pelagic species (e.g. off Ningaloo).

Recreational fishing is predominantly for tropical species such as emperors, tropical snappers, groupers, mackerels, cods, trevallies and other

game fish, as well as blue swimmer crab and squid. Some temperate species at the northern end of their ranges, such as (pink) snapper, tailor and whiting, provide significant catches, particularly in Shark Bay.

Improved infrastructure (e.g. sealed roads) has led to increasing levels of domestic and international tourism to the Gascoyne. Enhanced access to coastal waters via new boat ramps (e.g. Bundegi, Coral Bay, Tantabiddi) and camping sites/facilities and the sustained popularity of recreational fishing also contribute to pressure on local fish stocks.

Vessel retrievals from key boat ramps have been monitored using remote cameras for previous state-wide surveys[1], The typical seasonal pattern of vessel retrievals at Exmouth, Denham and Monkey Mia was not observed during the early stages of COVID-19 restrictions from March to August 2020[2].



GASCOYNE COAST OVERVIEW FIGURE 3
Recreational catches (by number) in the Gascoyne Coast Bioregion. Finfish and invertebrate catches were as assessed in the statewide survey of boat-based recreational fishing in 2017/18[1]. Charter boat catch is for the same period. Estimates of shore based recreational catch are unavailable.

Aquaculture

Aquaculture in the Gascoyne focuses on the blacklip oyster *Pinctada margitifera*. The local aquaculture sector is also focusing on the production of aquarium species, including coral, live rock and edible oysters.

Tourism

The Gascoyne Coast Bioregion is a focal point for winter recreation by the Western Australian community. The typical seasonal tourism pattern was impacted by COVID-19. Apart from its scenic beauty, the main attraction of the coastline for tourists is the quality of marine life. The region supports extensive scuba diving and snorkelling activities, particularly inside the coral lagoons of Ningaloo. Specialised eco-tourism activities include whale shark and manta ray observation at Ningaloo and dolphin and dugong viewing in Shark Bay. Fishing is a key component of many tourist visits, and a full range of angling activities is available.

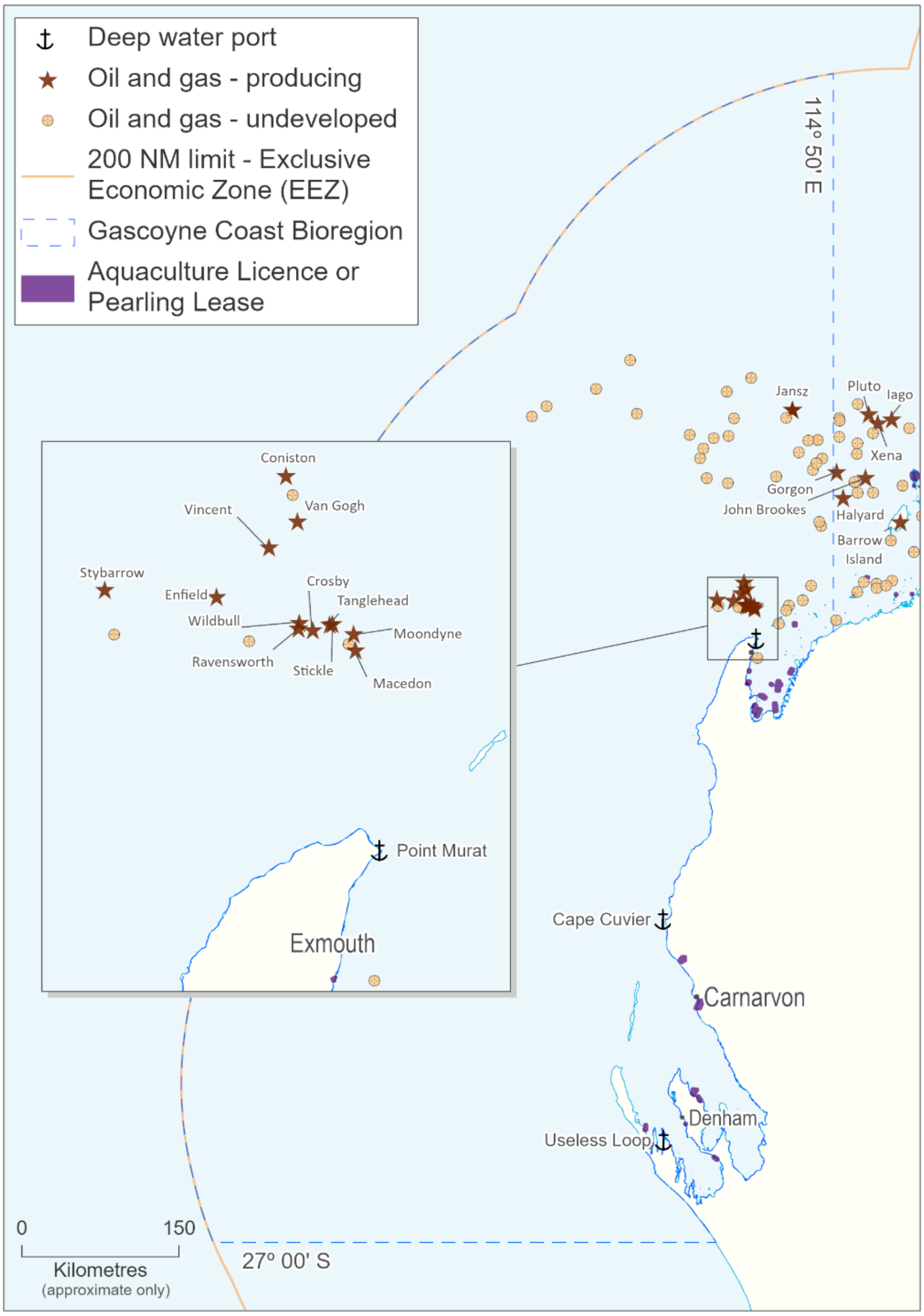
Oil and Gas Activity

Exploration and appraisal drilling has occurred mainly in the northern part of the Gascoyne Coast Bioregion (Gascoyne Overview Figure 4). There continues to be significant oil and gas mining activity offshore of North West Cape in the Exmouth Sub-basin, and the Australian Government has also recently released two areas offshore of Carnarvon in the Southern Carnarvon Basin for further exploration.

The main disturbances associated with oil and gas exploration and production include noise pollution from seismic surveys (e.g. potential for fish movement/impact arising from seismic surveys), disturbance to the marine habitat through drilling and/or dredging activities, introduction of marine pest species, release of produced formation water, shipping and transport activities and oil spill risks.

1 Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia.

2 Ryan KL, Desfosses CJ, Denham AM, Taylor SM, Jackson, G. 2021. Initial insights on the impact of COVID-19 on boat-based recreational fishing in Western Australia. Marine Policy 132: 104646



GASCOYNE OVERVIEW FIGURE 4
Exmouth Sub-basin offshore oil and gas production sites and Aquaculture Licences and Pearling Leases.

Shipping and Maritime Activity

There are three deepwater port facilities currently operating in the Gascoyne Coast Bioregion: Useless Loop, Cape Cuvier (both private facilities servicing salt fields) and Point Murat, a naval port facility at Exmouth. The majority of shipping movements involve coastal cargo vessels, shipping associated with the two salt fields in the region, shipping associated with oil and gas industries, large passenger cruise vessels and fishing vessels operating out of the numerous small ports along the coast.

Other harbours and maritime facilities of the Gascoyne Coast Bioregion include Denham, Carnarvon, Coral Bay and Exmouth, all of which largely service local fishing and charter vessels, as well as the private vessels of local residents and tourists. The expansion of oil and gas, along with increased recreational, charter and eco-tourism activities, in the area has led to the expansion of many of these facilities.

The impacts from vessels and ships tend to be concentrated around ports and favoured anchorage areas. Impacts include physical damage to the habitat, ship strikes of marine animals and the potential to introduce and spread marine pest species.

BIOREGIONAL SPECIFIC ECOSYSTEM MANAGEMENT

Within each Bioregion there are a range of management measures that have been implemented to manage the potential impact of activities (See Ecosystem Management Section for an overview). Management measures specific to the Gascoyne Coast Bioregion are outlined in the following sections.

Spatial Closures

The Department has established a comprehensive set of spatial management closures within the Gascoyne region that are equivalent to a number of IUCN categories for marine protected areas. Extensive trawl closures inside the 200 m depth zone in the Shark Bay and Exmouth region provide protection to sensitive benthic habitat, including coral reef, sand flats and seagrass beds of the continental shelf. These areas provide significant fish nursery, breeding and feeding habitat (Gascoyne Overview Figure 5). The extent of these areas means that most of the Gascoyne Bioregion inside 200 m depth could be classified as one of the marine protected area IUCN categories (Gascoyne Ecosystem Management Table 1; as per Dudley, 2008[1] and Day et al. 2012[2]). There are also a number of other 'formal' marine protected areas in this Bioregion that have been established under both the Conservation and Land Management Act 1984 and the Fish Resources Management Act 1994 (see Gascoyne Overview Figure 6). These include the Ningaloo and Shark Bay Marine Parks, the Murion Islands Marine Management Area, and the Quobba and Miaboolya Beach Fish Habitat Protection Areas. Commercial and recreational fishing activities are restricted in these regions.

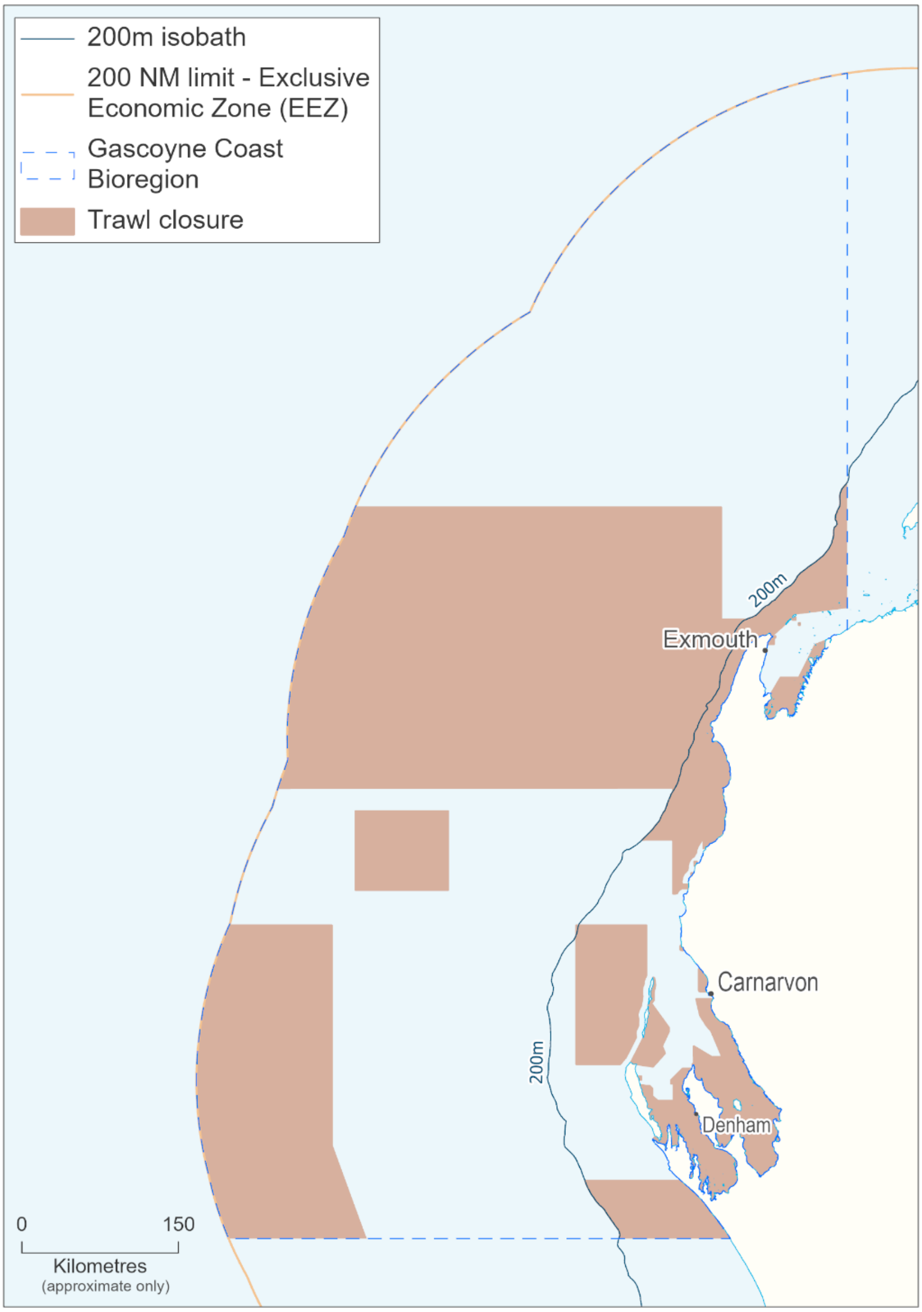
The Commonwealth Government has recently implemented its marine bioregional planning which includes a number of protected areas in Commonwealth waters between Shark Bay and the Northern Territory border that are in the Gascoyne Coast Bioregion (see Gascoyne Overview Figure 6).

GASCOYNE ECOSYSTEM MANAGEMENT TABLE 1
The areas and proportions of the Gascoyne Coast Bioregion making up State Waters and all continental shelf waters, out to 200 m depth, which are consistent with IUCN criteria for classification as marine protected areas.[3] This table does not yet include the closures that may be implemented by the Commonwealth as part of their marine planning zones (see next Gascoyne Overview Figure 6).

IUCN category or equivalent	State Waters only ($24,100\ km^2$)				All Waters ($416,300\ km^2$ (including State Waters))			
	Fisheries		Existing MPA		Fisheries		Existing MPA	
	km^2	%	km^2	%	km^2	%	km^2	%
I	0	0	0	0	0	0	0	0
II	0	0	2,500	10	0	0	5,000	1
III	0	0	0	0	0	0	0	0
IV	3,100	13	6,400	27	13,200	3	6,400	2
V	0	0	0	0	0	0	0	0
VI	9,500	39	2,600	11	389,100	93	2,600	1

1 Dudley, N. (editor) 2008. Guidelines for applying protected area management categories. IUCN. Gland, Switzerland.

2 Day, J. et al. 2012. Guidelines for applying the IUCN Protected Area Management Categories to Marine Protected Areas. Gland, Switzerland: IUCN. 36pp.



GASCOYNE OVERVIEW FIGURE 5
Map showing the Gascoyne Coast Bioregion and areas permanently closed to trawling, consistent with IUCN marine protected area category I. The area from Point Maud to Tantabiddi Well (23° 07.30' S to 21° 56.30' S) is closed to all commercial fishing activities.

GASCOYNE OVERVIEW FIGURE 6

Map showing the Gascoyne Coast Bioregion and State and Commonwealth marine parks and reserves in the Gascoyne Region.

ECOSYSTEM MONITORING AND STATUS

In order to assess the adequacy of management arrangements aimed at ensuring sustainability of the ecological assets within the Gascoyne Coast Bioregion, the Department must identify and monitor trends in the condition of these resources. This is achieved through application of an Ecosystem Based Fisheries Management (EBFM) framework (see How to Use section for more details) to identify, in a hierarchical manner, the key ecological resources that require ongoing monitoring and assessment.

These key ecological assets identified for the Gascoyne Bioregion are identified in Gascoyne Overview Figure 7 and their current risk status reported on in the following sections.

External Drivers

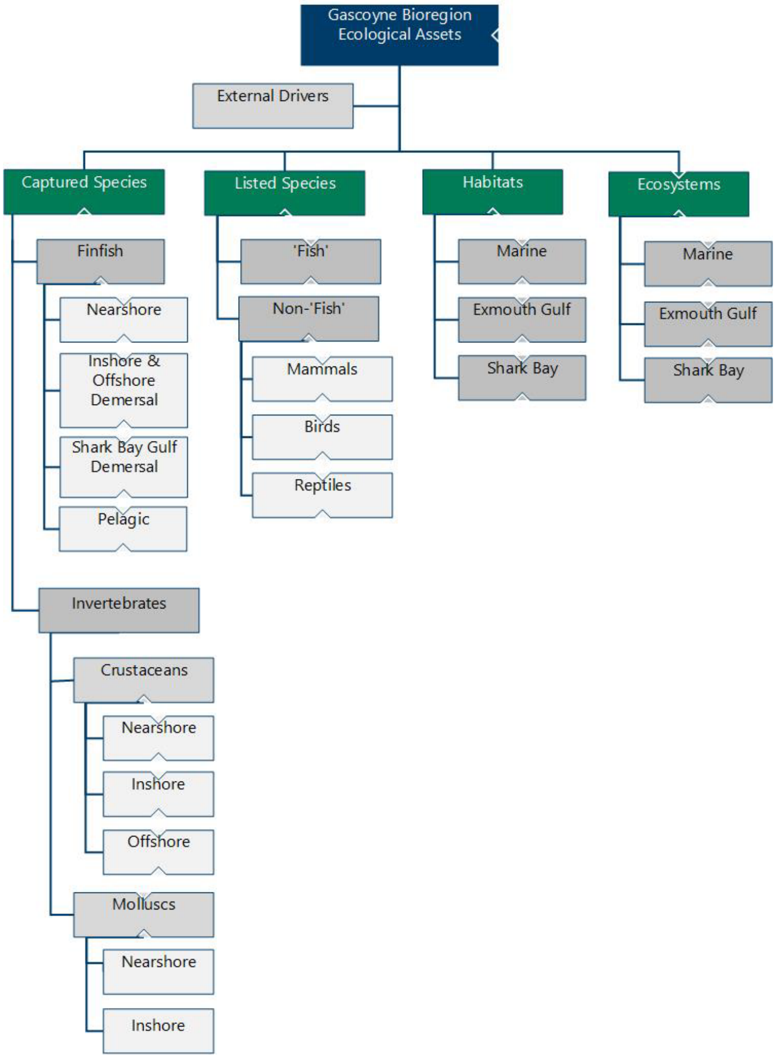
External factors include those impacting at the bioregional-level that are likely to affect the ecosystem as a whole and may not fall within the direct control of Fishery legislation (e.g. climate

change). An understanding of these factors, which are typically environmental (cyclones, ocean currents, water temperature) is necessary to fully assess the performance of the ecological resource. The main external drivers identified with potential to affect the Gascoyne Coast Bioregion include climate change and introduced pests and diseases[1].

Climate

External Drivers	Current Risk Status
Climate	MEDIUM in short term HIGH in medium term

Being a transitional zone between tropical and temperate regions, the biota of the Gascoyne Bioregion is at enhanced risk of being affected by climate change. Climate change can influence fisheries and biological systems by affecting the timing of spawning, range and distribution, composition and interactions within communities, exotic species invasions and impacts, community structure and productivity. Waters off the Gascoyne coast are strongly influenced by the Leeuwin Current which brings warm low salinity water southward. After experiencing a weakening trend from the 1960s to the early 1990s, the strength of the Leeuwin Current has shown an increasing trend in the past two decades which has been driven by changes in the frequency of El Niño/La Niña Southern Oscillation (ENSO) patterns.



GASCOYNE OVERVIEW FIGURE 7

Component tree showing the ecological assets identified and separately assessed for the Gascoyne Coast Bioregion.

During the summer of 2010/11, a significant warming event took place off the coast of Western Australia, with widespread reports of fish kills and of tropical species being found further south than their normal range. Sea-surface temperatures were > 3°C above the normal summer averages in some regions. The “marine heat wave” was associated with extremely strong *La Niña* conditions, leading to a record strength Leeuwin Current for that time of year, which resulted in record high summer sea levels along the mid-west and Gascoyne coasts. The heat wave resulted in

1 Biosecurity issues are now reported by the Biosecurity pillar of the Department of Primary Industries and Regional Development.

what is considered to be the first WA regional-scale coral bleaching event, affecting corals south to Rottnest Island and north to the Montebello and Barrow Islands. This warming event appears to have also contributed to a significant decline in blue swimmer crab and scallop stocks in Shark Bay and a subsequent recruitment failure for both of these species in 2011. Recruitment to the Gascoyne pink snapper stock may also have been affected.

A preliminary assessment of fisheries-dependent indicators of climate change in WA was undertaken in 2010. This work (FRDC Project Project 2010/535) assessed the effects of climate change on the marine environment and key fisheries, as well as management implications. The first phase of the project was to understand how environmental factors, such as water temperature and salinity, affect fish stocks in Western Australia based on available historical data. The second phase was to look at historical trends and possible future scenarios of Western Australian marine environments using climate model projections. Lastly, existing management arrangements were reviewed to examine their robustness to climate change effects.

Captured Species

FINFISH

The Gascoyne Coast Bioregion supports a diverse fish fauna and is noted for its high quality commercial and recreational fishing. Approximately 1,400 species of fishes inhabit this region. Of these only a relatively small number are targeted by commercial fishing activities with demersal finfish species (e.g. pink snapper) captured in the Zuytdorp region and nearshore finfish species (e.g. whiting) within the Shark Bay region.

Due to the broad spatial distribution of both species and fisheries, the majority of finfish species in this area are managed at the Bioregional scale within recognized aquatic zones. Indicator species which reflect the characteristics of the broader exploited stocks are monitored in order to assess ecological risk to the suite of species targeted. The major fishery operating at the bioregional level is the Gascoyne Demersal Scalefish Fishery. This line fishery originally targeted pink snapper but has been developed over the past decade into a broader fishing sector targeting other demersal finfish species including emperors, cods and deeper water species and is managed as the Gascoyne Demersal Scalefish (Managed) Fishery.

The Gascoyne Coast Bioregion also has the Shark Bay-based beach seine fishery (the Shark Bay Beach Seine and Mesh Net Managed Fishery) that since the 1960s has provided most of the whiting catch for the state.

Nearshore (0-20m depth)

Captured Species	Aquatic zone	Ecological Risk
Finfish	Nearshore (0-20 m depth)	MEDIUM

The indicator species for this suite (e.g. whiting) are all considered to have adequate breeding stocks, fishing catch and effort has been occurring at acceptable levels for over 40 years and there are no additional risks that have been identified. Annual catch and effort monitoring is continuing.

Inshore and Offshore Demersal

Captured Species	Aquatic zone	Ecological Risk
Finfish	Inshore and Offshore Demersal	MEDIUM

The main fishery operating in this region is the Gascoyne Demersal Scalefish Fishery, for which a detailed status report is provided at the end of this chapter. The indicator species for this fishery are pink snapper, spangled emperor, and goldband snapper.

Shark Bay Demersal

Captured Species	Aquatic zone	Ecological Risk
Finfish	Shark Bay Gulf Demersal	MEDIUM

The main fishery operating in this ecosystem is the Inner Shark Bay Scalefish Fishery, for which a detailed status report is included at the end of this chapter.

Pelagic

Captured Species	Aquatic zone	Ecological Risk
Finfish	Pelagic	LOW

The stock status and fishing levels of these species (e.g. Spanish mackerel) are at acceptable levels.

INVERTEBRATES

Commercial fishing for invertebrates is a very significant industry within the Gascoyne Coast Bioregion; three of the State's most valuable fisheries (the Exmouth Gulf Prawn, Shark Bay Prawn and Shark Bay Scallop Managed Fisheries) land combined catches valued in the range of $40-50 million annually. These trawl-based fisheries have operated in the region since the mid-1960s and are internationally recognised as 'best practice' in terms of both management and research[1]. A fishery for blue swimmer crabs (the Shark Bay Crab Managed Fishery) is based primarily in Carnarvon but operates throughout the waters of Shark Bay. The Gascoyne Coast Bioregion also supports the majority of the catch

1 Kangas, M. et al. 2019. Resource Assessment Report No. 3. Scallop Resource. Department of Primary Industries and Regional Development.

of deep sea crabs off the coast of Western Australia as part of the West Coast Deep Sea Crustacean Managed Fishery.

Molluscs

Captured Species	Aquatic zone	Ecological Risk
Molluscs (Pearl Oysters)	Nearshore	MEDIUM
Molluscs (Scallops)	Inshore	MEDIUM

The recent levels of pearl oysters in the bioregion have been low. Recovery management arrangements have been implemented and minimal catches have been taken in recent years.

The Shark Bay Scallop Managed Fishery is currently in a recovery phase. The stock has fully recovered in Denham Sound but is recovering more slowly in northern Shark Bay. The current status is the result of a series of poor recruitment events associated with sustained unfavourable environmental conditions resulting from the marine heat wave in 2010/11.

Crustaceans

Captured Species	Aquatic zone	Ecological Risk
Crustaceans (Crabs)	Nearshore	MEDIUM
Crustaceans (Prawns)	Inshore	MEDIUM
Crustaceans (Deep Sea Crabs)	Offshore	LOW

Blue swimmer crab stocks in Shark Bay continue to rebuild following declines in 2011/2012 that were attributed to the impacts of anomalous environmental conditions and heavy fishing pressure from trawl and trap sectors. Sustained stock recovery has allowed an increase to the Total Allowable Catch.

Stocks in both the Exmouth and Shark Bay Prawn Managed Fisheries are considered adequate with both fisheries being re-certified by the MSC in 2020.

Stocks in the West Coast Deep Sea Crustacean Managed Fishery, that operates primarily in the Gascoyne bioregion, are considered adequate with the fishery gaining MSC certification in 2016.

Listed species

A variety of endangered, threatened and protected[1] (ETP) species can be found within the Gascoyne Coast Bioregion, including cetaceans, dugongs, marine turtles, sea snakes, elasmobranchs, seahorses and pipefish, and sea/shore birds. These species are protected by various international agreements and national and state legislation. Primary pieces of legislation include the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*, the *Western Australian Wildlife Conservation Act 1950*, and the *Fish Resources Management Act 1994*.

Specific commercial fishing regulations implemented in the 1970s and 1980s preclude the use of large-mesh gillnets and long-lines throughout the region, to prevent the incidental entanglement of dugongs and turtles. These controls have also provided protection for the large shark species which are a feature of this region. Bycatch reduction devices (‘grids’) have been mandatory in all trawl nets in this bioregion since thr early 2000s and have further increased the protection for sharks, rays and any turtles encountered on the trawl grounds. In a further effort to protect sharks and rays, line-fishery vessels are not permitted to use wire snoods.

Fish

Listed species	Risk
Fish	MEDIUM

Statutory reporting indicates there are a low number of interactions with sawfish. However, increasing the understanding of the number and nature of the interaction of trawl fisheries in the bioregion with sawfish was raised as an issue through the MSC certification process.

Non-Fish

Listed species	Risk
Birds and Reptiles	MEDIUM
Mammals	LOW

While there are a number of listed species in the Gascoyne bioregion, only sea snakes, low numbers of sawfish and occasionally turtles and dolphins are encountered in the trawl catches. Most of these animals are returned alive.

All captures of listed species are recorded and their status at release are monitored and reported. Increasing the understanding of the number and nature of the interaction of trawl fisheries in the bioregion with sea snakes was raised as an issue through the initial MSC process. Research over the last 5 years has focused on increasing the knowledge of sea snake abundance and distribution and improved reporting of interactions by fishers. In recognition of these improvements, in the recent re-certification there are no conditions for additional research.

There are no recorded captures of mammals by the trawl fisheries in this bioregion.

Habitats and Ecosystems

A high level of protection of the ecosystems and habitats within the Gascoyne Coast Bioregion is ensured based on the limited area of the

1 Note that being on the listed species list does not automatically indicate that a species is either threatened or endangered.

Bioregion that is available to commercial fishing activity.

If the areas that are not trawled is taken into account, more than 90% of statewide benthic habitats out to the 200 m depth contour are, in practical terms, fully protected and may never have been trawled (Gascoyne Ecosystem Management Table 1). There are extensive trawl closures inside the 200 m depth zone in both Shark Bay and Exmouth Gulf that provide protection to sensitive benthic habitats including coral reef, seagrass and sand flats. These areas also provide significant nursery, breeding and feeding habitats for many retained and listed species. There is also a large area from Point Maud to Tantabiddi Well off the Ningaloo Coast (23° 07.30' S to 21° 56.30' S) that is closed to all commercial fishing activities (Gascoyne Overview Figure 5).

The Department identifies and monitors trends in the condition of ecosystems and their associated habitats to ensure the long term sustainability of both these key ecological assets and the fisheries that depend on them. Utilising the Integrated Marine and Coastal Regionalisation for Australia (IMCRA) scheme, the bioregion has been divided into four meso-scale ecosystems; the Ningaloo Coast, Shark Bay, Zuytdorp and Exmouth Gulf ecosystems (Gascoyne Overview Figure 1).

The key habitats occurring in depths of less than 40 m (where the vast majority of relevant fisheries resources are located and fishing activities are undertaken in this bioregion) include:

Coral reefs: The Ningaloo ecosystem has the only major coral reef system in the bioregion. The Ningaloo Reef is the largest continuous reef area in Western Australia and is considered one of Australia's most significant fringing coral reef systems.

Mangroves: The eastern coast of Exmouth Gulf supports one of the largest areas of mangroves in the region. These areas are thought to be significant sources of nutrients that contribute to the prawn fishery of the Gulf and provide nursery areas for juvenile fish and invertebrates.

Seagrasses: The central Gascoyne coast and Shark Bay support major seagrass communities, which play important roles in sedimentary processes, food chains and nutrient cycling. Smaller seagrass beds also occur in the eastern and southern sections of Exmouth Gulf. Seagrass beds provide important nursery habitats for many finfish and invertebrate species, such as spangled emperor. The 2011 marine heatwave event caused significant (35%) losses of seagrass and carbon from the Shark Bay system. The impacts of this are yet to be understood, but medium to long-term changes in productivity of some fisheries species is possible.

Sand banks: Extensive sand areas support seagrasses and provide substrate for microalgae in all areas, particularly Ningaloo Reef. In both Exmouth Gulf and Shark Bay, shallow sand banks provide productive habitat and nursery areas for local prawn and finfish stocks. Within the deeper central areas of Shark Bay and Exmouth Gulf, bare sandy/muddy bottom habitats provide the main habitat for juvenile and adult prawns within the trawl areas.

Other habitats that are located in the ecosystems within the Gascoyne Coast Bioregion include algal communities, rocky shore communities, hard- and soft-bottom benthic communities, and pelagic mid-water communities.

In depths beyond 40 m, ecosystems include hard- and soft-bottom benthic communities, sand banks and pelagic communities.

Gascoyne Marine

Ecosystem / Habitat	Aquatic zone / category	Current Risk Status
Gascoyne benthic habitat	Sand, Coral	LOW
Gascoyne ecosystem	Marine	LOW

Habitats

Protection of habitats within Ningaloo occurs mainly through the use of spatial zoning throughout the Ningaloo Marine Park. There are no commercial fishing activities conducted in this area. The main risk is to coral habitat is from tourism and other boating related activities. There are no major pressures on seagrass communities, which are in general small and patchily distributed in this region.

The remainder of the bioregion is dominated by mud/sand bottoms. The majority of non-trawl based fishing takes place over habitats in depths of 20-250 m, depending on which species is being targeted. The Gascoyne Demersal Scalefish Fishery operates in this ecosystem and is based on using hook and lines, resulting in no detectable impacts to benthic habitats. Fishing typically occurs over patches of hard bottom around the entrance to Shark Bay and the adjacent ocean. Fishing does not normally occur over sensitive seagrass or hard coral habitats. The West Coast Deep Sea Crustacean Fishery also operates in this area in depths from 150-1200 m. Crab traps are mainly set over mud bottom and occasionally bring up solitary corals or sponges that get entangled in the pot. The footprint of the pots and effort levels are both extremely small in relation to the extent of this habitat. There are thus few direct impacts of fishing activity to these habitats.

Ecosystems

Ningaloo is protected via the establishment of the Ningaloo Marine Park (NMP) which covers a total area of 4,566 km^2 from the shoreline to continental slope. No commercial fisheries operate in the waters of the NMP and 34% of the park is zoned as no-take sanctuary areas. A

significant level of research and monitoring has been undertaken in the Ningaloo marine park region by Department of Biodiversity, Conservation and Attractions (DBCA), CSIRO, AIMS and universities. This reflects the main pressures on the ecosystem which are largely not fishing-related.

The remainder of the ecosystem is largely protected due to the lack of trawling that occurs in this area.

An assessment of the community structure and trophic level of all commercially caught fish species in the Gascoyne Bioregion over the past 30 years found no evidence of systematic changes that could be evidence of an unacceptable impact on this ecosystem (Hall and Wise, 2011)[1].

Exmouth Gulf

Ecosystem / Habitat	Aquatic zone / category	Current Risk Status
Exmouth Gulf benthic habitat	Sand, Mud, Sponge, Seagrass	MEDIUM
Exmouth Gulf ecosystem	Marine	MEDIUM

Habitats

There is significant protection in place for all sensitive habitats and restrictions on the level of impacts that can occur in less sensitive habitats. Trawling is focused in the deeper central and north-western sections of the Gulf which is primarily mud. The total area trawled each year is monitored and has to remain below 40%.

Seagrass beds are spatially separated from trawling activities and are protected within the permanent nursery area closure along the southern and eastern sections of the Gulf. However, there are concerns over seagrass habitats after substantial die backs were associated with the marine heat wave in 2010/11. A better understanding of benthic habitats was also a key component of maintaining MSC certification for the Exmouth Gulf Prawn Managed Fishery. Research over the last 5 years has focused on increasing the knowledge of benthic habitats (e.g. FRDC project 2015/027) and their overlap with the footprint of the fisheries. In recognition of these improvements, the recent re-certification in 2020 does not contain any requirements for additional research. In a recent ERA[2], the risk level of impacts of the Exmouth Gulf Prawn Managed Fishery on the various types of habitat in Exmouth Gulf was assessed as between negligible and medium.

Ecosystems

Approximately 25% of Exmouth Gulf is trawled. Trawling is prohibited in a designated nursery area in the southern and eastern section of the Gulf. The nursery area covers 344 nm^2 and represents 28% of Exmouth Gulf. A major project surveying biodiversity on and off the trawl grounds in Exmouth indicated that trawled areas have similar diversity to the larger adjacent untrawled areas, indicating that the current level of trawling activity does not affect overall biodiversity and cannot be distinguished from other sources of variation in community structure.

In a recent ERA[2], the risk level of impacts of the Exmouth Gulf Prawn Managed Fishery on the ecosystem structure in Exmouth Gulf was assessed as between negligable and low. However, the ecosystem in this region could be at increased risk if a number of proposed industrial developments are implemented.

Shark Bay

Ecosystem / Habitat	Aquatic zone / category	Current Risk Status
Shark Bay Gulfs habitat	Sand, Sponge, Seagrass	LOW
Shark Bay Gulfs ecosystem	Marine	MEDIUM

Habitats

Benthic habitats and communities of Shark Bay have been described and mapped (CALM 1996). There is extensive seagrass throughout the eastern and western gulfs, while corals can be found primarily along the eastern coast of the western gulf, and the eastern coasts of Dirk Hartog, Dorre and Bernier Islands. Almost all of these areas are part of the Shark Bay Marine Park and are permanently closed to trawling activities. In addition, permanent trawl closures protect the majority of seagrass and coral habitats in the eastern and western gulfs. The few unprotected areas where corals occur (e.g. Egg Island and Bar Flats) are not part of the actively trawled areas. The main areas where trawling occurs, in the central bay, north Cape Peron and in the northern area of Denham Sound are sand/shell habitat.

A better understanding of benthic habitats and the overlap with the fishery footprint is also a key component of maintaining MSC certification for the Shark Bay Prawn Managed Fishery. Research over the last 5 years has focused on increasing the knowledge of benthic habitats and the overlap with the fishery footprint. In recognition of these improvements the recent MSC re-certification does not contain any requirements for additional research. In a recent ERA[1], the risk level of impacts of the invertebrate fisheries on the

1 Hall NG, and Wise BS. 2011. Development of an ecosystem approach to the monitoring and management of Western Australian fisheries. FRDC Report – Project 2005/063. Fisheries Research Report No. 215. Department of Fisheries, Western Australia. 112 pp.

2 Department of Primary Industries and Regional Development (DPIRD) 2020. Western Australian Marine Stewardship Council Report Series No. 17: Ecological Risk Assessment of the Exmouth Gulf Prawn Managed Fishery. DPIRD, Western Australia.

various types of habitat in Shark Bay was assessed as between negligable and low.

Ecosystems

In a recent ERA[1], the risk level of impacts of the invertebrate fisheries on the various types of trophic interactions in Shark Bay was assessed as between negligable and medium. Any interaction of discarding and provisoning over the long term likely representes a steady-state ecosystem structure and function. A previous study of biodiversity in Shark Bay found no significant difference in the fish and invertebrate abundance, species richness, evenness or diversity between trawled and untrawled areas (Kangas et al. 2007)[2]. Therefore, the closed areas provide protection to those species more vulnerable to trawling (Kangas et al. 2007[2]).

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

2Kangas MI, Morrison S, Unsworth P, Lai E, Wright I, and Thomson A. 2007. Development of biodiversity and habitat monitoring systems for key trawl fisheries in Western Australia. Final FRDC Report 2002/038. Department of Fisheries, Western Australia. Fisheries Research Report, No. 160. 333 pp.

FISHERIES

SHARK BAY PRAWN RESOURCE STATUS REPORT 2021

M. Kangas, S. Wilkin, P. Cavalli and G. Grounds

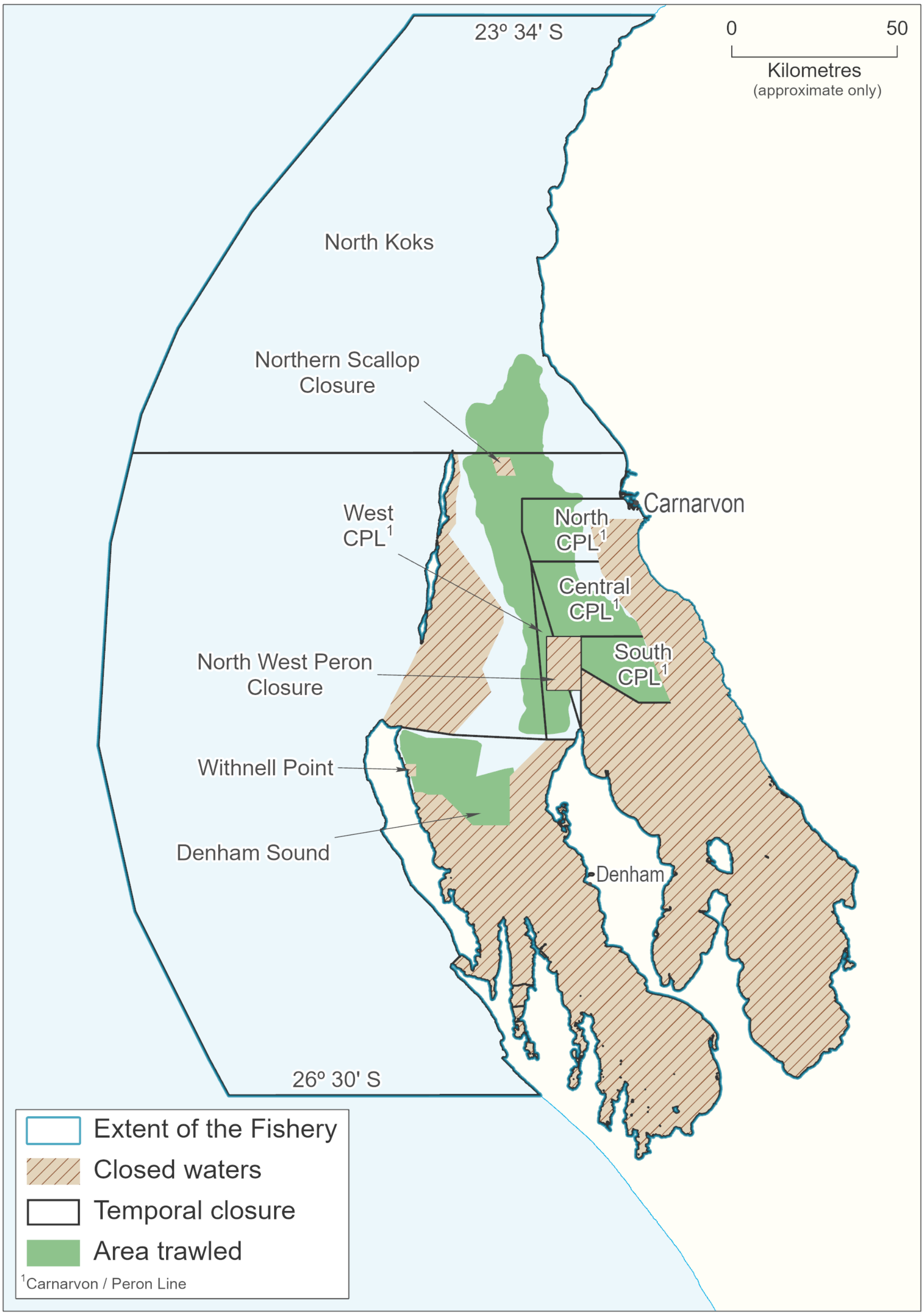
OVERVIEW

The Shark Bay Prawn Managed Fishery (SBPMF) uses low opening, otter prawn trawl systems within inner Shark Bay (Kangas *et al*. 2015) to target western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*) and lesser quantities of endeavour (*Metapenaeus endeavouri*) and coral prawns (*Metapenaeopsis sp.*). The SBPMF is managed in accordance with the *Shark Bay Prawn Managed Fishery Management Plan 1993* (SBP Management Plan) and the *Shark Bay Prawn Managed Fishery Harvest Strategy, 2014-2019* (SBP Harvest Strategy). Management of the SBPMF is based on input controls such as limited entry, gear controls (e.g. maximum headrope units), seasonal and spatial openings and closures designed to keep fishing effort at levels that will maintain a sufficient spawning biomass of prawns. Bycatch reduction devices (BRDs) are mandatory in this fishery, with all boats required to fish with a 'grid' and a secondary fish escape device (FED) fitted in each net.

In October 2015 this fishery received Marine Stewardship Council (MSC) certification. The fishery was sucessfully recertified in December 2020. It was also accredited for export under the provisions of the EPBC Act (1999) in 2015 for ten years. A more detailed account of the resource is provided in Kangas et al. (2015) (www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_2.pdf).

SUMMARY FEATURES

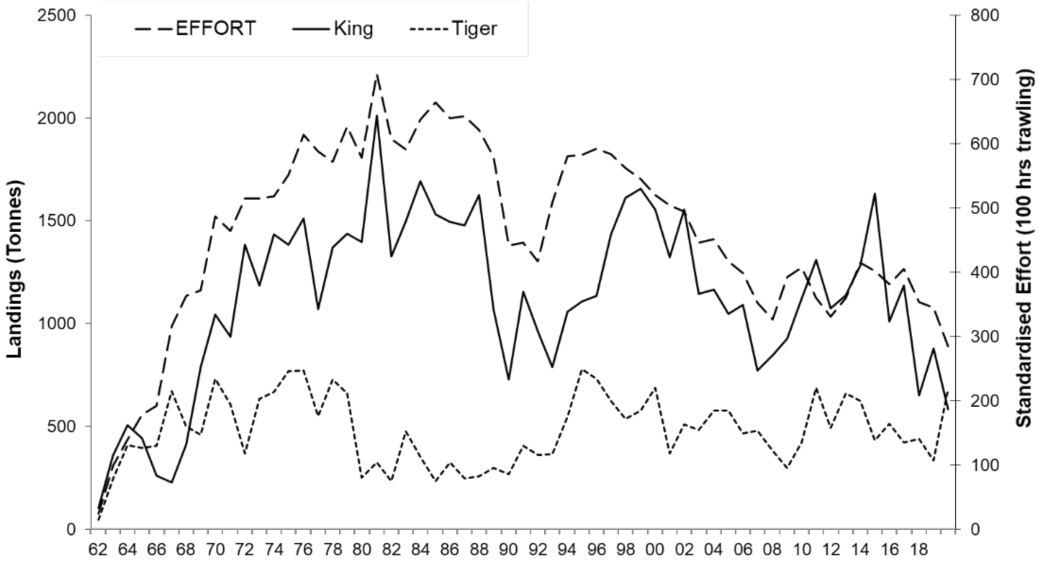
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (1350-2150 t)	Total Catch 2020: 1268 t	Acceptable
Recreational fishery	Total Catch 2020: NA	NA
EBFM		
Indicator species		
Western King Prawn	Moderate Risk: Breeding stock: Below target	Adequate
Brown Tiger Prawn	Moderate Risk: Breeding stock: Above target	Adequate
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Medium Risk	Adequate
Habitat	Low Risk	Adequate
Ecosystem	Medium Risk	Adequate
Economic (GVP $17.9 m)	Moderate Risk	Acceptable
Social (4 amenity)	Low Risk	Acceptable
Governance	Moderate Risk	Acceptable
External Drivers	High Risk	Acceptable



SHARK BAY PRAWN FIGURE 1.
Map showing boundaries of Shark Bay Prawn Managed Fishery for the 2020 fishing season.

CATCH AND LANDINGS

The total landings of target prawns in Shark Bay in 2020 were 1,268 t, with 586 t of western king prawn and 680 t of brown tiger prawn (Shark Bay Prawn Figure 2). The recorded landings of byproduct were 54 t of coral prawns, 31 t of mixed finfish, 22 t of mantis shrimp, 19 t of cuttlefish, 5 t of squid, 5 t of bugs (*Thenus orientalis*), 2 t of endeavour prawn and >1 t of octopus. Scallop and blue swimmer crab landings are reported in the Saucer Scallop Resource and Shark Bay Blue Swimmer Crab Resource Status Reports.



SHARK BAY PRAWN FIGURE 2
Annual prawn landings (t) and fishing effort (total adjusted hours to twin gear units) for the Shark Bay Prawn Managed Fishery 1962-2020.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Western king prawns (Sustainable-Adequate)

The status of the stock is assessed annually using a weight-of-evidence approach primarily based on fishery-independent indices of recruitment and spawning stock levels relative to specified reference points in the harvest strategy (DoF 2014).

There are 58 years of catch and effort data supporting the assessment that this stock has never been reduced to levels considered to be recruitment overfished (Caputi *et al*. 1998) and current effort levels are below the level of effort applied in the 1970's and 1980's (Shark Bay Prawn Figure 2). Analysis of a stock-recruitment relationship for western king prawns showed that the spring spawning stock, which is the major contributor to recruitment, has never been reduced to levels where it had a significant effect on recruitment. However, there is some uncertainty regarding the level of autumn spawning stock which is currently being examined.

There is no evidence of a declining trend in recruitment in fishery-independent survey indices since 2000 (Kangas *et al*. 2015), with the annual recruitment indices being well above the target reference level each year (25 kg/hr). In 2020 it was 67.6 kg/hr, comparatively low compared to historically observed recruitment levels. Most of the recruitment variability is driven by environmental factors (e.g. water temperature, Caputi *et al*. 2015, 2016). The fishery-independent recruitment survey in 2020 indicated a catch prediction (Caputi *et al.* 2014) for western king prawns between 690 and 1,040 t with the catch of 586 t well below the lower end of the prediction range.

In 2020 the mean spawning stock survey catch rate was 22.7 kg/hr, which is just below the catch rate target. Biomass dynamics modelling of the prawn stocks in the fishery has indicated that the target reference levels are close to MSY biomass levels.

Historical catch and catch rates from 1989 to 1998, when it was known that recruitment was not affected by fishing effort, were used as the basis for calculating the catch tolerance range for this stock (950 to 1,450 t) and mean catch rate (21 kg/hr; range 16 to 29 kg/hr). The total commercial western king prawn landings for 2020 were the lowest in over 40 years, and below the target catch tolerance range. The overall mean catch rate of 20.4 kg/hr was lower than the 10-year average (25.5 kg/hr) and less than 2019 (25 kg/hr) reflecting the lower recruitment abundance of western king prawns in 2020.

The recruitment surveys have also highlighted a declining trend in the size of western king prawns which may be influencing total catch levels. The possible reasons for this, such as the effect on changes in the water temperature cycle on the spawning and recruitment cycles are being investigated.

Brown tiger prawns (Sustainable-Adequate)

The status of brown tiger prawns is assessed annually using a weight-of-evidence approach similar to that of western king prawns. A spawning

stock–recruitment relationship exists for brown tiger prawns (Penn *et al*. 1995, Caputi *et al*. 1998), and the maintenance of adequate spawning stock is the key management objective (Kangas *et al*. 2015).

The spawning survey catch rate for brown tiger prawns in the northern Carnarvon Peron Line (NCPL) in June after it was closed was 26.4 kg/hr. There was an increase in August to 28.4 kg/hr with catch rates then remaining at a similar level (25.6 kg/hr) in September. The brown tiger prawn spawning stock level in NCPL was therefore just above the target reference level of 25 kg/hr between June and July (27.4 kg/hr). Biomass dynamics modelling of the prawn stocks in the fishery has indicated that the target reference levels are close to MSY biomass levels.

The southern Carnarvon Peron Line (SCPL) is the most southern area of the fishing grounds on the eastern side of the fishery. It mostly provides important protection for small size prawns (recruits) before they migrate to more northerly spawning areas. Fishery-independent surveys conducted in June, August and September showed brown tiger prawn catch rates of 71.3, 16.7 and 18.7 kg/hr respectively in the SCPL. The significant decline between June and August was due to the opening of the SCPL in July for a period of seven nights only. The short fishing duration was due to the relatively low western king prawn catch rates in 2020. The combined catch rate of the NCPL and SCPL was higher than the target level. The use of a combined brown tiger prawn catch rate for the two areas, with the development of an appropriate catch rate target reference level, will be examined during the next harvest strategy review in 2021.

The current harvest strategy has an annual catch tolerance range of 400 to 700 t. The brown tiger prawn catch prediction (based on fishery-independent recruitment surveys) was 435 to 650 t. The total catch (680 t) was above the upper end of the catch prediction but within the catch tolerance range.

The level of fishing effort since 2007, when all boats adopted quad gear (4 standardised nets), has been between 33 to 41 thousand trawl hours (standardised to twin nets). In 2020 fishing effort was 29 thousand trawl hours, the lowest effort recorded for the fishery, in part due to the reduced allocation of days to fish as a precautionary approach due to lower brown tiger prawn catch rates and lower western king prawn landings the past two years. This evidence indicates that the current level of fishing mortality is unlikely to cause the management unit to become recruitment overfished.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

Overall bycatch taken in Shark Bay trawl nets is moderate relative to other subtropical trawl fisheries. Bycatch composition is a mixture of small size fish species generally not taken by other sectors, significant quantities of small blue swimmer crabs (under commercial size) and other crustacean species which are normally returned alive. At times, quantities of seagrass which have broken off the shallow seagrass banks and not trawled, are moved onto the trawl grounds by tides and currents and are caught in nets.

A study of the bycatch of trawled and untrawled areas of Shark Bay in 2002/03 indicated a highly diverse fish and invertebrate fauna (Kangas and Morrison 2013, Kangas *et al*. 2007) with no significant differences between trawled and untrawled areas for species richness, diversity or evenness for the major faunal assemblages. Bycatch composition for a subset of sites sampled in 2002/03 were resampled between 2015 and 2017 as part of the MSC annual audit for this fishery. This comparison indicated that the majority of the 20 most common species of fish and invertebrates recorded were still generally amongst the top 20 in these recent samples and that there was no major change in faunal species composition in almost 15 years of trawling. Bycatch sampling will be undertaken in 2021 as part of MSC requirements. Bycatch reduction devices have been fully implemented since 2003. A recent ecological risk assessment[1] identified that the risk level of impacts of the Shark Bay Invertebrate Fisheries on bycatch was **Low**.

Protected species

Protected species including whales, dolphins, dugongs, turtles and sea snakes are particularly abundant in Shark Bay. However, only sea snakes are seen in the trawl catches in any numbers. Most are returned to the sea alive. Protected species reporting by skippers has improved in the last five years following targeted education and monitoring of daily logbooks. Interactions with protected species are also recorded during Departmental fishery-independent surveys in the fishery. The full implementation of bycatch reduction devices (grids) in the fishery has reduced the occasional capture of turtles in trawl nets (Shark Bay Prawn Table 1). A recent ecological risk assessment[2] identified that the risk level of impacts of the Shark Bay Invertebrate Fisheries on protected species was **Medium** risk.

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

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

SHARK BAY PRAWN TABLE 1.
Protected species interactions recorded in the daily logbooks during 2020. Note: Reported dolphin impacted by the propeller of the vessel.

Species	Alive	Dead	Unknown
Turtles	46	0	0
Syngnathids	153	6	0
Sea Snakes	2255	191	0
Saw Fish	0	0	0
Dolphin	1	0	0

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

As a result of the extensive permanent and temporary closures first introduced in the 1960s, the fleet operates in approximately 5-7% of the overall legislated area of the fishery. Inside Shark Bay, trawl fishing is focused in the deeper areas (predominantly sand/mud/shell habitats) of the central bay, north of Cape Peron, and in the northern area of Denham Sound. The majority of sponge/coral habitats are contained within specific trawl closures to protect these areas (Kangas et al. 2015).

Due to the predominantly mud and sand habitats of the trawl grounds, the trawl gear has relatively little physical impact. Overall, the nature of this trawl fishery and the controls on effort indicate that its environmental effect are likely to be moderate. Performance measures for habitat impact relate to the spatial extent of trawling within the SBPMF. In 2020 the total area trawled, at approximately 684 square nautical miles, was 15% of inner Shark Bay, and 6% of the total fishery. **Low** risk.

Ecosystem interactions

Although the prawn species are managed at relatively high levels of annual harvest, the impact of the catch on local food chains is unlikely to be significant in view of the high natural mortality of prawns, extent of non-trawled nursery areas and variable biomass levels of prawns resulting from variable environmental conditions. Because of this natural variation in prawn populations, most prawn predators are opportunistic, and it is unlikely that the commercial take of prawns impacts significantly on the upper trophic levels of the Shark Bay ecosystem. The gear modifications to reduce unwanted catch, have further lessened the impact the fishery has on the wider Shark Bay food chain. Any interaction of discarding and provisoning over the long term likely representes a steady-state ecosystem structure and function. **Medium** risk.

SOCIAL AND ECONOMIC OUTCOMES

Social

This industry is a major contributor to regional employment. During 2020, approximately 100 skippers and crew were employed in the fishery. There are also processing and support staff employed at Carnarvon. One of the key operators with 10 licensed fishing boats is based in Carnarvon with administration, wharf and engineering staff based at the small boat harbour. A further eight boats travel to the region and utilise local contractors during the fishing season. The prawn sector also utilises, wherever possible, Western Australian service companies providing engineering supplies, packaging, transport logistics, ship stores and fuel. **Low** risk.

Economic

The value of the fishery including coral prawns, cuttlefish, squid, octopus and bugs is $17.9 million. This value excludes scallops and blue swimmer crabs which are separate Managed Fisheries (see the Saucer Scallop Resource and Blue Swimmer Crab Resource Status Reports) and low quantities of various finfish species that are retained. Ex-vessel (beach) prices for prawns vary, depending on the type of product and the market forces operating at any one time. Average prices per kg for 2020 were generally higher than 2019. **Moderate** risk.

GOVERNANCE SYSTEM

Harvest Strategy

The fishery is managed in accordance with the SBP Harvest Strategy (DPIRD, 2015). The primary management objective is to maintain the spawning biomass of each target species at a level where the main factor affecting recruitment is the environment.

Annual Catch Tolerance Levels

The total landings of brown tiger prawn were within their annual catch tolerance range. The western king prawn landings were below their annual catch tolerance range; however, the recruitment survey index catch rate targets were all achieved. Due to the lower recruitment level of western king prawns and lower spawning index, the SCPL area was only opened for seven days to reduce fishing effort.

The annual fishing levels adopted in 2020 are considered **acceptable**.

SHARK BAY PRAWN TABLE 2.
Annual catch tolerance levels (acceptable)

Total Prawn Catch	1,350-2,150 t
Western King Prawns	950-1,450 t
Brown Tiger Prawns	400-700 t
Blue Endeavour Prawns	1-30 t
Coral Prawns	80-280 t

Compliance

It is a requirement that all vessels in the fishery are fitted with an Automatic Location Communicator (ALC). The implementation of an ALC enables the Department of Primary Industries and Regional Development (the Department) to monitor the fleet using a Vessel Monitoring System (VMS) and manage compliance with temporal and spatial closures. The Department also undertakes regular vessel inspections to ensure fishing is being undertaken in accordance with the governing legislation (e.g. gear requirements, catch reporting).

Consultation

Management Meetings are held between the Department and licensees, in conjunction with the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC). These meetings provide an opportunity for the Department, WAFIC and industry to discuss research outcomes and initiatives, management of the fishery and industry issues.

Season arrangements are developed each year in consultation between the Department and licensees. During the season, the Department and licensees undertake collaborative management to ensure the protection of smaller prawns and to maintain the spawning stock biomass.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

The fishery received a recertification through MSC in December 2020.

The Department introduced a set of guidelines for in-season decision making in 2020, to complement the SBP harvest straegy and support its review. The guidelines provide transaprency and guidance for in season operational decision making.

The SBP Harvest Strategy and Bycatch Action Plan are being reviewed in 2021.

In 2020, the two scallop protection areas introduced in 2019 were retained in northern Shark Bay to protect scallops from prawn trawling and to aid recovery. The areas were closed to all trawl fishing.

An external review of the research and management of the Shark Bay trawl fisheries was undertaken in April 2019. The Department has developed a workplan, which is being implemented to address and incorperate findings of the review in the management and science programs.

EXTERNAL DRIVERS

Economic

The major impact in early 2020 was Covid-19, however the fishing industry continued to operate and markets improvded during the year with moderate to high demand for local product. Traditional export markets were impacted during this time but some exports have resumed.

Industry has sought to maximise the return from byproduct species in the fishery where possible. **Moderate** risk.

Environmental

The major environmental factors influencing these stocks appears to be: i) water temperature, which is influenced by the Leeuwin Current strength is positively correlated with growth and catchability of prawns; and ii) turbidity during flood events is likely to increase production due to lower natural mortality. A decreasing trend and earlier onset of winter water temperatures and an increasing summer temperature are being monitored, and their effect on egg production and recruitment needs to be assessed. **High** risk.

REFERENCES

Caputi N, Kangas M, Hetzel Y, Denham A, Pearce A, and Chandrapavan A. 2016. Management adaptation of invertebrate fisheries to an extreme marine heat wave event at a global warming hotspot. Ecology and Evolution. doi: 10.1002/ece3.2137 http://onlinelibrary.wiley.com/doi/10.1002/ece3.2137/full

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2015. *Management implications of climate change effect on fisheries in Western Australia*: Part 1, Fisheries Research and Development Corporation project 2010/535. *Fisheries Research Report*, Western Australian Department of Fisheries.

Caputi N, de Lestang S, Hart, A, Kangas M, Johnston D and Penn J 2014, Catch Predictions in Stock Assessment and Management of Invertebrate Fisheries Using Pre-Recruit Abundance—Case Studies from Western Australia, Reviews in Fisheries Science and Aquaculture, 22:1, 36-54.

Caputi N, Penn JW, Joll LM, and Chubb CF. 1998. *Stock–recruitment–environment relationships for invertebrate species of Western Australia*, in: Jamieson GS and Campbell A. (eds) Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management, *Canadian Special Publication of Fisheries and Aquatic Sciences*, 125: 247–255.

Department of Fisheries. 2015. Shark Bay Prawn Managed Fishery Harvest Strategy 2015 – 2019. *Fisheries Management Paper*, No. 267. Department of Fisheries, Western Australia.

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

Kangas MI, Sporer EC, Hesp SA, Travaille KL, Brand-Gardner SJ, Cavalli P, and Harry AV. 2015. Shark Bay Prawn Managed Fishery, *Western Australian Marine Stewardship Council Report Series* 2: 294 pp.

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

Kangas M, Morrison S, Unsworth P, Lai E, Wright I, and Thomson A. 2007. *Development of biodiversity and habitat monitoring systems for key trawl fisheries in Western Australia*, final report, Fisheries Research and Development Corporation project 2002/038. *Fisheries Research Report*, 160. Fisheries Western Australia, North Beach.

Penn JW, Caputi N, and Hall NG. 1995. Stock–recruitment relationships for the tiger prawn (*Penaeus esculentus*) stocks in Western Australia, *ICES Marine Science Symposium*, 199: 320–333.

SAUCER SCALLOP RESOURCE STATUS REPORT 2021

M. Kangas, S. Wilkin, N. Breheny, P. Cavalli, G. Grounds, S. Brown

OVERVIEW

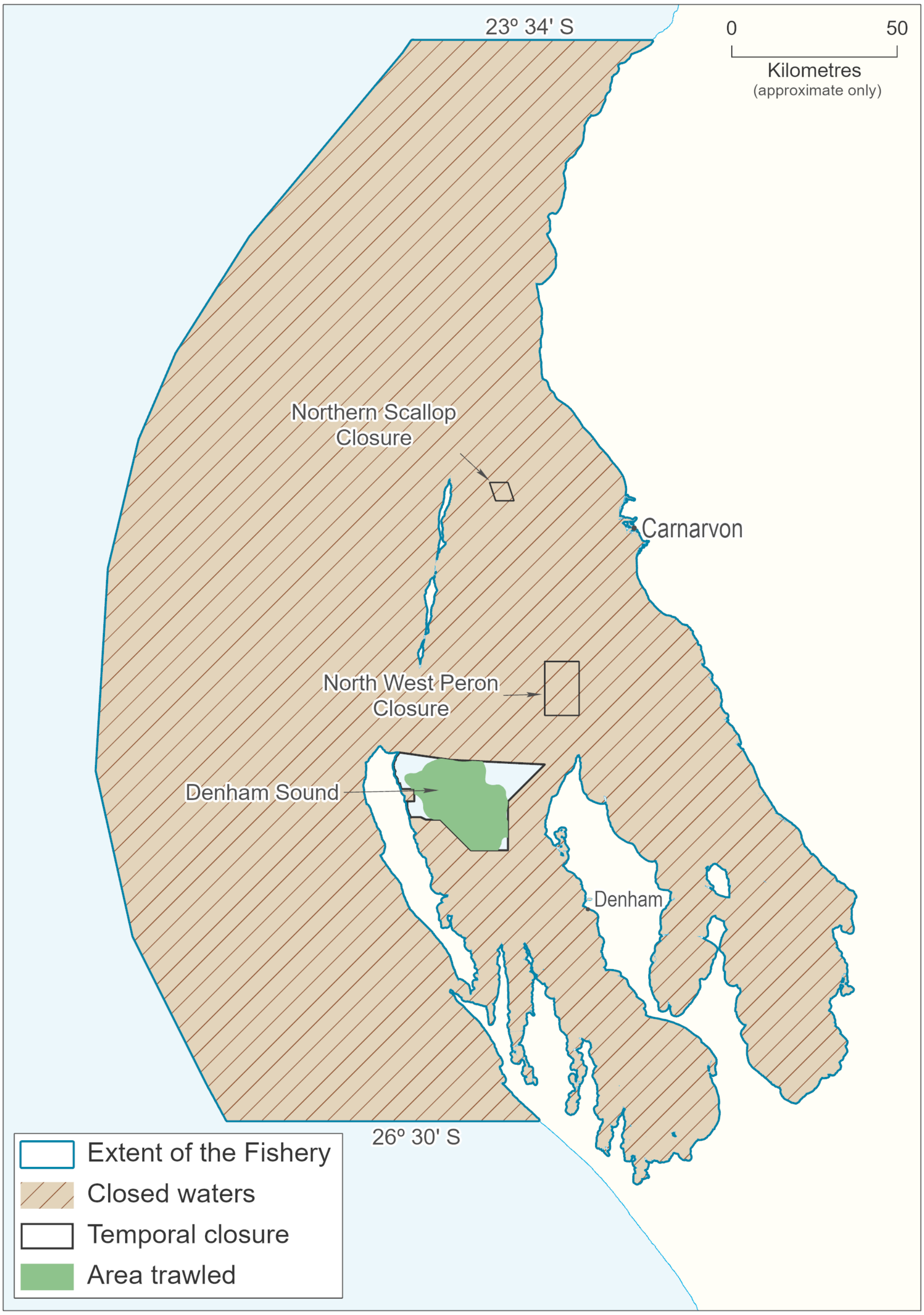
Saucer scallops, *Ylistrum balloti* (formerly *Amusium balloti*), are fished using otter trawls in four separate fisheries in Western Australia. The Shark Bay Scallop Managed Fishery (SBSMF) is usually Western Australia's most valuable scallop fishery with boats licensed to take only scallops (11 Class A licenses) and boats that also fish for prawns (18 Class B licenses). The second largest scallop fishery is the Abrolhos Islands and Mid-West Trawl Managed Fishery (AIMWTMF) (11 licenses), while the South Coast Trawl Fishery (SCTF) targeting scallops on the south coast is small (four vessels). The South West Trawl Managed Fishery (SWTMF) is a multi-species trawl fishery that primarily targets scallops. Management is generally based on limited entry, gear controls and seasonal closures however the SBSMF has been managed under a quota management framework since the fishery reopened in 2015 with an allocation between the Class A and B sectors.

Catches in these fisheries vary widely depending on the strength of recruitment, which is thought to be influenced by the strength of the Leeuwin Current and water temperature. Extreme environmental events, as was observed with a marine heat wave in the summer of 2010/11, can have a significant impact on scallop stocks, particularly in Shark Bay and the Abrolhos Islands.

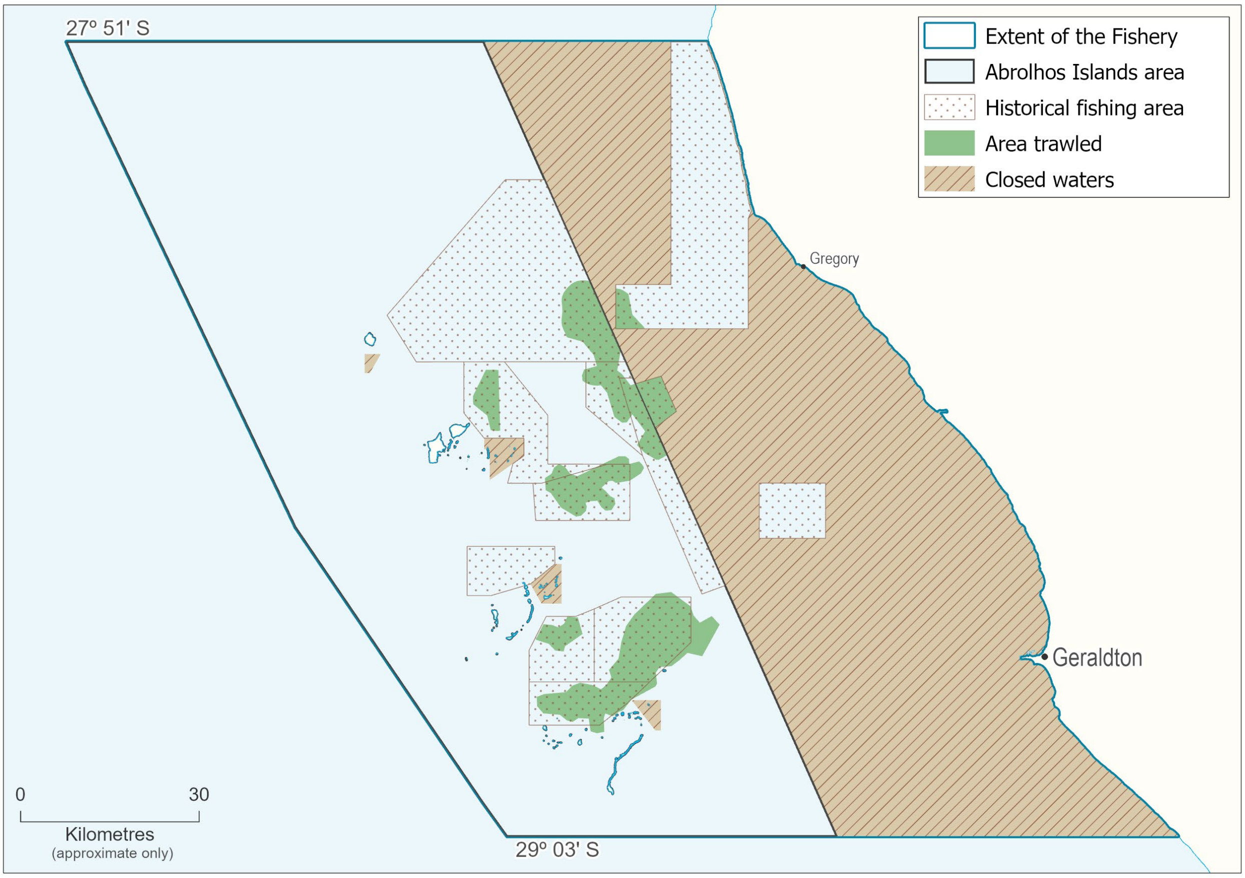
Further details on the resource assessments are provided at: http://www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_20.pdf and https://www.fish.wa.gov.au/Documents/resource_assessment/resource_assessment_report_003.pdf

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (2020)	Total Catch 2020: 418 t meat weight (2092 t whole weight)	Acceptable
Recreational fishery (N/A)		
EBFM		
Indicator species		
Saucer Scallop	Shark Bay – northern Shark Bay	Inadequate
	Shark Bay – Denham Sound	Adequate
	Abrolhos	Adequate
	South-west	Adequate
	South coast	Adequate
Ecological		
Bycatch	Low risk	Adequate
Listed Species	Low risk	Adequate
Habitat	Low risk	Adequate
Ecosystem	Low risk	Adequate
Economic (GVP $9.8 m)	High risk	Acceptable
Social (3 amenity)	Moderate risk	Acceptable
Governance	Moderate risk	Acceptable
External Drivers	High risk	Acceptable



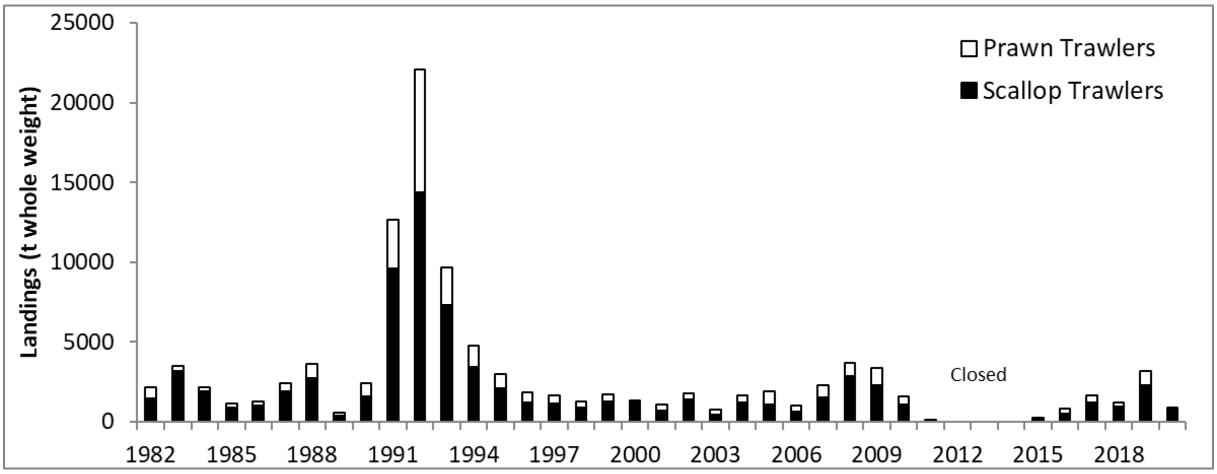
SAUCER SCALLOP FIGURE 1.
Map showing boundaries of Shark Bay Saucer Scallop Managed Fishery for the 2020/21 fishing season.



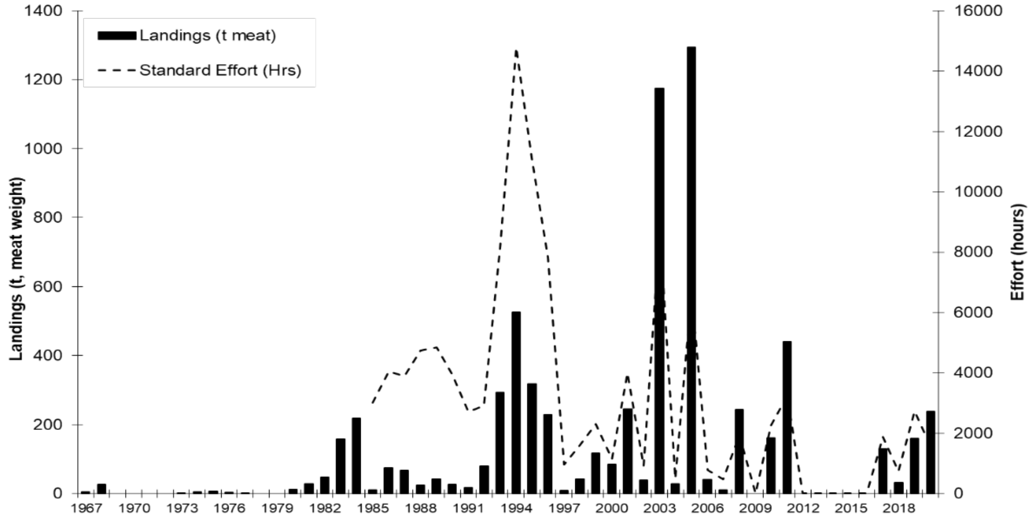
SAUCER SCALLOP FIGURE 2.
Map showing boundaries of Abrolhos Islands and Mid-West Trawl Managed Fishery for the 2020 fishing season.

CATCH AND LANDINGS

The total scallop landings in WA in 2020 was 418 t meat weight (2092 t whole weight). There was 177.1 t meat weight (885.5 t whole weight) taken from Shark Bay, which was 98% of the total quota of 180 t (season 1 May 2020 to 30 April 2021; Saucer Scallop Figure 3). Minimal by-product was retained by Class A boats in Shark Bay and vessels in the Abrolhos Islands. The scallop landings in the AIMWTMF were 238.6 t meat weight (1192.8 t whole weight; Saucer Scallop Figure 4). Only one boat fished in the SWTMF, whilst the South Coast was not fished in 2020.



SAUCER SCALLOP FIGURE 3.
Annual scallop catch (t whole weight) for the Shark Bay scallop fishery, 1982 to 2020/21. The fishery was closed between 2012 and 2014 and has operated under quota since 2015.



SAUCER SCALLOP FIGURE 4.
Annual scallop catch (t whole weight) and standardised trawl hours fished for the AIMWTMF 1967 to 2020. The fishery was closed in 2009, and from 2012 to 2016.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Shark Bay Scallop Managed Fishery (Sustainable-adequate in Denham Sound and inadequate in northern Shark Bay)

The status of the stock in Shark Bay is determined from the annual fishery-independent survey of recruitment (0+) and residual (1+) stock (Caputi et al. 2014) carried out in November–December since the 1980s. Some additional multi-species surveys have been conducted in recent years during February/March and June which are now used to inform the Total Allowable Commercial Catch (TACC) and season management arrangements. These surveys infuence the management arrangements of the fishery to maintain an adequate level of breeding stocks and set a conservative TACC limit for the fishery.

The annual survey in December 2019 indicated continued low abundance of scallops in northern Shark Bay, noting the abundance was higher than the year before. This area remained closed to fishing in 2020 and two small spatial closures that were in place in 2019 were also retained in 2020. Continued improvement in recruit scallop abundance was evident in the February and November 2020 surveys with indices being above the threshold level in November. However, a precautionary approach has been adopted until there is evidence that the recruit scallops have survived through into 2021.

In contrast the scallop abundance in Denham Sound was high due to strong recruitment and abundance of 1+ individuals that would be harvested as part of the 2020/21 quota.

Abrolhos Islands and Mid-West Trawl Managed Fishery (Sustainable-adequate)

The AIMWTMF is managed using a constant escapement approach in the Harvest Strategy (DPIRD 2020). The impact on the spawning biomass is limited by fishing after the peak spawning period; setting the duration of fishing according to catch predictions (based on pre-season surveys); closing the fishery at a minimum catch rate threshold (150 kg meat weight per day); avoiding areas of high concentrations of small scallops and by not opening the fishery if scallop abundance is considered too low (below a specified limit reference point).

The December 2019 and February 2020 pre-season surveys showed a further improvement in scallop abundance with two key areas of high abundance in the central and northern areas. The total catch for the season (1193 t whole weight), however, was not within the prediction catch range (1800 to 2700 t whole weight) due to multiple issues; product marketability, COVID restrictions and export challenges, reduced effort, and poor meat yields in areas of very high abundance which were avoided by fishers. The hyper-abundance of scallops in several areas appear to have affected growth and meat condition.

South West Trawl Managed Fishery (Sustainable-adequate)

Effort in the SWTMF has been related to either the abundance of western king prawn or saucer scallop, which can be highly variable due to sporadic scallop recruitment. One to four vessels have operated in the fishery since 2005, and have covered approximately 1-3% of the allowable

fishery area. Only one boat fished in the SWTMF in 2020 for a total of 30 boat days. This level of fishing pressure is unlikely to adversely impact the spawning biomass.

South Coast Trawl Fishery (Sustainable-adequate)

Effort is related to the abundance of scallops in any given year, which can be highly variable due to sporadic recruitment. The few vessels (up to four) that operate in the fishery only fish over 1-3 % of the allowable fishery area. No vessels went to the SCTF in 2020.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

Bycatch and protected species interactions for Class B Shark Bay Scallop vessels is discussed in the status report for the Shark Bay Prawn resource. Owing to the legislated 100 mm mesh size of the nets and the reduced number of boats operating since quota was implemented, the total bycatch landed is minimal.

Bycatch reduction devices (BRDs) are mandatory in the SBSMF and AIMWTMF, with all boats required to fish with a 'grid' with these management conditions, and grids have been fully implemented in these fisheries since 2003.

Protected species

Protected species are occasionally captured in the SBSMF but are generally released alive due to the relatively short duration of trawls. For 2020, there were 11 sea snakes reported, with ten reported as returned to the sea alive by Class A vessels (nets). **Low** risk.

Protected species that are susceptible to capture by trawling do not occur regularly in the fishing areas of the SWTMF and the SCTF and while turtles occur in the Abrolhos Islands, these are toward the southern extent of their range, and do not breed in the area because water temperatures are too low. Consequently, interactions with turtles were always minimal, and with the compulsory use of grids in the AIMWTMF, their capture has been minimised. No protected species interactions were reported in the AIMWTMF or the SWTMF in 2020. **Low** risk.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

Habitat effects are considered **low risk**, with trawl boats generally sweeping a small proportion of the designated trawl area. Because these areas are sandy habitats, and trawling activity has low impact on the substrate (Laurenson et al. 1993); the overall habitat effects are **low**. In Shark Bay, only 8.7% of the allowable trawl area was fished in 2020. Only 4.0% of the allowable area was trawled in the AIMWTMF and <1% in the SWTMF.

Ecosystem

The ecosystem impacts of scallop fisheries are considered to be **low risk**, due to the relatively low total biomass taken by these operations. The high natural recruitment variability, and therefore scallop stock abundance, and short life span (up to 3 years) also means that few predators will have become highly dependent on the species.

SOCIAL AND ECONOMIC OUTCOMES

Approximately 30-40 skippers and other crew were employed in scallop fishing in WA in 2020, with support staff in Geraldton and Fremantle. In Shark Bay, an additional 100 crew are employed in the prawn fishery (Class B) that can also retain scallops. The overall GVP for the fisheries that operated in 2020 (including scallop landings for Class B boats in Shark Bay) was $9.8 million.

GOVERNANCE SYSTEM

Harvest Strategy

The harvest strategies for Shark Bay and the Abrolhos Islands fisheries is based on the abundance of scallops during the annual recruitment/spawning stock surveys with limit and threshold levels based on the stock recruitment relationships established for each fishery (Caputi et al. 2021). For Shark Bay, the harvest strategy is based on a quota management framework, in consultation with industry (DPIRD 2021). A formal harvest strategy for the Abrolhos Islands was published in July 2020 (DPIRD 2020). This outlines the long and short-term management objectives for the fishery, the performance indicators, reference levels and harvest control rules required to achieve these objectives.

For Shark Bay, a quota management system with a conservative TACC, a mid-year review and target reference levels for resumption of fishing was implemented in 2015 to provide protection for the breeding stock and aid in recovery. Catch predictions in Shark Bay for 2020/21 for the two separate stocks are used in determining the conservative TACC for each part of the fishery in a Departmental/industry consultative framework. In 2020/21, no TACC was set for northern Shark Bay due to very low scallop abundance. Additional conservative management measures have been implemented each year since 2015, including a limit on the level of scallop

harvest pre-spawning complemented by small scale spatial closures

According to the HS, scallop catch rates in the Abrolhos Islands were well above the threshold level in 2020. Fishers ceased fishing at a catch rate above the target (150 kg/24 hours).

Annual Catch Tolerance Levels

Shark Bay: A catch limit of 900 t (whole weight) (equivalent to 180 t meat weight) was set for 2020/21 and 885 t was achieved.

Abrolhos Islands: The landings (1193 t whole weight) were within the target range (95-1830 t whole weight), but below the catch prediction (1800-2700 t whole weight).

South West: Catch range not developed.

South Coast: Catch range not developed.

Compliance

It is a requirement that all vessels in each of the fisheries are fitted with an Automatic Location Communicator (ALC). The implementation of an ALC enables the Department of Primary Industries and Regional Development (Department) to monitor the fleet using a Vessel Monitoring System (VMS) and manage compliance with temporal and spatial closures. Regular vessel inspections are also conducted to ensure fishing is being undertaken in accordance with the governing legislation (e.g. gear requirements, catch reporting).

Under the trial quota management arrangements in the SBSMF, operators are required to provide catch and disposal records (CDRs), including the weight of scallops landed. Inspections at the landing port and CDRs are monitored throughout the season to maintain the integrity of the quota system.

Consultation

Management Meetings are held between the Department and licensees, in conjunction with the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC). These meetings provide an opportunity for the Department, WAFIC and industry to discuss research outcomes and initiatives, management of the fishery and industry issues. A Shark Bay Scallop Working Group was established in 2016 to provide advice on the TACC, conduct in-season TACC reviews and assist in the development of a Shark Bay Scallop resource harvest strategy.

Skippers briefings are also conducted prior to the commencement of each season.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department’s Stakeholder Engagement Guidelines.

Management Initiatives

Measures to aid recovery of scallops in northern Shark Bay were implemented in 2020 and included a complete closure to the take of scallops in the area and two scallop protection areas closed to all trawl fishing. An external review of the research and management of the Shark Bay trawl fisheries was undertaken in April 2019. The Department continues to follow a management and science workplan to address and incorperate findings of the review in the management and science programs.

The AIMWTMF completed MSC assessment during early 2021.

A FRDC project involving the collection of scallop broodstock from the SWTMF to trial hatchery rearing of scallops with growth and development in situ, aiming for subsequent release back into the fishery and for potential contributions to stock enhancements was to commence in 2020/21 but has been delayed to 2021/22.

EXTERNAL DRIVERS

Strong La Niña events that typically result in strong Leeuwin Currents and warm sea-surface temperature often result in below-average scallop recruitment in Shark Bay and the Abrolhos Islands, whilst these warmer conditions are better for recruitment in the SCTF (Chandrapavan et al. 2020). Between 2012 and 2014, the SBSMF was closed due to the 2011 marine heatwave event (associated with a strong La Niña), which resulted in the reduction of breeding stock and subsequent very poor recruitment for a number of years (Caputi et al. 2015, 2016). Cooler conditions in the following three years (Feng et al. 2021) improved scallop recruitment. The Abrolhos Islands were adversely affected by the 2011 marine heatwave, closing the AIMWTMF from 2012 to 2016, however, cooler water temperatures in this region has assisted the fishery to recover. A La Niña event was experienced in the latter part of 2020, with potential impacts to the fisheries to be assessed and reported in 2021. **Significant** risk.

REFERENCES

Caputi N, de Lestang S, Hart A, Kangas M, Johnston D, and Penn J. 2014. Catch predictions in stock assessment and management of invertebrate fisheries using pre-recruit abundance case studies from Western Australia. Reviews in Fisheries Science and Aquaculture 22: 36-54.

http://dx.doi.org/10.1080/10641262.2013.832144.

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2015. Management implications of climate change effects on fisheries in Western Australia. Part I. Fisheries Research and Development Corporation project 2010/535. Fisheries Research Report No. 260. Department of Fisheries, Western Australia. http://www.fish.wa.gov.au/Documents/research_reports/frr260.pdf.

Caputi N, Kangas M, Hetzel Y, Denham A, Pearce A, and Chandrapavan A. 2016. Management adaptation of invertebrate fisheries to an extreme marine heat wave event at a global warming hotspot. Ecology and Evolution 6 (11): 3583-3593. https://doi.org/10.1002/ece3.2137.

Caputi N, Chandrapavan A, Kangas M, de Lestang S, Hart A, Johnston D and Penn J. 2021. Stock-recruitment-environment relationships of invertebrate resources in Western Australia and their link to pro-active management harvest strategies. Marine Policy 133: 1-16. https://doi.org/10.1016/j.marpol.2021.104728.

Chandrapavan A, Kangas M, and Caputi N. 2020. Understanding recruitment variation (including the collapse) of Ballot's saucer scallop stocks in Western Australia and assessing the feasibility of assisted recovery measures for improved management in a changing environment. Fisheries Research Report No. 308. Department of Primary Industries and Regional Development, Western Australia. 76p.

Department of Primary Industries and Regional Development. 2020. Fisheries Management Paper No. 301. Saucer Scallop Resource of Shark Bay Harvest Strategy 2020-2025. Version 1.0.

Department of Primary Industries and Regional Development. 2020. Fisheries Management Paper No. 299. Saucer Scallop Resource of the Abrolhos Islands Harvest Strategy 2020-2025. Version 1.1.

Feng M., Caputi N., Chandrapavan A., Chen M., Hart A. and Kangas M. 2021. Multi-year marine cold-spells off the west coast of Australia and effects on fisheries. Journal of Marine Systems 214: 103473.

Laurenson LJB, Unsworth P, Penn JW, and Lenanton, RCJ. 1993. The impact of trawling for saucer scallops and western king prawns on the benthic communities in coastal waters off South Western Australia. Fisheries Research Report No. 100. Fisheries Department, Western Australia. 93p.

SHARK BAY BLUE SWIMMER CRAB RESOURCE STATUS REPORT 2021

M.Kangas, S. Wilkin, N. Breheny, G. Grounds and P. Cavalli.

OVERVIEW

The blue swimmer crab (*Portunus armatus*) resource in Shark Bay is harvested commercially by the Shark Bay Crab Managed Fishery which consists of Shark Bay crab trap, Shark Bay prawn trawl and Shark Bay scallop trawl operators. This crab stock also supports a regionally important recreational fishery (<5 t). Management of the commercial sector moved from an effort-controlled system to an Individual Transferable Quota (ITQ) management system at the start of the 2015/16 season under the *Shark Bay Crab Managed Fishery Management Plan 2015*.

Recreational fishing for blue swimmer crabs mainly takes place using drop nets or scoop nets. This sector is managed through a combination of input and output controls including a minimum size limit that is well above the size at sexual maturity along with bag and boat limits.

The fishery was assessed under the provisions of the Commonwealth's EPBC Act in 2015 and has been accredited for export for a period of ten years (re-assessment in 2025).

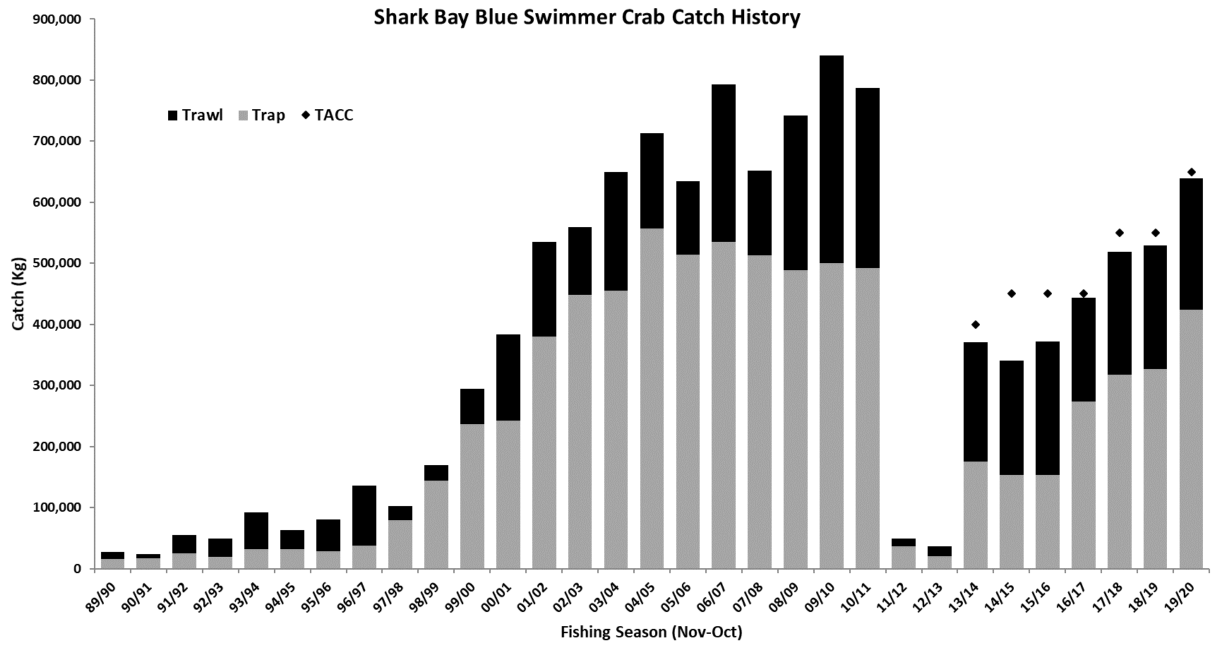
SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (650 t TACC)	Total Catch 2019/20: 639 t	Acceptable
Recreational fishery	Total Catch 2017/18: ~5 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Blue Swimmer Crab	CPUE above target	Adequate
Ecological		
Bycatch	Negligible risk (trap) Low risk (trawl)	Adequate
Listed Species	Low risk	Adequate
Habitat	Low risk	Adequate
Ecosystem	Low risk	Adequate
Economic (GVP $4.3million)	GVP Level 2 – ($1 - 5 million)	Acceptable
Social	Amenity Score 3	Acceptable
Governance	Moderate risk	Acceptable
External Drivers	Environment – Risk Level 5 (climate)	Ongoing monitoring

CATCH AND LANDINGS

A Total Allowable Commercial Catch (TACC) of 650 tonnes was set for the 2019/20 fishing season (1 November 2019 to 31 October 2020). The total catch landed for the 2019/20 season was 639 t (~98% of the TACC), the highest landed catch since the resumption of fishing in 2013 (Shark Bay Blue Swimmer Crab Figure 1). The trap sector's total catch was 424 t and represented 65% of the total landings for this season. The prawn trawl sector's total catch was 215 t which represented 33% of the total landings. The scallop trawl sector only retained 70 kg.

The estimated boat-based recreational catch of blue swimmer crab in the Gascoyne Coast was 5.4 t in 2017/18 (Ryan *et al*. 2019). The estimated boat-based recreational harvest range for blue swimmer crab for inner Shark Bay during 2016/17 was 1–2 tonnes (Taylor *et al*. 2018).



SHARK BAY BLUE SWIMMER CRAB FIGURE 1.
Commercial catch history for the blue swimmer crab (*Portunus armatus*) between trap and trawl sectors since 1989/90. *The catch for 2012/13 is generated from the experimental commercial fishing trial. A TACC of 400 tonnes was set for 2013/14 and this increased to 450 tonnes for the 2014/15, 2015/16, 2016/17 fishing seasons, it was then increased to 550 tonnes for the 2017/18, 2018/19 fishing seasons, and was further increased to 650 tonnes for the 2019/20 fishing season.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

The Shark Bay crab stock experienced a significant stock decline in late 2011, following a series of adverse environmental conditions between 2010 and 2011, particularly the extreme 2011 marine heatwave. The fishery was closed for a period of 18 months in 2012 and 2013 to promote stock recovery. Limited commercial fishing resumed under a notional quota management system for the 2013/14 (400 t) season, and continued for the 2014/15, 2015/16 and 2016/17 seasons with a TACC of 450 t. An increase of 100 tonnes was deemed appropriate for the 2017/18 season with a TACC of 550 tonnes, which was maintained for the 2018/19 season. A further increase of 100 tonnes was deemed appropriate for the 2019/20 season with a TACC of 650 tonnes.

Shark Bay crab stocks are assessed as part of a multi-species fishery-independent survey conducted in February, June and November each year. The current stock assessment indicates that spawning, recruitment and biomass levels have been increasing steadily under increasing catch levels and favourable environmental conditions. The biomass dynamics model for this resource also indicates an increasing biomass with a MSY point estimate of 672 t. The average commercial trap catch rate was 2.7 kg/traplift during 2019/20, well above the target reference level of 1.4 kg/traplift and is the highest on record. A TACC of 650 t was set for the 2020/21 season.

A harvest strategy has been developed for this fishery which now incorporates a mid-season review. This review during the 2019/20 season found no major changes in the stock indicators, as such the TACC was increased to 650 t for the remainder of the season and for the 2020/21 season.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

Bycatch from the prawn and scallop trawl fleets are described in the relevant status reports specific to the trawl fisheries (see Gascoyne Shark Bay Prawn Resource and Saucer Scallop Resource Reports).

Protected Species

The trap sector operates in a manner that avoids mortality or injury to endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities. Hourglass traps, used in the commercial fishery, are purpose-designed to minimise the capture of undersized blue swimmer crabs and non-target species, the majority of which are able to escape through the entrance gaps when the pot is soaking or being hauled. The number of bycatch species recorded in the fishery (mainly finfish and other invertebrates) is low and considered to pose a **negligible** risk to these stocks.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

Fishing with traps results in limited habitat disturbance, as only minor dragging of traps on the sea bottom occurs during trap retrieval. Sand and associated biota does not get brought to the surface in commercial blue swimmer crab traps, as the mesh used on traps is sufficiently large to allow the escape of any sand-dwelling macro-benthos. Although seagrasses are occasionally uprooted and brought to the surface with the trap, the infrequent nature of this occurrence, and the small amount of living seagrass removed, results in minimal habitat damage and therefore poses a **low** risk. The impacts of interactions specific to the trawl sectors are described in the relevant status reports.

Ecosystem

As the commercial take of crabs represents a relatively small portion of the biomass, which is effectively renewed annually, secondary food chain effects are likely to be minimal in this fishery.

SOCIAL AND ECONOMIC OUTCOMES

Social

The trap sector employs approximately 12 people as skippers and crew on vessels fishing for blue swimmer crabs in the Gascoyne Coast Bioregion, as well as additional employment for 10-20 workers for the post-harvest processing of the crab catch.

For the trawl sector, approximately 100 skippers and crew were employed in the fishery. There are also approximately 35 processing and support staff employed at Carnarvon. One of the large operators with 10 licensed fishing boats is based in Carnarvon with administration, wharf, coldstore and engineering staff based at the small boat harbour. Eight other boats travel to the region and utilise local contractors during the fishing season. The trawl sector also utilises, wherever possible, Western Australian service companies providing engineering supplies, packaging, transport logistics, ship stores and fuel.

Economic

The average beach price for uncooked crabs across WA was $8.10/kg. The estimated value of the commercial blue swimmer crab resource from Shark Bay for 2019/20 season was $4.3 million.

GOVERNANCE SYSTEM

Harvest Strategy

The harvest strategy for the Shark Bay blue swimmer crab resource outlines the long and short-term management objectives for the fishery, the performance indicators, reference levels and harvest control rules required to achieve these objectives (DPIRD 2020).

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.

Noting the short-lived and dynamic nature of blue swimmer crabs, the TACC is reviewed each year in April/May based on the state of the resource relative to specific reference levels.

DPIRD and industry have implemented a co-management arrangement whereby industry will abide by a TACC that is less than the legislated capacity. This voluntary agreement provides DPIRD with the flexibility to increase or decrease the TACC in accordance with fluctuations in the crab stock.

A constant catch harvesting strategy is applied to the commercial fishery. A weight-of-evidence approach is adopted to support the TACC setting process. The weight-of-evidence approach takes into account information from fishery-independent surveys, commercial catch and effort, environmental conditions and also results from a biomass dynamics model.

Annual Catch Tolerance Levels

A TACC of 650 t was set for the 2019/20 fishing season of which 639.3 t was achieved (~98% of TACC). This was the highest catch landings since fishing resumed in 2013, and with an annual catch tolerance range of >90%, the annual catch achieved is at an **acceptable** level.

Compliance

The Department undertakes regular vessel and landing inspections to ensure fishing is being undertaken in accordance with the governing legislation (e.g. gear requirements, catch reporting and size and bag limits). It is also a statutory requirement that commercial fishers submit Catch and Disposal Records, including the weight of crabs landed after each fishing trip. This information enables the Department to monitor the TACC and investigate any breaches of relevant legislation.

Consultation

A Shark Bay Crab Working Group was established in early 2017 to provide a transparent and inclusive decision making process between the Department, licensees and the recreational sector, that supports the review of the annual TACC for the Fishery and development of the Shark Bay crab resource harvest strategy. Annual Working Group meetings convened by the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC) are also used as an opportunity for the Department, WAFIC and industry to discuss research outcomes and initiatives, management of the fishery and industry issues. The Department undertakes consultation directly with commercial licensees on operational issues.

Focused recreational consultation occurs with Recfishwest, and broader recreational consultation processes are facilitated by Recfishwest.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives/Outlook Status

The SB Crab Harvest Strategy was formally published in June 2020, following the public consultation period held in April 2020.

EXTERNAL DRIVERS

Shark Bay is currently exhibiting an atypical seasonal SST profile compared to historical years (pre 2010). Average peak summer SST ranges are 25 to 26°C since 2010, which is almost 1°C warmer than temperatures between 1980-2000. Since 2016, summer SST's have been average to below-average, which is most favourable for recruitment and has likely contributed to increased landings in recent years including the 2017/18, 2018/19 and 2019/20 seasons.

The greatest shift in water temperatures in Shark Bay is occurring over the autumn/winter period which has been cooling since 2000 and more rapidly since 2015. This unique phenomenon that persists within Shark Bay is associated with the shift in the position of the subtropical ridge that drives climatic conditions at this latitude. Winter 2019 was the coldest on record, ~ 1.8 °C cooler than average (Chandrapavan *et al.* 2019).

Blue swimmer crabs are ranked "high risk" under the current climate change scenario with Shark Bay now considered at "High Risk" from climate change impacts (National Environmental Science Program (NESP) 2018). While recent cooler summer water temperatures pose a low risk to crab recruitment, the peak spawning period appears to be shifting earlier as a response to the shifting winter season and cooler water temperatures. Earlier spawning is consistent with the increased juvenile recruitment biomass occurring in November in recent years. Uncertainty from environmental variability continues to pose high risk to the stock.

REFERENCES

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

Chandrapavan A, Kangas MI, Johnston D, Caputi N, Hesp A, Denham A, and Sporer E. 2017. Improving the confidence in the management of the blue swimmer crab (*Portunus armatus*) in Shark Bay. Part 1: Rebuilding of the Shark Bay Crab Fishery*.* FRDC Project No. 2012/15. Fisheries Research Report No. 285. Department of Fisheries, Western Australia.

Chandrapavan A. 2017. Improving the 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.* FRDC Project No. 2012/15. Fisheries Research Report No. 285. Department of Fisheries, Western Australia.

Daley R, and van Putten I. 2017. Improving the confidence in the management of the blue swimmer crab (*Portunus armatus*) in Shark Bay. Part 11. Socio-economic significance of commercial blue swimmer crabs in Shark Bay. FRDC Project No. 2012/15. Fisheries Research Report No. 284. Department of Fisheries, Western Australia.

DPIRD (2020). Blue Swimmer Crab Resource of Shark Bay Harvest Strategy 2020-2025 Version 1.0. Fisheries Management Paper No. 300. Department of Primary Industries and Regional Development, Western Australia.

Caputi N, Kangas M, Denham A, Feng M, Pearce A, Hetzel Y and Chandrapavan A. 2016. Management adaptation of invertebrate fisheries to an extreme marine heat wave event at a global warming hot spot. Ecology and Evolution. 6 (11): 3583-3593.

NESP Earth systems and Climate Change Hub. Climate change and the Shark Bay World Heritage Area: foundations for a climate change adaptation strategy and action plan. Earth Systems and Climate Change Hub Report No. 7. 2018. NESP Earth systems and Climate Change Hub, Australia.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, and Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297. Department of Primary Industries and Regional Development, Western Australia.

Taylor SM, Steffe AS, Lai EKM, Ryan KL and Jackson G. 2018. A survey of boat-based recreational fishing in inner Shark Bay 2016/17. Fisheries Research Report No. 291. Department of Primary Industries and Regional Development, Western Australia.

EXMOUTH GULF PRAWN RESOURCE STATUS REPORT 2021

M. Kangas, S. Wilkin, I. Koefoed and S. Brown

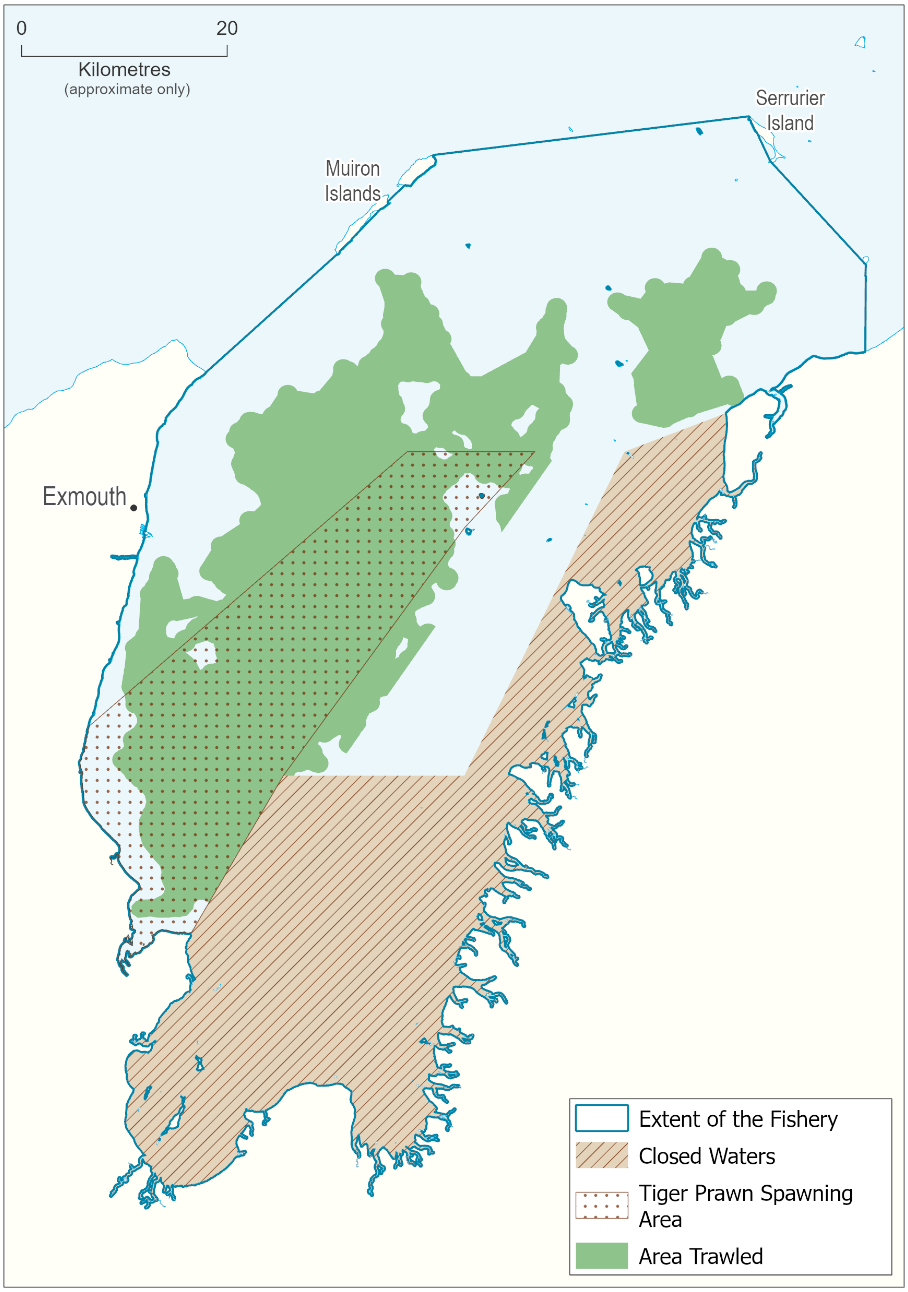
OVERVIEW

The Exmouth Gulf Prawn Managed Fishery (EGPMF) uses low opening, otter prawn trawl systems within the sheltered waters of Exmouth Gulf (Kangas *et al*. 2015) to target western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), blue endeavour prawns (*Metapenaeus endeavouri*) and banana prawns (*Penaeus merguiensis*). Management of this fishery is in accordance with the *Exmouth Gulf Prawn Managed Fishery Harvest Strategy 2021 – 2026* (EGP Harvest strategy) and is based on input controls; including limited entry, gear controls (maximum headrope units), seasonal and spatial openings and closures, and monthly moon closures. Management arrangements are designed to keep fishing effort at levels that will maintain a sufficient spawning biomass of prawns (particularly brown tiger prawns). Bycatch reduction devices (BRDs) and a secondary fish escape device (FED) are mandatory.

This fishery received Marine Stewardship Council (MSC) certification in October 2015 and was recertified in December 2020 for another five years. The Commonwealth Government Department of the Environment and Energy (now known as the Department of Agiculutre, Water and the Evironment (DAWE)) assessed the fishery in 2015 under the provisions of the *Environmental Protection and Biodiversity Act 1999* (EPBC Act) and accredited the fishery for a period of ten years (re-assessment in 2025), allowing product from the fishery to be exported from Australia https://www.environment.gov.au/marine/fisheries/wa/exmouth-gulf-prawn). A more detailed account of the resource is provided in Kangas *et al*. (2015) (www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_1.pdf).

SUMMARY FEATURES

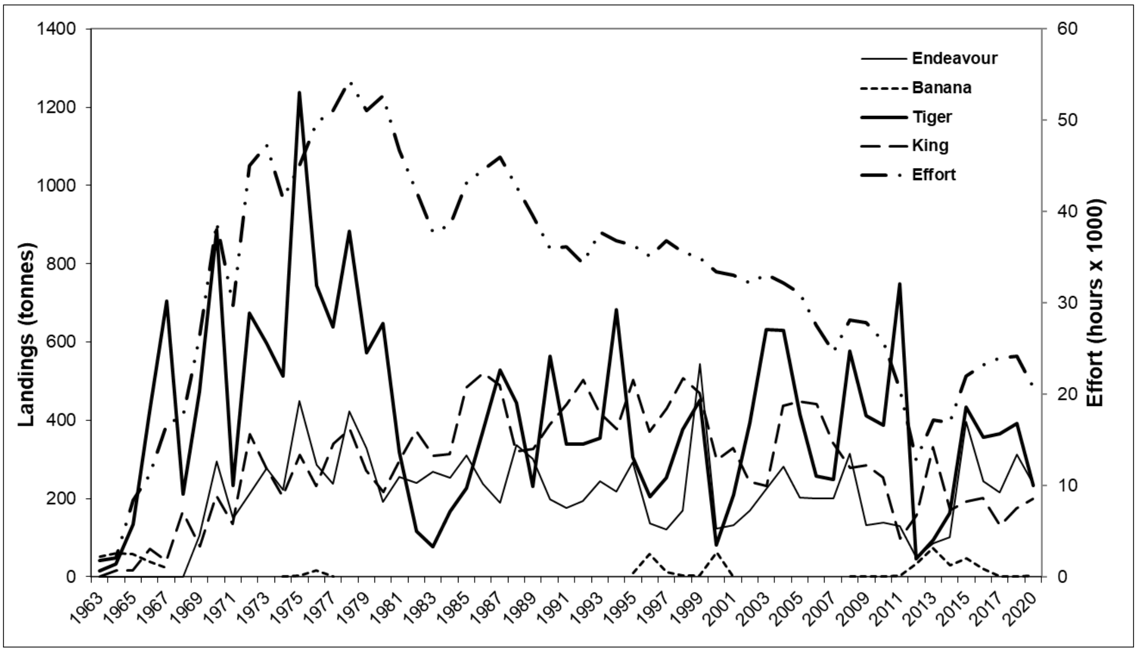
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (436-1347t)	Total Catch 2020: 673 t	Acceptable
Recreational fishery (NA)		
EBFM		
Indicator species		
Brown Tiger Prawn	Breeding stock above target	Adequate
Western King Prawn	Breeding stock above target	Adequate
Blue Endeavour Prawn	Breeding stock above target	Adequate
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Medium Risk	Adequate
Habitat	Medium Risk	Adequate
Ecosystem	Low Risk	Adequate
Economic (GVP $6.7 m)	Moderate Risk	Acceptable
Social (3 amenity)	Moderate Risk	Acceptable
Governance	Moderate Risk	Acceptable
External Drivers	High Risk	Acceptable



EXMOUTH GULF PRAWN FIGURE 1.
Map showing boundaries of the Exmouth Gulf Prawn Managed Fishery and the area trawled in 2020.

CATCH AND LANDINGS

The total landings of prawns in 2020 were 673 t, comprising 234 t of brown tiger prawns, 199 t of western king prawns, 237 t of blue endeavour prawns and 4 t of banana prawns (Exmouth Gulf Prawn Figure 2). Recorded landings of by-product were; 17 t of coral prawns, 5 t of cuttlefish, 4 t of blue swimmer crab (*Portunus armatus*), 2 t of squid, 1 t of bugs (*Thenus orientalis*) and <1 t octopus. Historical landings are provided in Kangas *et al*. (2015).



EXMOUTH GULF PRAWN FIGURE 2.
Annual prawn landings (t) and fishing effort (total adjusted hours) for the Exmouth Gulf Prawn Managed Fishery 1963-2020.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

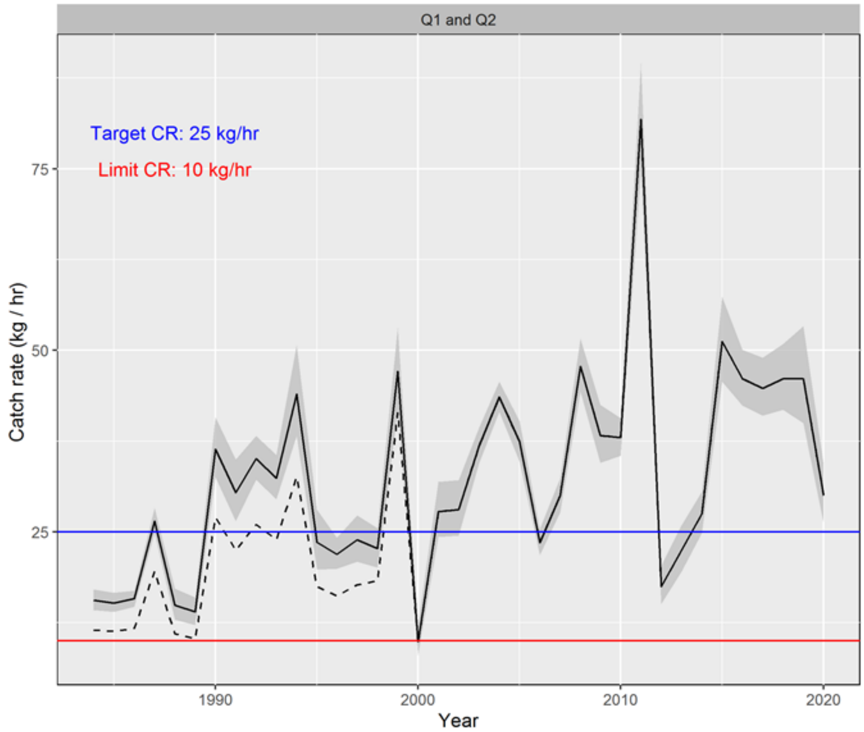
Brown tiger prawns (Sustainable-Adequate)

The status of the stock is assessed annually, using a weight-of-evidence approach primarily based on fishery-independent indices of recruitment and spawning stock levels relative to specified reference points. Recruitment surveys provide the basis of an annual catch prediction (Caputi *et al*. 2014).

The management objective for brown tiger prawns is to maintain the spawning biomass above the historically determined biological reference points, with a target of 25 kg/hr and a limit of 10 kg/hr in the spawning stock surveys (DPIRD 2018). The standardised spawning stock surveys that were carried out from August to October 2020 had an average catch rate of 30.2 kg/hr, above the target level (Exmouth Gulf Prawn Figure 3), indicating that the stock is unlikely to be recruitment overfished. Biomass dynamic modelling of the brown tiger prawn stocks in the fishery has indicated that the target reference levels are close to MSY biomass levels. The fishery has fully recovered from the effects of the 2010/2011 marine heat wave (Caputi *et al*. 2016) that may have affected the structured inshore nursery habitat.

With respect to fishing mortality, temporal and spatial closures (based on fishery-independent and industry surveys) ensure that brown tiger prawns are not harvested at sub-optimal sizes. The annual catch tolerance range for brown tiger prawns is 250 to 550 t (DPIRD 2018). With a catch prediction range of 175 to 260 t for 2020 (this revised prediction was derived using the lower historical landings in recent years) the total catch (234 t) was just below the catch tolerance range and within the prediction range.

The standardised fishing effort in 2020 was 20.8 thousand trawl hours. This is a reduction from historical levels (35 to 50 thousand hours standardised to twin gear) and the lowest effort in the last six years in line with an expected lower catch, and in line with ceasing fishing at the target catch rate. The current level of fishing mortality is unlikely to cause the stock to become recruitment overfished and stock level is considered **adequate**.



EXMOUTH GULF PRAWN FIGURE 3.
Brown tiger prawn spawning stock mean catch rate (kg/hr) and 95% confidence interval (shaded area) for August, September and October combined for two areas (Q1 and Q2) and target (upper line) and limit (lower line) reference levels. The blue line indicates the target reference point (25 kg/hr) and the red line indicates the limit reference point (10 kg/hr). The dotted line indicates catch rates that have not been adjusted for the difference in net spread between twin and quad gear.

Western king prawns (Sustainable-Adequate)

Fishery-independent recruitment surveys are undertaken each year to assess the abundance and size structure of prawns and are used for catch predictions (Caputi *et al*. 2014) and management decisions, such as spatio-temporal opening of fishing areas. In 2020, the recruitment index was 32.2 kg/hr, just above the target (30 kg/hr), however fishing was restricted in key western king prawn grounds until August, similar to what has occurred since 2017. The spawning stock index for 2020 (commercial catch rates in key western king prawn fishing grounds in August and September) was 33.7 kg/hr, which was above the target (25 kg/hr). Fishery-independent surveys of western king prawn grounds during August and September commenced in 2016 to provide additional spawning stock abundance information. In 2020, these surveys indicated a mean catch rate of 38.8 kg per hour in August and 31.9 kg per hour in September with an average over that period of 35.4 kg per hour, well above the target reference level. Biomass dynamic modelling of the western king prawn stocks in the fishery has indicated that the target reference levels are close to MSY biomass levels.

Catch and catch rate levels from 2001 to 2016 are now used as the basis for calculating the catch tolerance range (100 – 450 t) and mean catch rate range (8-16 kg/hr), due to the negative impacts of increased water temperatures on western king prawn recruitment (Caputi *et al.* 2015 a and b), and with the level of effort having declined as a result of fleet reductions and targeting larger prawns. The commercial catch for 2020 was 199 t and is within the revised target range with a mean catch rate (9.5 kg per hour) at the lower end of the target catch rate range.

The above evidence indicates that the biomass of the stock is unlikely to be recruitment overfished and that the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished. Stock levels are considered **adequate**.

Blue endeavour prawn (Sustainable-Adequate)

In 2018, the Harvest Strategy for the Exmouth Gulf Prawn Managed Fishery was modified to include blue endeavour prawns (DPIRD 2018) with specific limit (4.5 kg/hr) and target (9 kg/hr) reference levels for the spawning stock. Overall the stock assessment of this species is based on a weight of evidence approach. Fishery-independent spawning stock and recruitment surveys of brown tiger and western king prawns record the abundance of blue endeavour prawns and provide an annual spawning stock and recruitment abundance index expressed in terms of a survey catch rate. In 2020, the mean survey catch rate for the blue endeavour prawn spawning stock was 26.2 kg/hr, well above the target.

Biomass dynamics modelling of the blue endeavour prawn stocks in the fishery has indicated that the target reference levels are close to MSY biomass levels.

A secondary performance indicator is the annual recruitment survey catch rate, which indicates recruitment strength. A catch prediction has been developed based on the mean annual recruitment index and landings since 2012, when blue endeavour prawns began to be retained more consistently due to improved markets. The recruitment catch rate index in 2020 of 13.8 kg/hr was below the 10-year mean (2007–2016) of 16.7 kg/hr. The catch prediction was 150 – 230 t and landings (237 t) were just above the upper end of this range. There has been no declining trend in the fishery-independent survey catch rates over the periods sampled for either the spawning stock or recruitment. The above evidence indicates that the biomass of the stock is unlikely to be recruitment overfished.

A target catch range is set at 120–300 t, based on historical catches between 1989 and 1998, a period when the stock was considered to be moderately exploited (Gaughan and Santoro 2018) and retention rates varied due to the abundance of the key target species (brown tiger and western king prawns) as well as market demand. Total catch in 2020 was within the target catch range.

A significant portion of the breeding biomass is protected by the brown tiger prawn spawning closures and an additional portion of the blue endeavour prawn biomass occurs inshore of the key fishing grounds for brown tiger prawns, which are permanently closed.

The above evidence indicates that the biomass of the stock is unlikely to be recruitment overfished and that the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished. Stock levels are considered **adequate**.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

Bycatch levels for Exmouth Gulf are relatively low by tropical trawl fisheries standards, with few species of significance to other fishing sectors being taken. Bycatch reduction devices (BRDs) are mandatory, with all boats required to fish with a 'grid' and a secondary fish escape device (FED) fitted in each net. Secondary bycatch reduction devices (square mesh panels) were implemented in all nets in 2005. All boats also use hoppers (in-water catch sorting systems), which add another level of improvement for bycatch survival and product quality. An examination of bycatch composition between 2015 and 2017 was undertaken as part of the second MSC annual audit for this fishery. This examination compared a subset of the sites sampled in 2004 in both trawled and untrawled areas. The results indicated that the majority of the most common 20 species of fish and invertebrates recorded in 2004 were still generally amongst the top 20 in these recent samples. There also was no major change in overall faunal species composition. A recent ecological risk assessment[1] identified that the risk level of impacts of the Exmouth Gulf Prawn Managed Fishery on bycatch was **Low**.

Protected species

Sea snakes, sawfish, syngnathids and turtles are encountered in the trawls (Exmouth Gulf Prawn Table 1). Most are typically returned alive (Kangas *et al*. 2015). Grids keep captures of turtles and other large animals to low levels. The increase in reported species numbers in recent years, in particular sea snakes and sawfish is due to an increase in awareness, education and commitment from both crew and skippers to improve reporting. A recent ecological risk assessment identified that the risk level of impacts of the Exmouth Gulf Prawn Managed Fishery on protected species was **Medium** risk.

EXMOUTH GULF PRAWN TABLE 1.
Protected species interactions recorded in the daily logbooks during 2020

Species	Alive	Dead	Unknown
Turtles	14	0	0
Sea Snakes	1286	61	0
Syngnathids	0	1	0
Sawfish	3	3	0

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

Owing to the predominantly mud and sand habitats of the trawl grounds, the trawl gear has relatively little physical impact. Overall, the nature of this fishery and controls on effort indicate that its environmental effect is likely to be low (Kangas *et al*. 2015). Performance measures for habitat impact relate to the spatial extent of trawling within the licensed area of the Exmouth Gulf fishery. In 2020, the total area trawled, at approximately 363 square nautical miles (31.9%) of trawlable grounds in Exmouth Gulf, was well below the 50% target level. A **Medium** risk was assigned to habitat during a recent ecological risk

1 Department of Primary Industries and Regional Development. 2020. Ecological Risk Assessment of the Exmouth Gulf Prawn Managed Fishery. Western Australian Marine Stewardship Council Report Series No. 17. Department of Primary Industries and Regional Development, Western Australia.

assessment for the Exouth Gulf Prawn Managed Fishery[1].

Ecosystem

The impact of the catch on local food chains is unlikely to be significant given the high level of natural mortality, extent of the non-trawled areas and, variable biomass levels of prawns resulting from changing environmental conditions such as cyclone events. A **Low** risk was assigned to the ecosystem in the recent ecological risk assessment.

SOCIAL AND ECONOMIC OUTCOMES

The estimated employment in the fishery in 2020 was 18 people including skippers and other crew. Additional support staff are based in Exmouth and Fremantle. Within the Exmouth area, the fishery is an important regional employer contributing to the economic viability of the Exmouth township. Ex-vessel (beach) prices for prawns vary, depending on the type and quality of product and the market forces operating at any one time. In this fishery there is a high degree of vertical integration, with the licensee undertaking direct marketing of the product into domestic and overseas markets. For this reason, the prices quoted for prawns and byproduct are provided by the licensee on an overall average price taking into account each grade landed. The total estimated value of the fishery, including byproduct is $6.7 million for 2020.

GOVERNANCE SYSTEM

Harvest Strategy

The fishery is managed in accordance with the EGP Harvest Strategy, which was reviewed and revised in 2020/2021. The EGP Harvest Strategy now incorporates the Bycatch Action Plan, which was previously a standalone document.

The primary management objective for the Harvest Strategy is to maintain the spawning stock biomass of each target species at a level where the main factor affecting recruitment is the environment.

The key stock indicator for each primary species was above their respective target levels hence no changes to management arrangements will occur for 2021.

Annual Catch Tolerance Levels

Total landings of blue endeavour prawns were within the catch tolerance range whilst brown tiger prawns were just below. The western king prawns were within the revised catch tolerance range.

The annual fishing level is considered **acceptable**.

EXMOUTH GULF PRAWN TABLE 2.
Annual catch tolerance levels (acceptable)

Total Prawn Catch	Revised 436–1,347 t
Western King Prawns	100-450 t
Brown Tiger Prawns	250–550 t
Blue Endeavour Prawns	120–300 t
Banana Prawns	1–60 t

Compliance

It is a requirement that all vessels in the fishery are fitted with an Automatic Location Communicator (ALC). The implementation of an ALC enables the Department of Primary Industries and Regional Development (the Department) to monitor the fleet using a Vessel Monitoring System (VMS) and manage compliance with temporal and spatial closures. The Department also undertakes regular vessel inspections to ensure fishing is being undertaken in accordance with the governing legislation (e.g. gear requirements, catch reporting).

Consultation

The Department, in conjunction with the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC), holds Management Meetings (MM) for this fishery. The MM is an opportunity for the Department, WAFIC and industry to discuss research outcomes, initiatives, management of the fishery and industry issues. Season arrangements are developed each year in consultation with the licence holder. During the season, the Department and the licence holder undertake collaborative in-season management to ensure the protection of smaller prawns and to maintain the spawning stock biomass. Skipper's briefing meetings are held annually prior to the season commencing, which are attended by skippers and other industry members and the Department.

In 2020, industry hosted the inaugural Exmouth Community Forum in Exmouth. The community were invited to attend to hear presentations about the fishery from industry, MSC and the Department.

The Department has an industry/department steering group for managing MSC conditions.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department Stakeholder Engagement Guidelines.

1 Department of Primary Industries and Regional Development. 2020. Ecological Risk Assessment of the Exmouth Gulf Prawn Managed Fishery. Western Australian Marine Stewardship Council Report Series No. 17. Department of Primary Industries and Regional Development, Western Australia.

Management Initiatives

Management initiatives in 2020 included works to support MSC recertification, revision of the EGP Harvest Strategy incorporating the Bycatch Action Plan and Exmouth Community Forum planning and delivery.

EXTERNAL DRIVERS

External drivers for this fishery include economic and environmental factors.

The major impact in early 2020 was Covid-19, however the fishing industry continued to operate and markets improvded during the year with moderate to high demand for local product. Traditional export markets were impacted during this time but some exports have resumed.

Cyclones appear to have a significant effect on the productivity of Exmouth Gulf and can either have a positive or negative impact on prawns depending on the timing and severity of the cyclone, the species of prawn and their location in the fishery.

Brown tiger prawns were ranked as a **high** risk to climate change effects and western king prawns as **moderate-high**, so both these species need to be monitored closely (Caputi *et al*. 2015a and b). Heat wave events appear to contribute to a reduced abundances of brown tiger prawns in Exmouth Gulf. The causes of low recruitment periods appear to be related to impacts on nursery habitats (Loneragan *et al*. 2013) and environmental factors (including temperature).

Higher than average water temperatures also appear to be having a negative effect on western king prawn catches (Caputi *et al.* 2015a and b) and will continue to be investigated.

Higher than average water temperatures were experienced in the latter part of 2020 due to the La Niña and a marine heatwave event. Potential impacts of any increased temperatures will continue to be monitored into 2021.

REFERENCES

Caputi N, Kangas M, Hetzel Y, Denham A, Pearce A and Chandrapavan A. 2016. Management adaptation of invertebrate fisheries to an extreme marine heat wave event at a global warming hotspot. Ecology and Evolution. http://onlinelibrary.wiley.com/doi/10.1002/ece3.2137/full

Caputi N, de Lestang S, Hart A, Kangas M, Johnston D, and Penn J. 2014. Catch Predictions in Stock Assessment and Management of Invertebrate Fisheries Using Pre-Recruit Abundance—Case Studies from Western Australia, Reviews in: *Fisheries Science & Aquaculture*, 22:1, 36-54.

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2015a. Management implications of climate change effect on fisheries in Western Australia, Part 2: Case studies. FRDC Project 2010/535. *Fisheries Research Report*, No. 261. Department of Fisheries, Western Australia. 156pp.

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2015b. Management implications of climate change effect on fisheries in Western Australia: Part 1, Fisheries Research and Development Corporation project 2010/535. *Fisheries Research Report*, Western Australian Department of Fisheries, Perth.

Department of Primary Industries and Regional Development. 2020. Ecological Risk Assessment of the Exmouth Gulf Prawn Managed Fishery. Western Australian Marine Stewardship Council Report Series No. 17. Department of Primary Industries and Regional Development, Western Australia.

DPIRD. 2018. Exmouth Gulf Prawn Managed Fishery Harvest Strategy 2014 - 2019. *Fisheries Management Pape*r, No. 265. Department of Fisheries, Western Australia.

Grey DL, Dall W, and Baker A. 1983. A Guide to the Australian Penaeid Prawns, Northern Territory Department of Primary Production, Darwin.

Kangas MI, Sporer EC, Hesp SA, Travaille KL, Moore N, Cavalli P, and Fisher EA. 2015. Exmouth Gulf Prawn Fishery, Western Australian Marine Stewardship Council Report Series 1: 296p.

Loneragan NR, Kangas M, Haywood MDE, Kenyon RA, Caputi N, and Sporer E. 2013. Impact of cyclones and aquatic macrophytes on recruitment and landings of tiger prawns *Penaeus esculentus* in Exmouth Gulf, Western Australia. Estuarine Coastal and Shelf Science 127: 46-58.

WEST COAST[1] DEEP SEA CRUSTACEAN RESOURCE STATUS REPORT 2021

J. How and G. Baudains

OVERVIEW

The West Coast Deep Sea Crustacean resource consists primarily of Crystal (snow) (*Chaceon albus*), Champagne (spiny) (*Hypothalassia acerba*) and Giant (king) (*Pseudocarcinus gigas*) crabs. The resource is accessed primarily by the commercial West Coast Deep Sea Crustacean Managed Fishery (WCDSCMF) which targets crystal crabs, with the West Coast Rock Lobster Managed Fishery (WCRLMF) retaining a small amount of champagne crabs as by-product. The WCDSCMF is a pot fishery using baited pots operated in a long-line formation in shelf edge waters (>150 m) of the West Coast and Gascoyne Bioregions (see How *et al*. 2015). The fishery is primarily managed using a total allowable catch. In 2016, the WCDSCMF achieved Marine Stewardship Council certification, confirming the sustainability credentials of the fishery. For more details on the fishery and assessment methodology see How *et al*. (2015) http://www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_4.pdf.

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery: (154 t TACC crystal crab)	Total Catch 2020: 153.0 t	Acceptable
Recreational fishery (NA)		N/A
EBFM		
Indicator species		
Crystal crab (*Chaceon albus*)	Below threshold	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Low Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (GVP $6.8 m; 2019/20)	Medium Risk	Acceptable
Social (low amenity)	Low Risk	Acceptable
Governance	Major adjustments	Acceptable
External Drivers	Low Risk	Acceptable

1 This is the official name of the fishery. Boundaries include Gascoyne.

DEEP SEA CRUSTACEAN FIGURE 1.
Map showing boundaries of the West Coast Deep Sea Crustacean Managed Fishery.

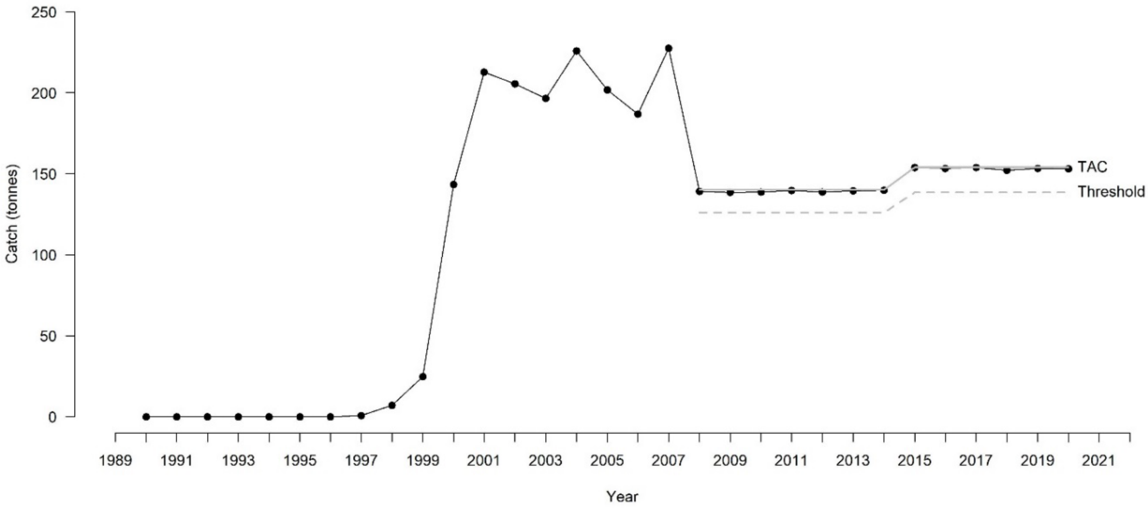
CATCH AND LANDINGS

The total landings from this west coast offshore resource in 2020 as targeted by the WCDSCMF was 156.1 t. Catches are dominated by crystal crabs, of which 99% of their TAC was landed (Deep Sea Crustacean Figure 2). In addition, 3.1 tonnes of champagne crabs were landed in 2020. Landings of crystal, champagne and giant crabs also occur off the south coast, as accessed by the South Coast Crustacean Managed Fishery (SCCMF). For more information on SCCMF landings see South Coast Crustacean Resource Status Report.

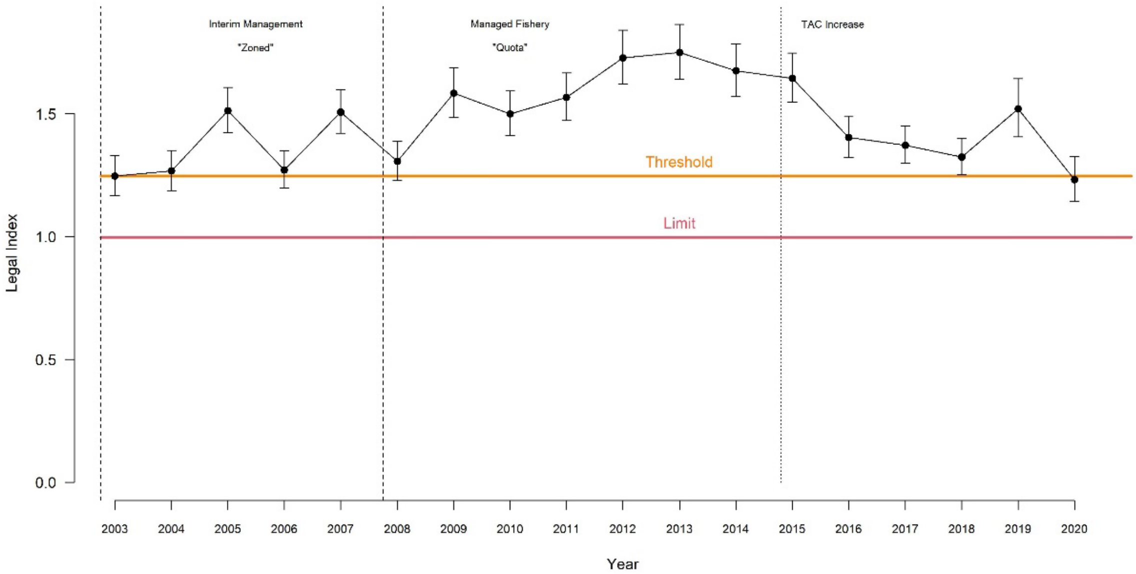
INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Crystal crab

Most lines of evidence indicate that it is likely the stock biomass of crystal crabs is near its threshold level, but above its limit level and is therefore **adequate**. The standardised catch rate of legal crystal crabs in 2020 was 1.16 kg/pot-lift (Deep Sea Crustacean Figure 3), just below the threshold reference level of 1.18 kg/pot-lift.



DEEP SEA CRUSTACEAN FIGURE 2.
Annual landings of crystal crab in the West Coast Deep Sea Crustacean Fishery and its associated total allowable catch (TAC, solid) and catch threshold level (dotted).



DEEP SEA CRUSTACEAN FIGURE 3.
Annual standardised catch rate (kg / pot-lift) of legal crystal crabs (± 95 CI) and its 3-year moving average with their associated target (light grey) and threshold region (dark grey) and limit reference point.

BYCATCH AND PROTECTED SPECIES INTERACTION

Bycatch

The gear used in this fishery generates minimal bycatch. **Negligible** risk.

Protected Species

There was one reported interactions of WCDSC gear with protected species in 2020. A humpback whale became entangled in gear which was unable to be disentangled. **Low** risk.

The bycatch and protected species performance measures for the fishery are that:

a) Fishing impacts are considered to generate an acceptable level of risk to all bycatch species' populations, i.e. moderate risk or lower;

b) Less than three interactions with any particular ETP species in a year; and

c) Fishing impacts are considered to generate an acceptable level of risk to all ETP species' populations, i.e. moderate risk or lower.

All of the measures were met.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

Potting is also considered to have a low impact on the habitat over which the fishery operates. **Low** risk.

Ecosystem

The effects of the removal of deep sea crabs has been assessed for the WCDSCMF as having negligible food chain effects by the removal of crabs. Therefore, at current catch levels, it is unlikely that removal of crabs is likely to result in any food chain effects. **Negligible** risk.

The habitat and ecosystem performance measures for the fishery are that:

- Fishing impacts are considered to generate an acceptable level of risk to ecological processes within the ecosystem, i.e. moderate risk or lower;
- Fishing impacts on each ecological resource / asset impacts are considered to generate an acceptable level of risk, i.e. moderate risk or lower.
- The area fished is ≤ 125 (10' x 10') blocks; and
- Fishing effort is ≤ 169 000 trap lifts

All of the measures were met.

SOCIAL AND ECONOMIC OUTCOMES

Social

The WCDSCMF is considered to have a low social amenity. This fishery is based on vessels that employ a skipper and two or three crew and there is no recreational fishery. The product is landed live at ports between Carnarvon and Fremantle, generating some additional economic activity and benefits. There were five vessels operating in 2020. **Low** risk.

Economic

The GVP (gross value of production) for the fishery was approximately $6.8 million in 2019/20, with the majority of the catch sold live to Asian markets both locally and internationally. **Moderate** risk.

GOVERNANCE SYSTEM

Harvest Strategy

The West Coast Deep Sea Crustacean Harvest Strategy 2020-2025 (see Fisheries Management Paper No. 302) is the basis for the setting of the Total Allowable Catch (TAC) for the WCDSCMF.

For 2020:

- The standardised catch rate of legal crystal crabs was just below the threshold level,

The catch of champagne and giant crab were both within their respective target ranges.

Fishery-independent surveys have been initiated in collaboration with fishers to obtain improved estimates of undersize and berried females as well as the legal size catch.

Annual Catch Tolerance Levels

For the 2020 season (1 January – 31 December 2020) the crystal crab quota was set at 154 t. With an annual tolerance range of > 90%, and based on the catch of 153.0 t, the annual catch is **acceptable**. The quota of champagne (B Class Units) and giant crab (C Class Units) was set at 20 and 1 t respectively. The catch of these two species was 3.1 and 0 t respectively.

Compliance

The compliance program is developed using a risk assessment process, and intelligence led investigations, particularly TAC verification which is undertaken at unload inspections.

Consultation

Management Meetings are held between the Department and licensees, in conjunction with the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC). These meetings provide an opportunity for the Department, WAFIC and industry to discuss research outcomes and initiatives, management of the fishery and industry issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines

Annual surveillance audits are conducted by MSC and are attended by licence holders, the Department and WAFIC.

Management Initiatives

Management initiatives in 2021 will focus on responding to sustainability concerns of crystal crab stocks. This will include a reduction in TAC, along with minor administrative changes to the management plan.

EXTERNAL DRIVERS

Given product is exported; fluctuation in the Australian dollar can have impacts on the economic performance of the fishery. The WCDSCMF is thought to be relatively resilient to environmental change due to the depth of fishing operations. **Low** risk.

REFERENCES

Department of Fisheries. 2020. West Coast Deep Sea Crustacean Resources Harvest Strategy 2020-2025. Fisheries Management Paper, 302. Department of Fisheries Western Australia.

How JR, Webster FJ, Travaille KL, Nardi K, and Harry AV. 2015. Western Australian Marine Stewardship Council Report Series No. 4: West Coast Deep Sea Crustacean Managed Fishery. Department of Fisheries, Western Australia. 172pp.

Jones DS and Morgan GJ. 1994. A field guide to crustaceans of Australian waters. Reed. Sydney Australia. 216pp.

Melville-Smith R, Gould R, and Bellchambers L. 2006. The crystal crab fishery in Western Australia: first steps in the development of a sustainable deepwater crab fishery. Ed. Shotton R. DeepSea 2003: conference on the governance and management of deep sea fisheries. Part II: Conference poster papers and workshop papers. FAO Fisheries Proceedings Rome, Italy.

Melville-Smith R, Norton SMG, and Thomson WA. 2007. Biological and Fisheries Data for Managing Deep Sea Crabs in Western Australia. Final report to Fisheries Research and Development Corporation on Project No 2001/055. Fisheries Research Report, No 165. Department of Fisheries Western Australia. 248pp.

Wadley V and Evans D. 1991. Crustaceans from the deepwater trawl fishery of Western Australia. CSIRO Division of Fisheries, Australia. 44pp.

GASCOYNE DEMERSAL SCALEFISH RESOURCE STATUS REPORT 2021

G. Jackson, S. Walters and S. Turner

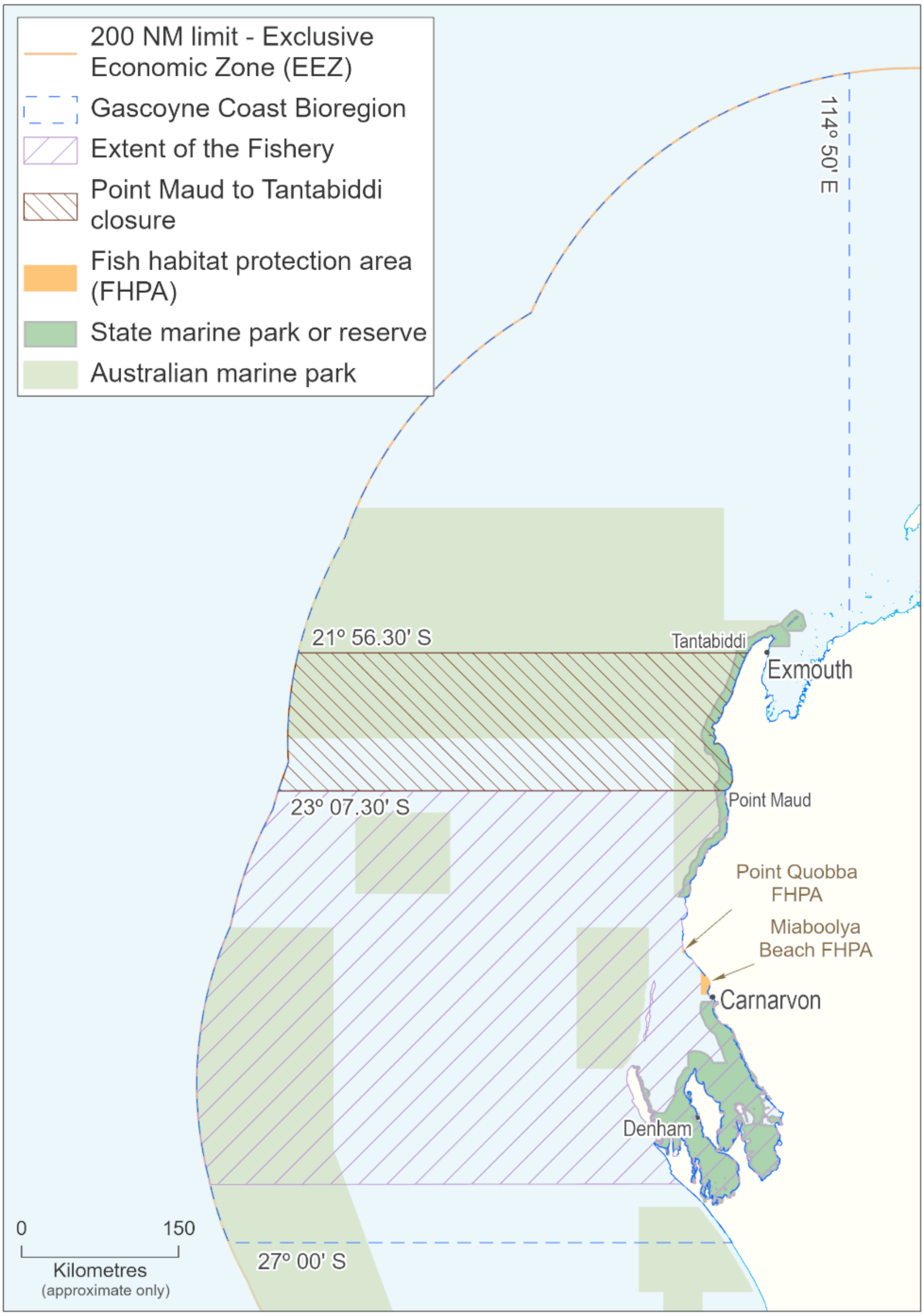
OVERVIEW

The Gascoyne Demersal Scalefish Resource (GDSR) includes 60+ demersal species inhabiting marine waters deeper than 20 m in the Gascoyne Coast Bioregion. Commercial vessels in the Gascoyne Demersal Scalefish Managed Fishery (GDSMF) fish with mechanised handlines and target pink snapper (*Chrysophrys auratus*) and goldband snapper (*Pristipomoides multidens*). Other demersal species caught include other tropical snappers, emperors, cods, mulloway and trevallies. A limited number of licensed charter vessels and a large number of recreational vessels fish out of Denham, Carnarvon and around the Ningaloo-Exmouth area and catch a similar range of demersal species, including spangled emperor (*Lethrinus nebulosus*). More details on this resource can be found in Jackson *et al*. (2020).

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (Pink snapper 51 t, Other demersals 227 t)	Total Catch 2020: Pink snapper 40 t, Other demersals 167 t	Pink snapper = Acceptable Other demersals = Acceptable
Recreational fishery	Total Catch 2017/18: 82–110 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Pink snapper	Biomass around Limit	Inadequate, Additional management action taken in 2018
Goldband snapper	Fishing mortality below & SPR above Threshold	Adequate
Spangled emperor	Fishing mortality below Threshold	Adequate
Ecological		
Bycatch	Negligible Risk	Not an issue
Listed Species	Negligible Risk	Not an issue
Habitat	Negligible Risk	Not an issue
Ecosystem	Low Risk	Acceptable
Economic (GVP $1-5 m)	Moderate Risk	Acceptable
Social (High amenity)	Moderate Risk	Acceptable
Governance	High Risk	Acceptable
External Drivers	High Risk	Acceptable

*Top 10 demersal species only from 2017/18 statewide survey (Ryan *et al.* 2019); ** Pink snapper and Goldband stocks only.



GASCOYNE DEMERSAL SCALEFISH FIGURE 1.
Waters of Gascoyne Coast Bioregion including Gascoyne Demersal Scalefish Fishery, 'Point Maud to Tantabiddi Well' fishing closure and state and Commonwealth marine parks.

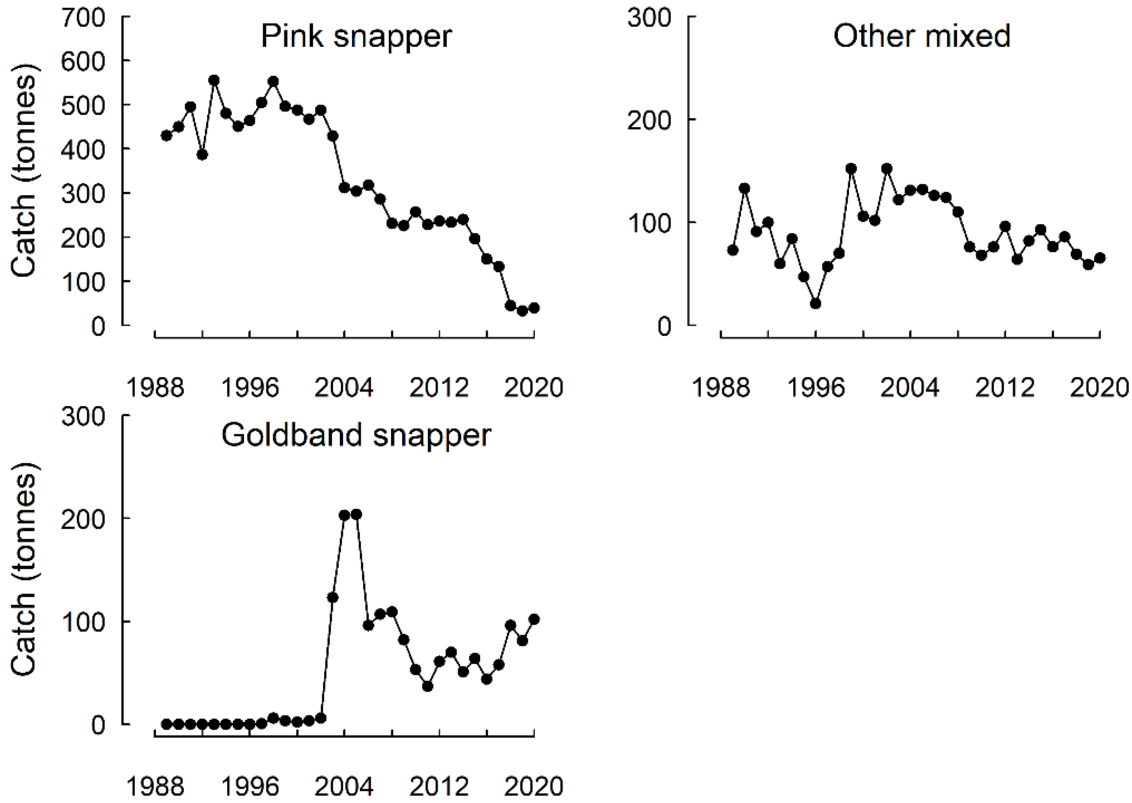
CATCH AND LANDINGS

In 2019/20, the total commercial catch reported by the GDSMF was 207 t, comprising 40 t pink snapper, 102 t goldband snapper and 65 t of other mixed species (Gascoyne Demersal Scalefish Table 1).

The top 10 demersal species in the Gascoyne Coast represented 81% of the boat-based recreational catch (kept by numbers) in 2017/18. The estimated recreational harvest range for the top 10 demersal species (or groupings) in the Gascoyne Coast were steady at 96 t (95% CI 82–110) in 2017/18 compared with 99 t (95% CI 85–114) in 2015/16, 98 t (95% CI 85–111) in 2013/14, but lower than the 144 t (95% CI 125–160) in 2011/12 (Ryan *et al*. 2019). The catch of pink snapper and goldband snapper in oceanic waters off the Gascoyne Coast reported by charter vessels in 2020 was 5 t and 13 t, respectively.

GASCOYNE DEMERSAL SCALEFISH TABLE 1.
Total catches of scalefish (excluding mackerel and tunas) taken by GDSMF in the previous five years.

Species	2015/16	2016/17	2017/18	2018/19	2019/20
Pink Snapper	149.8	133.3	45.1	33.2	39.7
Goldband Snapper	43.6	58.2	95.7	80.6	102.0
Other Jobfish	4.4	6.2	9.4	9.2	7.4
Red Emperor	10.0	13.5	10.0	9.2	5.1
Ruby Snapper	1.2	1.8	2.6	2.5	2.7
Other Snappers	1.5	2.5	1.4	1.3	2.2
Spangled Emperor	2.6	2.3	1.2	1.3	1.7
Redthroat Emperor	8.0	9.3	6.6	4.6	5.1
Other Emperors	0.6	<1.0	<0.5	<0.5	<0.5
Rankin Cod	10.5	10.8	6.8	6.9	7.7
Other Cods	10.7	12.1	9.5	6.3	7.3
Eightbar Grouper	1.6	2.2	2.4	0.9	2.1
Mulloway	6.4	4.6	2.7	3.3	2.7
Trevallies	3.6	2.4	<1.0	0.8	1.0
Other Species	15.1	17.2	15.2	12.3	13.6
Total	269.5	277.2	209.5	172.8	207.0



GASCOYNE DEMERSAL SCALEFISH FIGURE 1.
Commercial catches of Pink snapper, Goldband snapper and other mixed demersal species taken by GDSMF vessels in oceanic waters of the Gascoyne Coast Bioregion from 1988-2020.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Pink snapper Oceanic Stock (Inadequate)

The most recent integrated assessment (2017), that incorporated age composition data up to 2014/15, and catch rate data up to 2015/16, indicated that the spawning biomass had declined to around the limit (20% of unfished level). Based on this assessment and the weight of evidence, the status of the oceanic pink snapper stock was determined as **inadequate.**

Additional management action was taken in 2018 to assist recovery and rebuild the oceanic stock to the target level within two generation-times (i.e. by 2038).

Goldband snapper (Adequate)

The most recent assessment (2017) that included age composition data collected during 2010-2013, indicated that fishing mortality was below the threshold level and the spawning potential ratio was well above the threshold level. Based on this assessment and the associated weight of evidence information, the status of the goldband snapper stock in the Gascoyne was determined as **adequate.**

Spangled emperor (Adequate)

The most recent assessment (2012) that included age composition data collected during 2007-2008, indicated that while local depletion was occuring in the northern area of the bioregion (i.e. north of Point Maud outside of the Ningaloo sanctuary zones), fishing mortality for the stock overall was below the threshold level.

Based on this assessment, the status of the spangled emperor stock in the Gascoyne was determined as **adequate.**

BYCATCH and PROTECTED SPECIES INTERACTIONS

Bycatch

The GDSMF catch consists of a large number of demersal species of medium to high market value with very few species captured that are not retained and is a **negligible risk**.

Protected Species

As line fishing is highly selective, direct interactions with protected species by commercial, charter and recreational fishers in the waters of the GDSMF are a **negligible risk**.

HABITAT and ECOSYSTEM INTERACTIONS

Habitat

Line fishing for demersal scalefish by the commercial, recreational and charter sectors has virtually no direct impact on benthic habitats and represents a **negligible risk**.

Ecosystem

Food chain effects due to commercial line fishing for demersal species are considered to be low because the quota system restricts overall GDSMF catches to a relatively small percentage of the total biomass available.

The juvenile components of demersal fish stocks are likely subject to large, mostly-environmentally driven fluctuations in abundance even in the absence of fishing, resulting in significant variability in annual recruitment strength. The fishery therefore represents a **low risk**.

SOCIAL AND ECONOMIC OUTCOMES

Social

In 2020, ten GDSMF vessels fished at some point during the season (9 in 2019), 6 of which fished for more than 10 days during the traditional peak (pink snapper) season (same as in 2019), typically with a crew of 2-3. Commercial fishing and associated fish processing remain as important sources of local employment in Denham and Carnarvon.

Shark Bay and Ningaloo are popular recreational fishing destinations especially during the winter months and school holidays. The annual estimated boat-based recreational fishing effort in the Gascoyne Coast was steady in 2017/18 (42,186 boat days, SE=3,078) compared with 2015/16 (43,237 boat days, SE=3,152) and 2013/14 (53,832, SE=3,603), but lower than 2011/12 (58,123, SE=3,672) (Ryan *et al*. 2019).

Vessel retrievals at a key boat ramp in the Gascoyne (Exmouth) were significantly higher from March to August 2020, where COVID-19 measures relevant to recreational fishers included various travel restrictions, and social and physical distancing measures (Ryan et al. 2021). The current statewide recreational fishing survey (from 1 September 2020–31 August 2021) will provide an opportunity to review the medium-term impact of COVID-19 on recreational fishing in the Gascoyne and elsewhere.
The GDSR provides a high social amenity and represents a **moderate risk.**

Economic

The estimated GVP of GDSMF was in the range $1-5 million in 2020 which represents a **moderate risk.** Product from this fishery entirely supplies domestic fish markets, mostly in Perth.

The value of recreational fishing to the WA economy was recently estimated at $2.4 billion per year (McLeod and Lindner 2018) with recreational fishing in the Gsacoyne region estimated to be worth $27.5 million per year.

GOVERNANCE SYSTEM

Harvest Strategy

A formal harvest strategy for the Gascoyne Demersal Scalefish Resource (GDSR) was developed by a stakeholder based working group in 2016/17. The GDSR Harvest Strategy was approved by the Minister for Fisheries in 2017. It defines the ecological, economic and social objectives and establishes the explicit rules that determine the appropriate catch levels for the GDSR.

A recovery plan for GDSR oceanic pink snapper has been in place since 2020. This established explicit performance levels that represent an appropriate rate of recovery for the Gascoyne oceanic pink snapper spawning stock. This rate of recovery is consistent with the vulnerability and productivity of oceanic pink snapper and the dynamics of the commercial, recreational and charter fisheries that target the GDSR.

The primary ecological objective of the GDSR Harvest Strategy is to maintain spawning stock biomass of each retained species above B_{MSY} to maintain high productivity and ensure the main factor affecting recruitment is the environment.

The current harvest strategy for the GDSMF is based on a *constant catch approach* (where catch is kept constant) where a stock is in recovery, and a *constant exploitation approach* (where the catch varies in proportion to variations in stock abundance) where the stock is close to the target.

In line with this harvesting approach, the GDSMF is primarily managed using output controls via an ITQ system with a separate pink snapper TACC, and a combined TACC for other demersal scalefish species. The fishers also have to comply with gear restrictions, spatial closures and size limits that are in place for some species.

The recreational and charter fishery in the Gascoyne Coast Bioregion is also primarily managed using output controls, including size limits for some species, and daily bag and possession limits. Recreational fishers operating from a boat are required to hold a current Recreational Fishing from Boat Licence. Charter operators are also required to hold a Fishing Tour Operators Licence.

Allowable Catch/Catch Rate Tolerance Levels

Commercial

Pink snapper – Following the under-performance of the pink snapper component of the GDSR between 2014/15 and 2016/17, and outcomes of the the most recent assessment (2017) that indicated that the spawning biomass was around the limit level and therefore at **high risk**, substanial additional management measures were introduced in May 2018 that included an 81% reduction in the TACC (from 277 t to 51 t). This combined with recreational catches (including charter) and additional cyptic sources mortality (e.g. related to barotrauma, shark depredation) results in total mortality of <100 t.

In 2019/20, the landed commercial pink snapper catch was 40 t, i.e. well within the revised TACC, and therefore **acceptable**.

Goldband snapper – Within the combined TACC for other mixed demersal species (227 t) there is a maximum limit of 100-120 t for goldband. In 2019/20, the landed goldband catch was 102 t, and therefore **acceptable**.

Spangled emperor – Within the combined TACC for other mixed demersal species (227 t) there is a target catch range of 2-15 t for spangled emperor that historically has not been a commercial target species and thereby only a very minor component of the commercial mixed demersal catch. Within the combined TACC for other mixed demersal species (227 t), the landed spangled emperor catch was <2 t, and therefore **acceptable**.

Recreational

Catch tolerance levels and total mortality limits recreational and charter pink snapper catch are under development. It is likely these will be included in the GDSF Harvest Strategy when next reviewed.

The seasonal pink snapper spawning closure (1 June-31 August) adjacent to northern Bernier Island also applies to recreational and charter fishers.

Compliance

The GDSMF is managed through a combination of area closures, gear restrictions and the use of input controls in the form of individual transferable quota allocations. Compliance with nomination requirements and area boundaries is effectively monitored through a satellite-based Vessel Monitoring System (VMS). The Department undertakes regular compliance inspections at sea and landing ports. Catch and Disposal Records (CDRs) must be lodged for pink snapper and other demersal scalefish separately at the designated landing ports (Coral Bay, Carnarvon Denham and Kalbarri on the final trip for the quota season only).

Consultation

Following its implementation, a GDSR Harvest Strategy Reference Group (reference group) was formed to provide advice on strategies aimed at meeting objectives of the GDSR Harvest Strategy and ocenaic pink snapper recovery plan. The reference group meets at least once each yaer.

Management meetings between the Department and and licensees are coordinated by the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC). These meetings provide an opportunity for the Department, WAFIC and industry to discuss research outcomes and initiatives, management of the fishery and industry issues.

Focused recreational consultation occurs with Recfishwest. Broader recreational consultation processes are facilitated by Recfishwest under an Service Level Agreement (SLA).

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives/Outlook Status

The Department continues to engage the reference group to review the performance of the GDSR against the Harvest Strategy and oceanic pink snapper Recovery Plan on at least an annual basis. The next stock assessment is due in 2021, and will provide the opprotunity to determine if the oceanic pink snapper stock recovery is on track or if further management action is required.

In 2020/21, the Department will work with Recfishwest to consider any action to address concerns for future sustainability of demersal scalefish stocks in response to increased levels of recreational participation as a result of COVID-19.

EXTERNAL DRIVERS

Under the Offshore Constitutional Settlement, commercial vessels licensed by the Commonwealth may operate in waters off the Gascoyne coast, outside the 200 m isobath, as part of the Western Deepwater Trawl Fishery (WDWTF) which in these waters targets deepwater bugs (*Ibacus* spp.) and eteline snappers (e.g. ruby snappers, *Etelis spp.*) (Butler & Steven 2019). While no fishing activity in these waters had been recorded by WDWTF vessels since the early 2000s, there was some limited activity in 2018 and 2019 with 100 and 53 fishing days respectively reported (Butler & Steven 2019).

Pink snapper were previously assessed as being at high risk due to the effects of climate change, particularly in the Gascoyne (Caputi *et al.* 2015). An FRDC-funded project is currently underway to investigate whether there have been any changes to stock connectivity and biology of pink snapper related to changes in oceanic conditions. These external drivers represent a **high risk**.

REFERENCES

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, Chandrapavan A. (2015). Management implications of climate change effect on fisheries in Western Australia Part 2: Case studies. FRDC Project 2010/535. Fisheries Research Report No. 261, Department of Fisheries, Western Australia.

Jackson G, Denham A, Hesp A, Hall N, Fisher E, Stephenson P. (2020). Gascoyne Demersal Scalefish Resource. Resource Assessment Report, Department of Primary Industries and Regional Development, Western Australia. https://www.fish.wa.gov.au/Documents/resource_assessment/resource_assessment_report_009.pdf

Butler I and Steven AH (2019). Western Deepwater Trawl Fishery in: Patterson, H, Williams, A, Woodhams, J and Curtotti, R 2019, Fishery status reports 2019, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. https://doi.org/10.25814/5d80431de3fae.

Marriott R, Jackson G, Lenanton R, Telfer C, Lai E, Stephenson P, Bruce C, Adams D, Norriss J, Hall N. (2012). Biology and stock status of inshore demersal scalefish indicator species in the Gascoyne Coast Bioregion. *Fisheries Research Report*, No 228. Department of Fisheries, Western Australia.

Macleod P, Lindner R (2018). Economic dimension of recreational fishing in Western Australia. Research Report for Recreational Fishing Initiatives Fund.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia.

Ryan KL, Desfosses CJ, Denham AM, Taylor SM, Jackson G 2021. Initial insights on the impact of COVID-19 on boat-based recreational fishing in Western Australia *Marine Policy*

GASCOYNE INNER SHARK BAY SCALEFISH RESOURCE STATUS REPORT 2021

G.Jackson, S. Blazeski, S.Walters and S.Turner

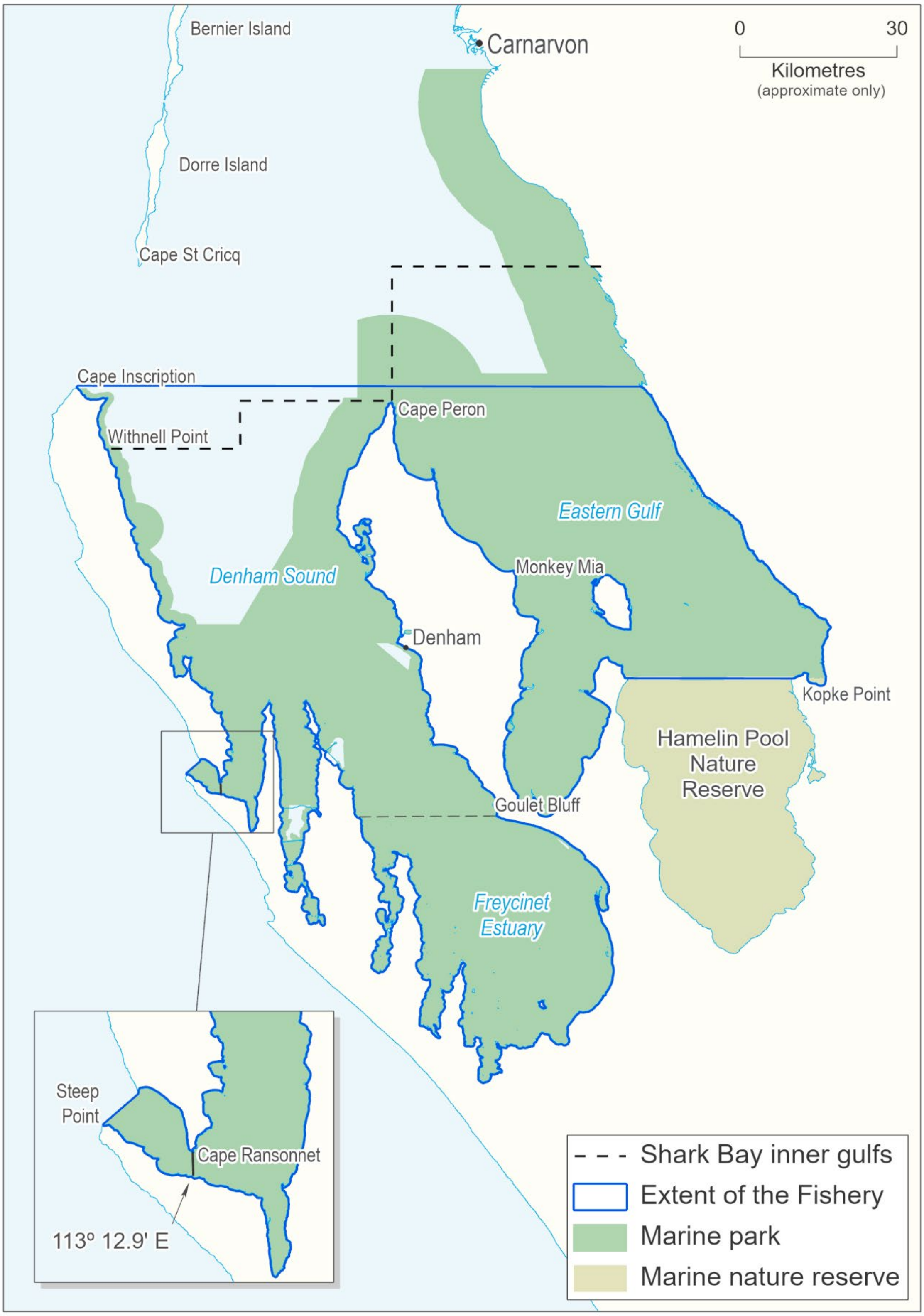
OVERVIEW

The Inner Shark Bay Scalefish Resource comprises 20-30 scalefish species taken by commercial and recreational fishers in the waters of the Eastern Gulf, Denham Sound and Freycinet Estuary in inner Shark Bay. The commercial fishery uses beach seine netting to target four species/groups: whiting (mostly yellowfin whiting, *Sillago schomburgkii*), sea mullet (*Mugil cephalus*), tailor (*Pomatomus saltatrix*) and western yellowfin bream (*Acanthopagrus morrisoni*). Most recreational fishing in Shark Bay is boat-based using hook and line to catch pink snapper (*Chrysophrys auratus*, three separate stocks), grass emperor (*Lethrinus laticaudis*), whiting (*Sillago spp.*), mackerel (*Scomberomorus* spp., *Grammatorcynus bicarinatus*), blackspot tuskfish (*Choerodon schoenleinii*), goldspotted rockcod (*Epinephelus coioides*), western butterfish (*Pentapodus vitta*) and tailor. A limited number of licensed charter vessels operate out of Denham and Monkey Mia.

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (235-335 t)	Total Catch 2020: 171 t	Acceptable
Recreational fishery (Pink snapper, 26 t)	Total Catch 2018: Pink snapper only, 22 t* (boat-based only, includes charter)	Acceptable in Eastern Gulf, Denham Sound Unacceptable in Freycinet Estuary
EBFM		
Indicator species		
Commercial fishery - Whiting	Fishing mortality below threshold (2014)	Adequate
Recreational fishery – Pink snapper (3 stocks)	Biomass of all 3 stocks above target (2015)	Adequate
Ecological		
Bycatch	Low Risk	Acceptable
Listed Species	Negligible Risk	Not an issue
Habitat	Negligible Risk	Not an issue
Ecosystem	Low Risk	Acceptable
Economic (GVP $1-5 m)	Moderate Risk	Acceptable
Social (High amenity)	Moderate Risk	Acceptable
Governance	Moderate Risk	Acceptable
External Drivers	High Risk	Acceptable

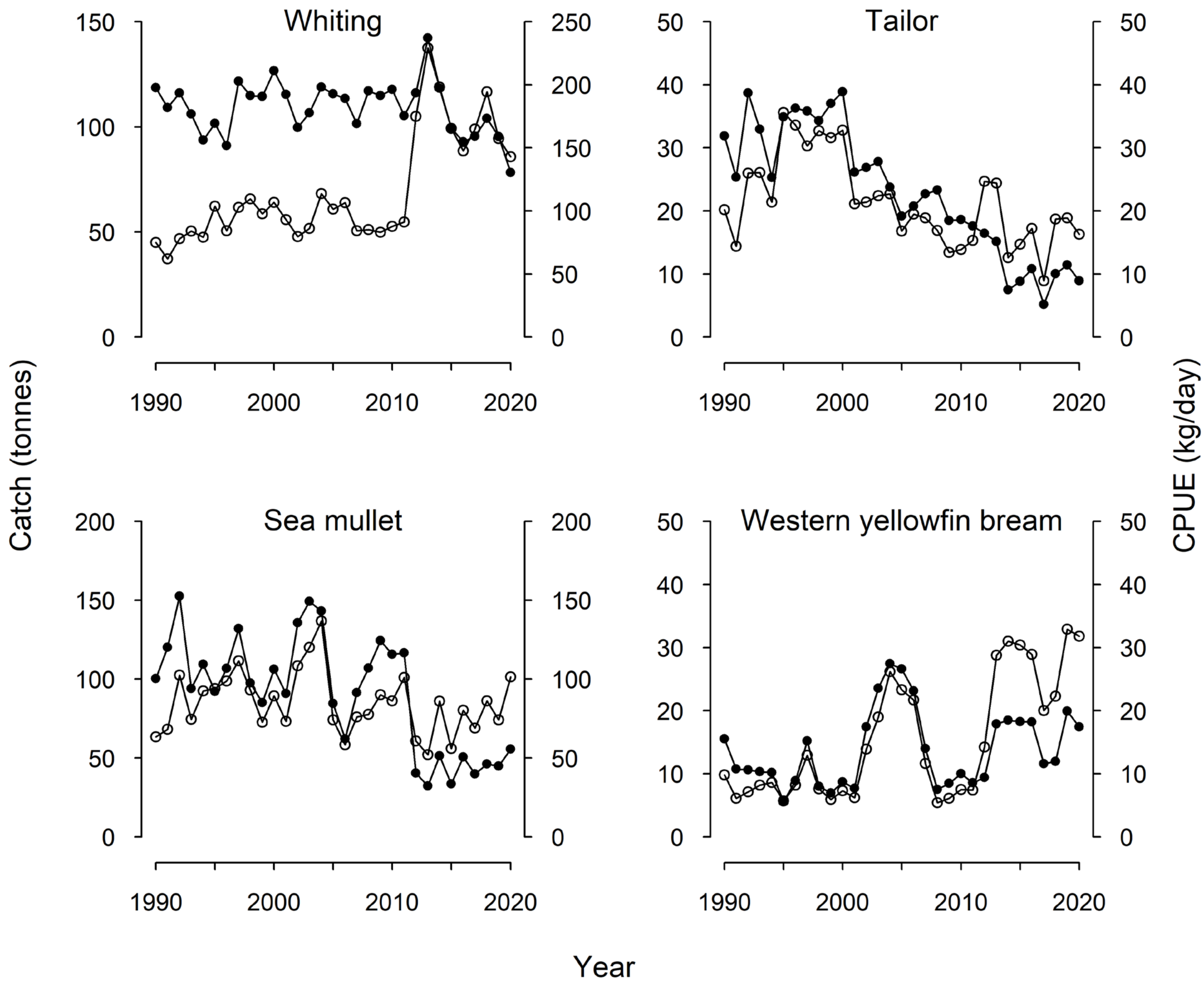
*Based estimates from on-site boat ramp survey conducted 2018/19 (Taylor et al. 2019)



GASCOYNE INNER SHARK BAY FIGURE 1.
Commercial and recreational fishing areas of inner Shark Bay.

CATCH AND LANDINGS

In 2020, the total catch reported by the commercial fishery (Shark Bay Beach Seine and Mesh Net Managed Fishery [SBBSMNF]) was 171 t, comprising 78 t of whiting, 55 t of sea mullet, 17 t of western yellowfin bream, 9 t of tailor and 11 t of other mixed species including <0.5 t of pink snapper. The total catch of pink snapper reported by charter vessels fishing in inner Shark Bay in 2020 was 4.8 t (all three areas combined). The total estimated recreational catch of pink snapper in 2020 was assumed to be similar to that in 2018 (i.e. 18 t, all three areas combined) (Taylor *et al.* 2019).



GASCOYNE INNER SHARK BAY FIGURE 2.
Commercial catches (●) and CPUE (○) of whiting, tailor, sea mullet and western yellowfin bream taken by SBBSMNF 1990-2020.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Pink snapper Inner Gulf Stocks (Adequate)

The three separate biological stocks found in inner Shark Bay (i.e. Eastern Gulf, Denham Sound, Freycinet Estuary) are predominantly fished by the recreational and charter sectors. Commercial catches of pink snapper in the inner gulfs are relatively small (<2 t) and limited to bycatch taken by the SBBSMNF.

Recreational fishing in inner Shark Bay steadily increased from the 1960s through to the 1990s with all three snapper stocks becoming over-exploited. Reductions in catch levels were generated by the additional management arrangements progressively introduced from 1998 onwards, this included notional Total Allowable Recreational Catches (TARCs) implemented in each area in 2003.

The most recent stock assessments (2015) that incorporated age composition data up to 2013 indicated that the spawning biomass of all three stocks was estimated to be above the target level (40% unfished level) in 2015. More recent Catch-MSY analyses (2020) indicated that all three stocks have continued to build under existing management arrangements and that stocks are well above target levels. On the basis of the evidence available, these pink snapper stocks are **adequate.**

Whiting (Adequate)

The commercial catch of whiting taken by the SBBSMNF is mostly (~70-90%) yellowfin whiting combined with smaller quantities of goldenline (*S. analis*), western trumpeter (*S. burrus*) and western school whiting (*S. vittata*). In 2020, the commercial catch of all whiting species taken by the SBBSMNF was 78 t, which is within the target catch range (93-127 t), with Catch Per Unit Effort (CPUE) at 143 kg/boat day well above the threshold catch rate (75 kg/boat day). The commercial catch of whiting in inner Shark Bay has been relatively stable at ~90-120 t since 1990 (Inner Shark Bay Figure 2). Whiting (mostly

yellowfin) are the third most retained scalefish species group taken by boat based recreational fishers in inner Shark Bay (Taylor *et al*. 2019).

A stock assessment of yellowfin whiting based on biological data collected in 2014 indicated that fishing mortality was above the threshold level. Based on the evidence available, whiting stocks in inner Shark Bay are classified as **adequate**.

Sea mullet (Adequate)

In 2020, the commercial catch of sea mullet taken by the SBBSMNF was 55 t and remains well below the target catch range (77-144 t). This maintains the trend in catches observed since 2000, down from the higher levels reported from 1990-2010 that typically ranged from 100–150 t. The CPUE in 2020 increased to 101 kg/boat day, well above the threshold catch rate (62 kg/boat day). While the low landings of sea mullet in more recent years reflect higher levels of fishing effort directed at the more valuable whiting, there may also be some effect of changing environmental conditions, including the 2011 marine heatwave, on stock abundance.

The sea mullet catch in inner Shark Bay represents approximately a quarter of the total commercial catch taken in WA with the majority taken in the West Coast Bioregion (West Coast Nearshore and Estuarine Finfish Resource Status Report).

Based on the evidence available, the sea mullet stock in inner Shark Bay is classified as **adequate**.

Tailor (Adequate)

In 2020, the commercial catch of tailor taken by the SBBSMNF was 9 t, and remains well below the target catch range (25-40 t). This maintains the declining trend in tailor catches observed since around 2000. The CPUE in 2020 declined to 16 kg/boat day which is below the threshold level (21 kg/boat day). While the low landings of tailor that have been a feature of the fishery in recent years are partly attributed to local processing restrictions, there may also be some effect of changing environmental conditions, including the 2011 marine heatwave, on stock abundance.

The tailor catch in inner Shark Bay represents approximately half of the total commercial catch taken in WA with the remainder taken in the West Coast Bioregion (West Coast Nearshore and Estuarine Finfish Resource Status Report).

Based on the evidence available, the tailor stock is classified as **adequate.**

Western yellowfin bream (Adequate)

In 2020, the commercial catch of western yellowfin bream taken by the SBBSMNF was 17 t, which is above the target catch range (7-15 t). The CPUE at 32 kg/boat day was well above the threshold catch rate (5 kg/boat day), as has been the case since 2013. Large variation in catches of yellowfin bream since 1990 are attributed to highly variable recruitment typical of this species that is mostly environmentally driven. The recent increase in both catch and CPUE reflect another strong year class passing through the fishery, as was previously observed in 2002-2007 and more recently, 2013-2016.

Based on the evidence available, the western yellowfin bream stock in inner Shark Bay is classified as **adequate.**

BYCATCH and PROTECTED SPECIES INTERACTIONS

Bycatch

Bycatch is minimal in the SBBSMNF because netting operations selectively target specific schools of fish and is therefore **low risk**.

Protected species

As nets are actively set and hauled, if any listed species such as dugongs, dolphins or marine turtles are caught (rare events) they are immediately released and therefore such interactions are a **negligible risk**.

HABITAT and ECOSYSTEM INTERACTIONS

Seine netting over shallow sand banks and other naturally dynamic nearshore environments combined with the low frequency of fishing in any one location represents a **negligible risk.**

SOCIAL AND ECONOMIC OUTCOMES

Social

In 2020, eight vessels operated in the SBBSMNF, employing around ~14-16 fishers. Commercial fishing and associated fish processing are still important sources of employment and income in Denham.

Shark Bay is a very popular recreational fishing destination especially during the winter months and school holidays. The annual total boat-based recreational fishing effort in inner Shark Bay between March 2018 and February 2019 was estimated at 8,596 boat trips which is within historical levels observed since 2000 (Taylor *et al*. 2019).

Vessel retrievals at key boat ramps in Shark Bay (Monkey Mia and Denham) were significantly higher from March to August 2020, where COVID-19 measures relevant to recreational fishers included various travel restrictions, and social and

physical distancing measures (Ryan et al. 2021). The current statewide recreational fishing survey (from 1 September 2020–31 August 2021) will provide an opportunity to review the medium-term impact of COVID-19 on recreational fishing.

The Inner Shark Bay Scalefish Resource therefore provides a high social amenity with **moderate risk.**

Economic

The estimated GVP of the SBBSMNF in 2019 was in the range $1-5 million that represents a **moderate risk**. Product from this fishery entirely supplies domestic fish markets (Perth and Sydney). The value of recreational fishing to the WA economy was recently estimated at $2.4 billion per year (McLeod and Lindner 2018) with recreational fishing in the Gascoyne region estimated to be worth $27.5 million per year.

GOVERNANCE SYSTEM

Harvest Strategy

The harvesting strategy for the SBBSMNF is based on a *constant exploitation approach* (where the catch varies in proportion to variations in stock abundance).

The SBBSMNF is managed through input controls in the form of limited entry, gear restrictions (e.g. vessel size, net length and mesh size) and permanently closed waters.

The recreational and charter fishery in Shark Bay is managed using a combination of output controls including daily bag, possession, size and gear limits. Recreational fishers operating from a boat are required to hold a current Recreational Fishing from Boat Licence (RFBL) while net fishers require a Recreational Net Fishing Licence. Pink snapper stocks are managed to notional maximum acceptable catch levels (TACC and TARC, set in 2003): Eastern Gulf (11.25 t recreational; 3.75 t commercial), Denham Sound (11.25 t recreational; 3.75 t commercial) and Freycinet Estuary (3.75 t recreational; 1.25 t commercial).

Annual Catch/Catch Rate Tolerance Levels

Commercial:

Total fishing effort in the SBBSMNF was 547 boat days in 2020, higher than in 2019 but still around the lowest levels on record. While the total commercial catch in 2020 at 171 t was below the target catch range (235–335 tonnes), when viewed against the historically low levels of current effort, the commercial catch level is considered **acceptable**.

In 2020, the commercial catch of snapper taken by the SBBSMNF was <0.5 t, well within the notional TACC (9 t all three areas combined).

Recreational:

Recreational (includes charter) catch tolerance levels are currently only in place for pink snapper.

Recreational catches of pink snapper in 2020 were assumed to be similar to those in 2018 that were estimated at 2.1 t [95% CI 0.8-3.4] in the Eastern Gulf, 4.6 t [95% CI 3.4-5.9] in Denham Sound, and 11.5 t [95% CI 4.3-18.7]) in Freycinet Estuary (Taylor *et al*. 2019).

In 2020, a total of ~2 t were reported by charter vessels (Eastern Gulf <0.5 t, Denham Sound ~1 t, Freycinet ~1 t).

Recreational catches of snapper in **Eastern Gulf** and **Denham Sound** were within the respective notional TARCs, and are therefore **acceptable**. However the cecreational catch in **Freycinet** was well above the TARC and is therefore **unacceptable.**

Compliance

The Department of Primary Industries and Regional Development undertakes regular compliance inspections at-sea and on-land.

Consultation

The Department undertakes consultation directly with licensees on operational issues. Industry Management Meetings are convened by the Western Australian Fishing Industry Council (WAFIC), who are also responsible for statutory management plan consultation under a Service Level Agreement.

Consultation processes are facilitated by Recfishwest under a Service Level Agreement although the Department undertakes direct consultation with the community on specific issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

A formal harvest strategy for the nearshore scalefish resource in the Gascoyne Coast Bioregion which would include the main species targetted by the SBBSMNF, the Exmouth Gulf Beach Seine Fishery and the Carnarvon Open Access Fishery (but would exclude demersal scalefish species such as pink snapper) is yet to be developed, however, it is noted as a management initiative for the future.

The Department will work with Recfishwest to consider options to address pink snapper catch in Freycinet in 2021.

EXTERNAL DRIVERS

The Inner Shark Bay system has been considered relatively stable as a result of its typically low-rainfall and arid environment. However, extreme but occasional events including cyclone-related riverine floods (occurred in the Gascoyne and Wooramel Rivers in 2010-2011 and more recently in 2018) and a marine heatwave (summer of 2010/11) had significant impacts on some marine habitats (e.g. temperate seagrasses) (Arias-Ortiz *et al.* 2018) and important invertebrate species (e.g. blue crabs and scallops) (Pearce *et al*. 2011, Caputi *et al*. 2014). The impact of these events on key scalefish species in Inner Shark Bay is unknown.

Pink snapper had previously been assessed as high risk, and grass empreror and tailor as medium risk due to the effects of climate change, particularly in the Gascoyne (Caputi *et al.* 2015).

These external drivers represent a **high risk**.

REFERENCES

Arias-Ortiz A, Serrano O, Masque P, Lavery P, Mueller U, Kendrick G, Rozaimi M, Esteban A, Fourqurean J, Marba N, Mateo MA, Murray K, Rule M and Duarte CM. (2018) A marine heatwave drives losses from the world’s largest seagrass carbon stock. *Nature Climate Change* 8: 338-344.

Caputi N, Jackson G, Pearce A. 2014. The marine heatwave off Western Australia during the summer of 2010/11 – 2 years on. Fisheries Research Report, No 250. Department of Fisheries, Western Australia, Perth.

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, Chandrapavan A. 2015. Management implications of climate change effect on fisheries in Western Australia Parts 1 & 2. FRDC Project 2010/535. Fisheries Research Report, No. 260. Department of Fisheries, Western Australia.

Macleod P, Lindner R (2018). Economic dimension of recreational fishing in Western Australia. Research Report for Recreational Fishing Initiatives Fund.

Pearce A, Lenanton R, Jackson G, Moore J, Feng M, Gaughan D. 2011. The “marine heatwave” off Western Australia during the summer of 2010/11. Fisheries Research Report, No 222. Department of Fisheries, Western Australia, Perth.

Ryan KL, Desfosses CJ, Denham AM, Taylor SM, Jackson G 2021. Initial insights on the impact of COVID-19 on boat-based recreational fishing in Western Australia *Marine Policy*

Taylor SM, *et al.* 2019. A survey of boat-based recreational fishing in inner Shark Bay 2018/19. Government of Western Australia. Department of Primary Industries and Regional Development, Western Australia. Fisheries Research Report, No. 298. Department of Primary Industries and Regional Development, Western Australia.

NORTH COAST BIOREGION

ABOUT THE BIOREGION

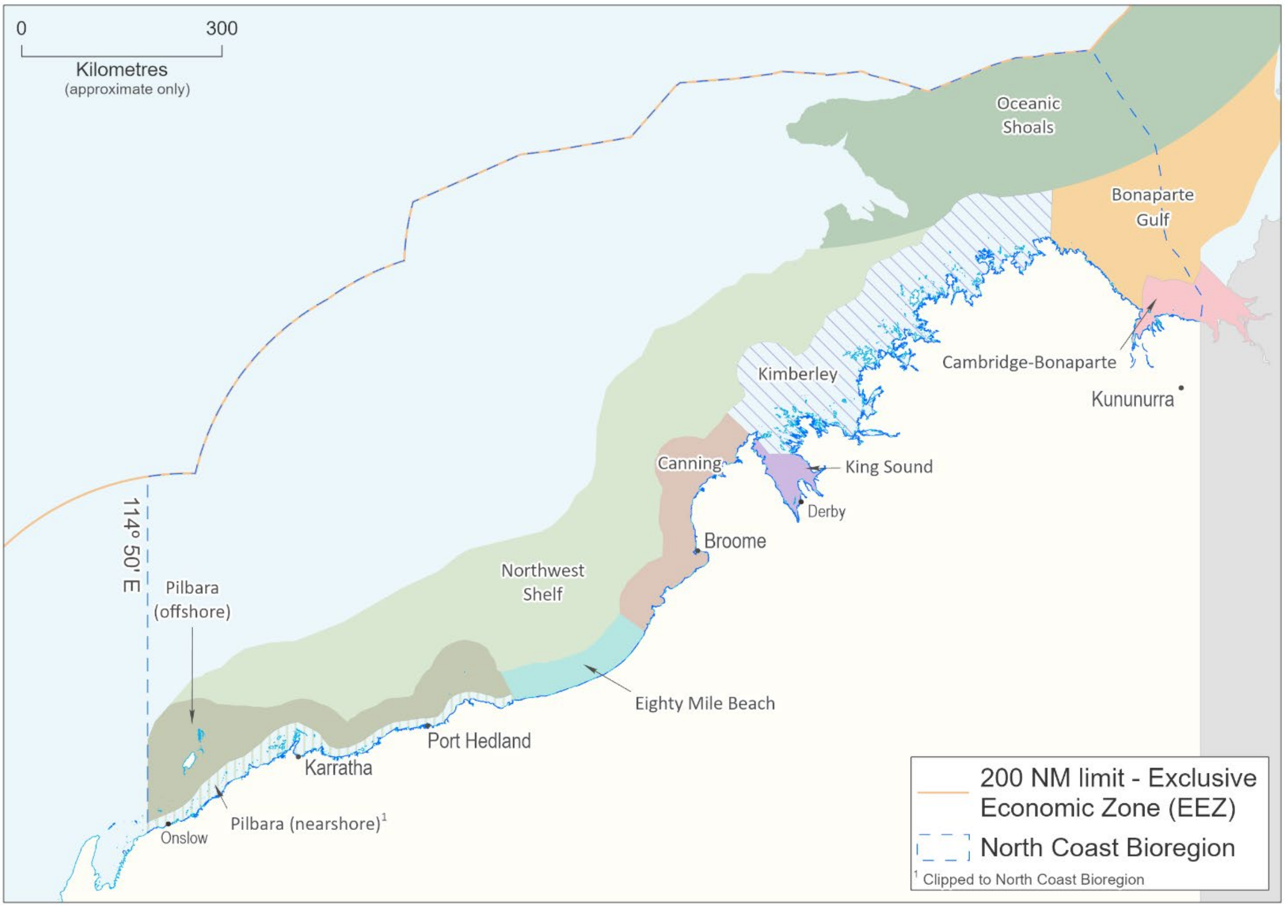
The oceanography of the North Coast Bioregion (North Coast Overview Figure 1) includes waters of Pacific Ocean origin that enter through the Indonesian archipelago bringing warm, low salinity waters polewards via the Indonesian Throughflow and Holloway Currents which flow seasonally and interact with Indian Ocean waters. The Integrated Marine and Coastal Regionalisation for Australia (IMCRA V 4.0) scheme divides this Bioregion into 10 meso-scale regions: Pilbara inshore, Pilbara offshore, North West Shelf, Eighty Mile Beach, Canning, King Sound, Oceanic Shoals and Kimberley (North Coast Overview Figure 1).

Ocean temperatures range between 22°C and 33°C, with localised higher temperatures in coastal waters, particularly along the Pilbara coastline. Fish stocks in the North Coast Bioregion are entirely tropical, with most having an Indo-Pacific distribution extending eastward through Indonesia to the Indian subcontinent and Arabian Gulf regions.

Coastal waters are generally low-energy in terms of wave action, but are heavily influenced by macro-tides and are seasonally influenced by intense tropical cyclones, storm surges and associated rainfall run-off. These cyclone events generate the bulk of the rainfall, although the Kimberley section of the coastline does receive monsoonal rainfall over summer.

Significant river run-off and associated localised coastal productivity can be associated with cyclone events, with run-off ceasing during winter. Despite localised areas of high productivity, the region is generally oligotrophic and large areas of the coastline receive no riverine input. The entire North Coast region is subject to very high evaporation rates (3 metres per year), although the Pilbara coastline is more arid than the Kimberley.

The macro-tidal regime is a result of the wide continental shelf and the convergence of ocean currents. Spring tides range from greater than 11 metres along the Kimberley section of the coast to more than 2 metres in the West Pilbara.



NORTH COAST OVERVIEW FIGURE 1
Map showing the North Coast Bioregion and IMCRA (V 4.0) meso-scale regions: Pilbara nearshore, Pilbara offshore, North West Shelf, Eighty Mile Beach, Canning, King Sound, Oceanic Shoals and Kimberley.

As a result of these factors, the generally tropical low-nutrient offshore waters can, in the few small locations with large adjacent rivers, be significantly influenced by rainfall run-off and tidal mixing to generate varying water quality in different sections of the North Coast Bioregion. Along the Kimberley coastline, waters are turbid and in areas locally productive, while the Pilbara Coast with its lower run-off and lesser tidal influence has the clear, low productivity waters more typical of the tropics.

The coastal geography of the various sections of the coastline also differs. The Kimberley Coast is complex, with bays and estuaries backed by a hinterland of high relief. Tidal mudflats and soft sediments with fringing mangroves are typical of this area. The eastern Pilbara Coast is more exposed than the Kimberley, with few islands and extensive intertidal sand flats. Softer sediments and mangroves occur around the river entrances. The western Pilbara coastline is characterised by a series of significant but low-relief islands including the Dampier Archipelago, Barrow Island and the Montebello Islands. Nearshore coastal waters include rocky and coral reef systems, creating significant areas of protected waters. West Pilbara shorelines also include areas of soft sediment and mangrove communities.

The potential threats and risks to IMCRA ecosystems are often similar. For simplicity, risk ratings were allocated by grouping the ecosystems into two broad groups; estuarine or marine. However, if a particular ecosystem is unique and/or is exposed to different or significant threats, risks were allocated to these ecosystems separately.

SUMMARY OF ACTIVITIES POTENTIALLY IMPACTING THE BIOREGION

Climate Change

Some of the key environmental trends that may be affecting ecosystems in WA include:

- Increasing frequency of *El Niño*/Southern Oscillation (ENSO) events;
- More years with a weaker Leeuwin Current;
- Increases in water temperature off the lower west coast of WA;
- Increases in salinity, which includes large annual fluctuations;
- Change in the frequency and location of storms (and rainfall) affecting the lower west coast; and
- Change in the frequency of cyclones (and summer rainfall) affecting the north-west coast.

The North Coast Bioregion is predicted to have relatively minor impacts from climate change, especially in the coming decade, compared to more southerly locations (Fletcher and Santoro 2012). The variables expected to drive climate change impacts include changes in water temperature, ocean currents, winds, rainfall, sea level, ocean chemistry and extreme weather conditions (e.g. cyclones and tropical storms).

Climate change will impact the biological, economic, and social aspects of many fisheries, potentially in both positive and negative ways. Climate change can influence biological systems by modifying the timing of spawning, range and distribution of species, composition and interactions within communities, exotic species invasions and impacts, and the structure and dynamics of communities, including changes in productivity. Species distribution shifts are the most commonly reported changes and are often the easiest to recognise and measure. Changes in the distribution of key species are monitored in a national citizen-science program (www.redmap.org.au) in which the Department is a collaborator.

Commercial Fishing

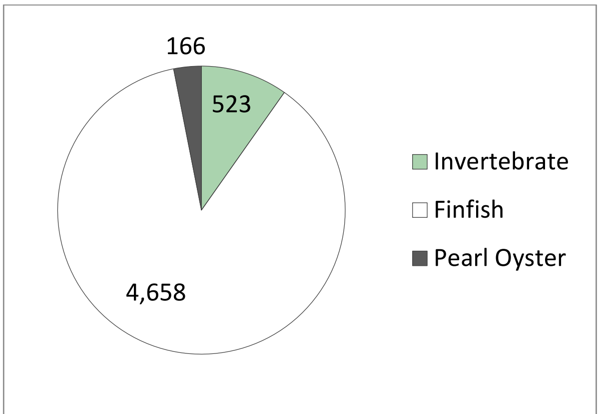
There are a diverse range of resources within the North Coast Bioregion (e.g. Pearl Oyster; Northern Demersal Scalefish; Northern Estuarine, Nearshore and Embayment Scalefish and Invertebrates; Hand Collection; Northern Invertebrates) that support a wide range of State-managed commercial fisheries. These fisheries target a variety of species including finfish, crustaceans, molluscs and echinoderms (North Coast Overview Figure 2). The principal commercial fisheries in the North Coast Bioregion focus on tropical finfish, particularly the high-value emperors, snappers and cods that are taken by the Pilbara trap, line and trawl fisheries and the Northern Demersal Scalefish Fishery (trap and line). The typical catch is up to 3,000-4,000 t annually, making these fisheries the most valuable finfish sector in the State, with an estimated annual value of more than $20 million. A number of other finfish fisheries operate in the Bioregion, including near-shore beach seining and gillnetting for barramundi and threadfin (the Kimberley Gillnet and Barramundi Managed Fishery) and surface trolling for Spanish mackerel (the Mackerel Managed Fishery).

Another significant commercial fishery in this Bioregion is based on the collection of pearl oysters (*Pinctada maxima*) for use in the aquaculture production of pearls. These are collected from fishing grounds primarily off Eighty Mile Beach, with smaller catches being taken around the Lacepede Islands (north of Broome).

The North Coast Bioregion also has a number of small, limited-entry trawl fisheries for prawns, producing about 200-500 t annually. These

fisheries include the Onslow, Nickol Bay, Broome and Kimberley Prawn Managed Fisheries (collectively referred to as the North Coast Prawn Managed Fisheries). Two small trap-based crab fisheries also exist in the Bioregion, targeting blue swimmer crabs in the Pilbara (the Pilbara Developing Crab Fishery) and mud crabs in the Kimberley (the Kimberley Developing Mud Crab Fishery). Sea cucumbers (also known as bêche-de-mer or trepang) are collected by hand by divers and waders throughout the Kimberley region as part of the Bêche-de-Mer Fishery. Catches are mainly comprised of two species, sandfish (*Holothuria scabra*) and redfish (*Actinopyga echinites*). The Trochus Fishery is a small fishery based on the collection of a single target species, *Tectus niloticus*, from King Sound and the Buccaneer Archipelago. This fishery is operated by the Bardi Jawi and Mayala Aboriginal Communities, who have traditionally collected trochus in this area.

A traditional artisanal fishery also exists in an area south of Roti Island, encompassing Scott Reef, Browse island, Cartier Island and Ashmore Reef known as the MOU box. The MOU Box within the Australian EEZ was established as part of a bilateral agreement between the Governments of Australia and Indonesia. The MOU allows Indonesian fishers to continue fishing using traditional methods within Australian waters of the MOU Box under an agreement formalised in 1974.

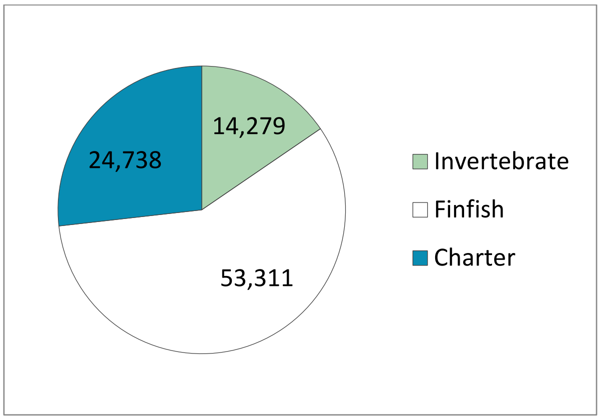


NORTH COAST OVERVIEW FIGURE 2
Contribution of finfish and invertebrates to the total commercial wild fishery catch originating from the North Coast Bioregion. Numbers represent total catch (in tonnes) based on all major assessed fisheries identified in the Overview section of this report (Overview Table 1, North Coast).

Recreational Fishing

Recreational fishing in the North Coast Bioregion typically has a distinct seasonal peak in winter when the population is increased by significant numbers of intra-state and inter-state tourists travelling through the area visiting the Onslow, Dampier Archipelago and Broome sections of the coastline. This adds to the increased recreational fishing effort resulting from people employed in the operation of major developments in this region. Owing to the high tidal range, much of the angling activity is boat-based, with beach fishing limited to periods of flood tides and high water. The numerous creek systems, mangroves, rivers and beaches provide shore and small boat fishing for a variety of finfish species including barramundi, tropical emperors, mangrove jack, trevallies, sooty grunter, threadfin, cods and catfish, and invertebrate species including blue swimmer crabs, mud crabs and squid (North Coast Overview Figure 3). Offshore islands, coral reef systems and continental shelf waters provide recreational fishing opportunities for species including tropical snappers, cods, coral and coronation trout, sharks, trevally, tuskfish, tunas, mackerels and billfish.

Vessel retrievals from key boat ramps have been monitored using remote cameras for previous state-wide surveys[1], The typical seasonal pattern of vessel retrievals at Broome was not observed during the early stages of COVID-19 restrictions from March to August 2020[2].



NORTH COAST OVERVIEW FIGURE 3
Recreational catches (by number) in the North Coast Bioregion. Finfish and invertebrate catches were as assessed in the statewide survey of boat-based recreational fishing in 2017/18[3]. Charter boat catch is for the same period. Estimates of shore based recreational catch are unavailable.

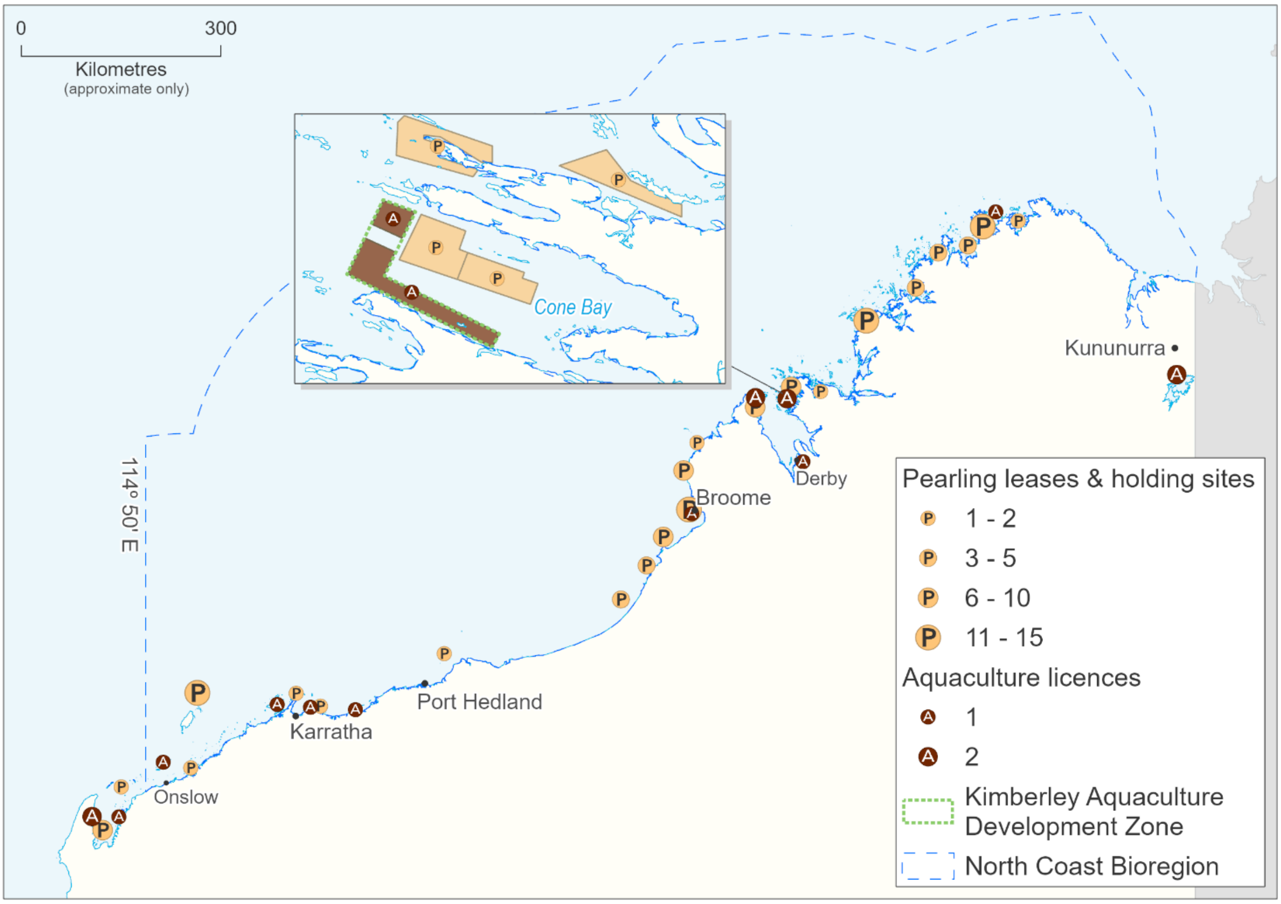
Aquaculture

Aquaculture in the North Coast Bioregion is dominated by the production of pearls from the species *Pinctada maxima*. An overview of aquaculture activities in the Bioregion is detailed in North Coast Overview Figure 4. A large number

1 Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia.

2 Ryan KL, Desfosses CJ, Denham AM, Taylor SM, Jackson, G. 2021. Initial insights on the impact of COVID-19 on boat-based recreational fishing in Western Australia. Marine Policy 132: 104646

of pearl oysters for seeding is obtained from wild stocks and supplemented by hatchery-produced oysters, with major hatcheries operating at Broome and the Dampier Peninsular. Pearl farm sites are located mainly along the Kimberley coast, particularly in the Buccaneer Archipelago, in Roebuck Bay and at the Montebello Islands.



NORTH COAST OVERVIEW FIGURE 4
Overview of aquaculture activity in the North Coast Bioregion, detailing locations of licensed finfish aquaculture facilities (A) and pearling leases (P). Also indicated is the Kimberley Aquaculture Development Zone.

Finfish aquaculture in the Kimberley region is dominated by barramundi farming within the Kimberley Aquaculture Development Zone, which was declared in August 2014. Located about 200 kilometres north-east of Broome, this zone encompasses almost 2,000 hectares of coastal waters within Cone Bay. The zone was declared after the completion of a strategic environmental study, which demonstrated the zone would be capable of producing 20,000 tonnes of finfish annually without significant environmental impact. MPA Fish Farms Pty Ltd, already established within the zone, has been granted an aquaculture licence to grow up to 15,000 tonnes of barramundi and other marine finfish per year on a 1,344-hectare site. A second aquaculture licence has been granted to Aarli Mayi Aquaculture Project Pty Ltd, which is authorised to grow 5,000 tonnes per annum.

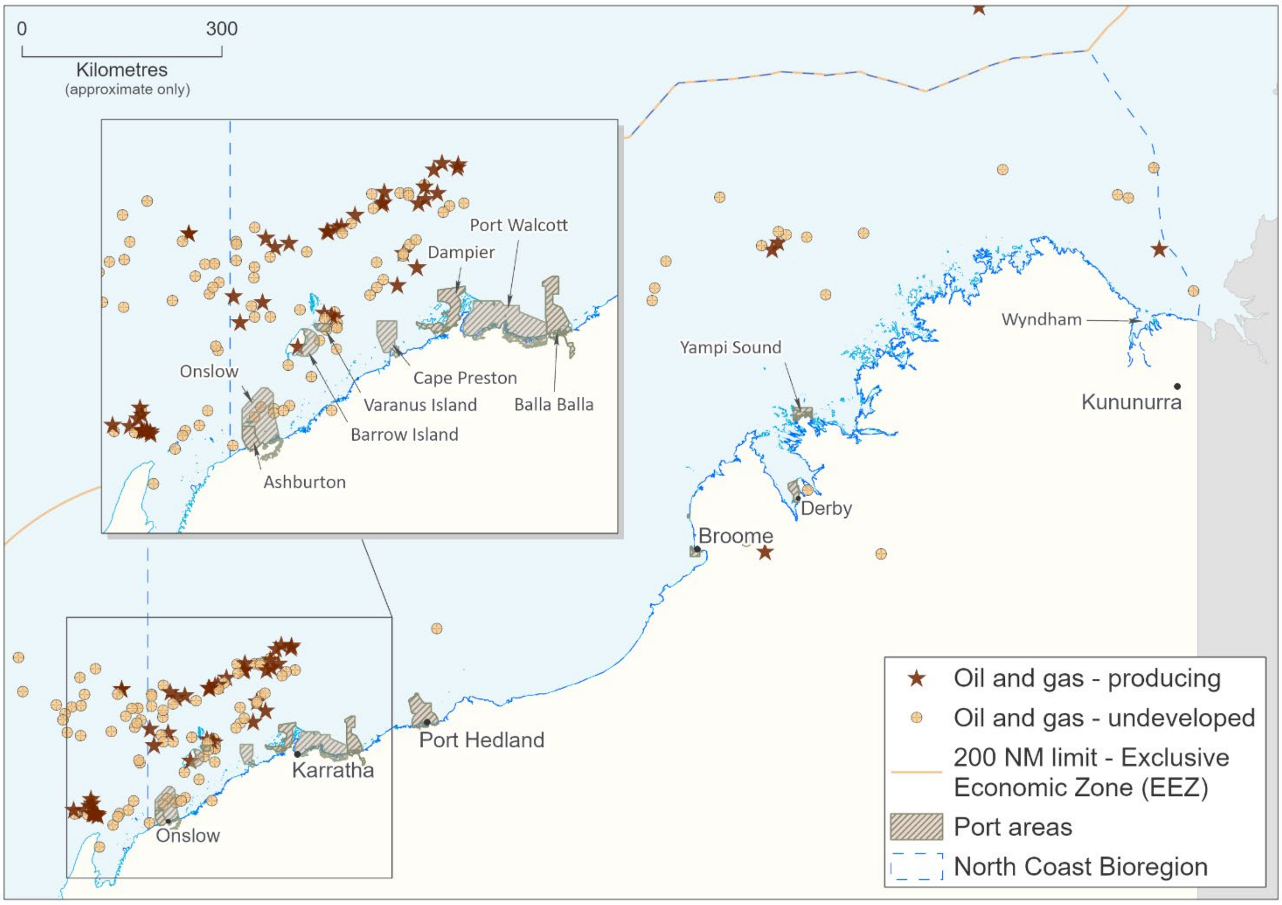
A focus of aquaculture development is supported by the Department's Broome Tropical Aquaculture Park, which houses a commercial pearl oyster hatchery and the North Regional TAFE aquaculture training facility.

An indigenous project at One Arm Point operates a marine hatchery that focuses on a variety of ornamental and edible marine species.

Tourism

The marine tourism industry has experienced significant growth within the North Coast Bioregion, particularly along the Kimberley coast in recent decades. As coastal access is limited, tourists generally access the coast by boat from major population centres, such as Broome and Wyndham. Activities include charter fishing, diving, snorkelling, whale, turtle and dolphin watching and sightseeing cruises.

Sites of greatest interest to tourists include places to fish, areas for sightseeing and secluded locations for general relaxation. Luxury cruises take tourists along the coastline and increasingly out to isolated coral atolls for fishing and diving. Primary dive locations include the Rowley Shoals, Scott Reef, Seringapatam Reef, Ashmore Reef and Cartier Island.



NORTH COAST OVERVIEW FIGURE 5
North Coast offshore oil and gas production sites and major ports.

Oil and Gas Activity

Offshore oil and gas is a large and growing industry in the North Coast Bioregion. Within the Bioregion, the Northern Carnarvon, Browse and Bonaparte Basins hold large quantities of gas, and multiple projects are in various stages of development, production and exploration (North Coast Overview Figure 5). The upcoming decommissioning of older facilities is leading to proposed projects on the value of this infrastructure to commercial and recreational fisheries. The main disturbances associated with oil and gas exploration and production include noise pollution from seismic surveys, potential for fish movement/impact arising from seismic surveys, disturbance to the marine habitat through drilling and/or dredging activities, introduction of marine pest species, release of produced formation water, shipping and transport activities and oil spills.

Shipping and Maritime Activity

There are three major ports in the North Coast Bioregion: Broome, Dampier and Port Hedland (North Coast Overview Figure 5). The Port of Broome provides vital support for the Browse Basin offshore oil and gas industry. Other business includes livestock export, cruise liner servicing, coastal trading vessels, pearling, fishing and tourism charters. The Port of Dampier services both the land-based iron ore reserves and the offshore gas fields of the Carnarvon Basin. Port Hedland is the world's largest bulk exporter, with 99% of the total cargo volume constituting exports. The port primarily exports iron ore, along with salt, livestock and petroleum products. There are eight other non-Port Authority ports in the North Coast Bioregion. In general, these ports and related export facilities are operated by resource companies. Most handle raw bulk commodity exports such as iron ore, crude oil and salt. An increase in shipping and port expansion associated with growth of the resources sector has potential implications for the marine environment. Potential threats include loss

or contamination of marine habitats as a result of breakwater construction, dredging and sea dumping, oil spills, interactions between vessels and listed species and the introduction of marine pests. The Department has surveillance in place for marine pests in key port areas to aid in the early detection of any unwanted aquatic species from other locations.

BIOREGIONAL SPECIFIC ECOSYSTEM MANAGEMENT

Within each Bioregion there are a range of management measures that have been implemented to manage the potential impact of activities (See the Ecosystem Management Section for an overview). Management measures specific to the North Coast Bioregion include:

Climate Change

Extensive work was undertaken by Caputi *et al*. (2015a, b) assessing the effects of climate change on the marine environment and key fisheries, as well as potential management implications. Although these studies focused on Bioregions more susceptible to increases in sea surface temperature (SST) to the south, there were no significant effects expected from climate change on the species selected (Caputi *et al*. 2015a, b). However, if a southward expansion in the range of Narrow-Barred Spanish Mackerel occurred then it is possible that the total biomass of this species in Western Australia may increase due to various factors associated with breeding and availability of suitable habitats (Caputi *et al*. 2015b).

Spatial Closures

Extensive fisheries closures in coastal and most offshore waters have been introduced to manage finfish trawling by Australian vessels (North Coast Overview Figure 6). However, trawling is still permitted in a small number of limited locations, which in total represent less than 11% of the shelf waters (North Coast Ecosystem Management Table 1; see specific commercial trawl fishery reports elsewhere in this volume). This activity is carefully managed to ensure that impacts are acceptable. The trawling is subject to Ecologically Sustainable Development (ESD) requirements in accordance with the Commonwealth Government '*Guidelines for the Ecologically Sustainable Management of Fisheries*' under the Environment Protection and Biodiversity Conservation Act, 1999. The extent of these areas means that 41% of the entire shelf region of the North Coast Bioregion could be classified as a marine protected area with an IUCN category of IV or higher (as per Dudley, 2008 and Day *et al 2012*[1]; North Coast Ecosystem Management Table 1).

In addition to these habitat-related marine protected area closures, the Bioregion has a number of other marine protected areas with various management objectives, summarised in North Coast Overview Figure 7. These include the Montebello and Barrow Islands and the Rowley Shoals proclaimed under the *Conservation and Land Management Act 1984*, and closures to fishing under section 43 of the Fish Resources Management Act 1994 at Point Samson and the wreck of the Kunmunya Samson II (Delambre Reef). The Department has also participated in the marine conservation reserve planning process in this Bioregion and has established baseline and ongoing monitoring and research to underpin ecosystem management. There is considerable interest in developing further marine protected areas within the Kimberley region, and the State Government is developing management plans, Indigenous Land Use Agreements (ILUA) and zoning arrangements for marine protected areas at Eighty Mile Beach, Roebuck Bay, Horizontal Falls and the North Kimberley. The proposed Dampier Archipelago marine conservation reserves are still under consideration by Government. The Department continues to work closely with relevant agencies and stakeholders to develop strategies to minimize environmental impacts in the marine environment. This includes participation in the Kimberley Science and Conservation Strategy developed with the Department of Biodiversity, Conservation and Attractions (DBCA) and collaboration on relevant Western Australian Marine Science Institute (WAMSI) Kimberley Marine Research Program projects.

The Commonwealth Government has recently implemented its marine bioregional planning which includes a number of protected areas in Commonwealth waters between Shark Bay and the Northern Territory border (see North Coast Overview Figure 7).

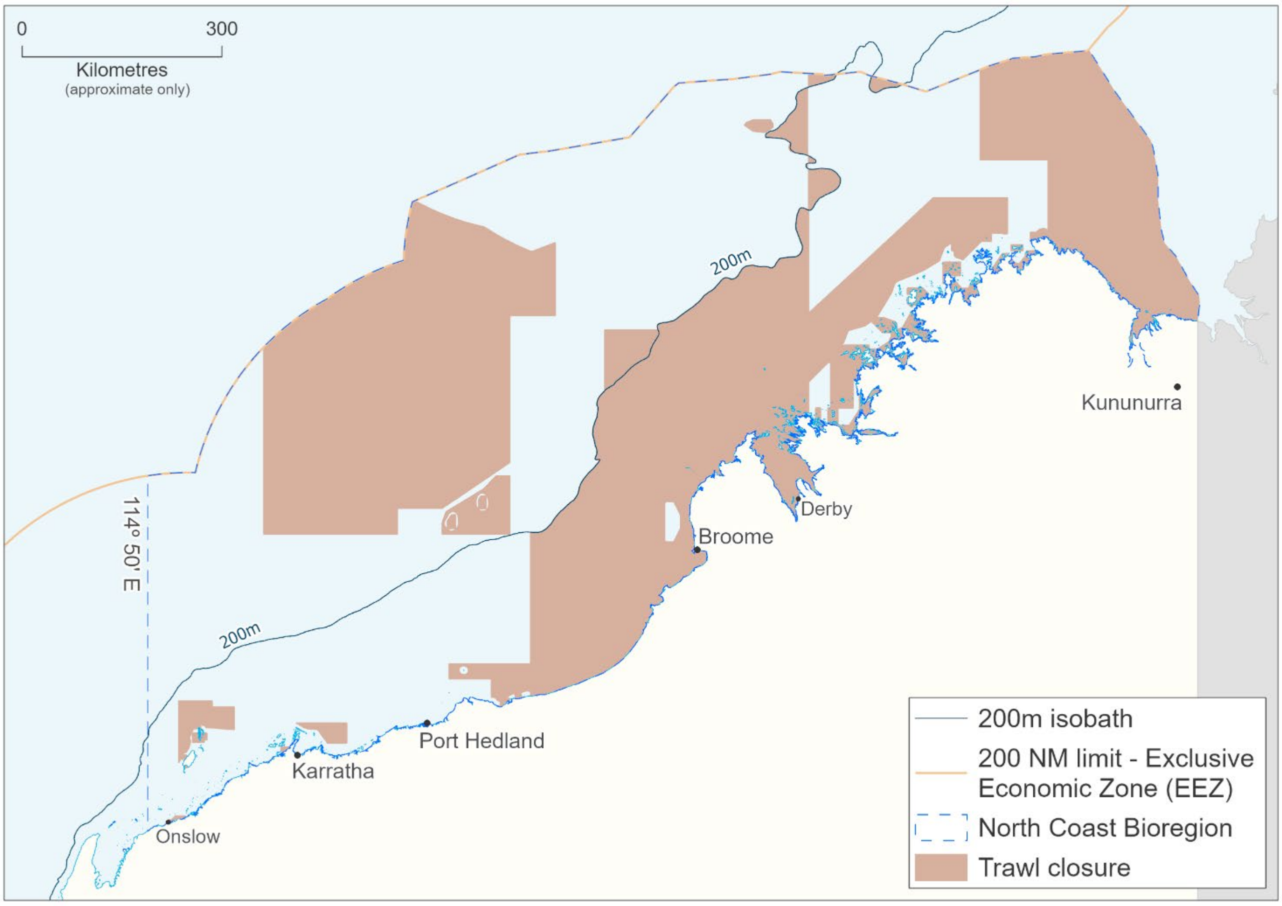
1 Dudley N. (editor) 2008. Guidelines for applying protected area management categories. IUCN. Gland, Switzerland.

Day J, Dudley N, Hockings M, Holmes G, Laffoley D, Stolton S, and Wells S. 2012. Guidelines for applying the IUCN Protected Area Management Categories to Marine Protected Areas. IUCN. Gland, Switzerland: 36pp.

NORTH COAST ECOSYSTEM MANAGEMENT TABLE 1

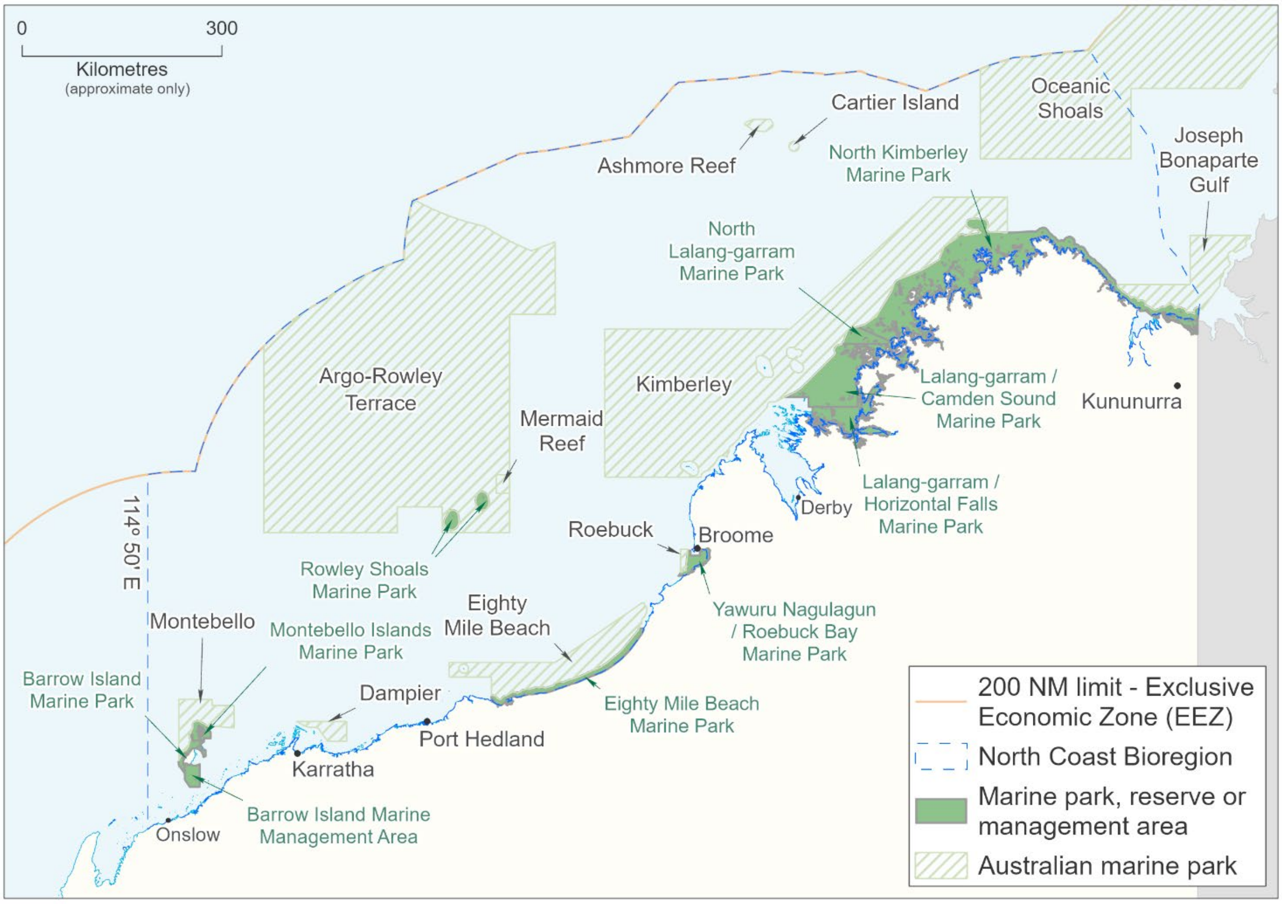
The areas and proportions of the North Coast Bioregion making up State Waters and all continental shelf waters, out to 200 m depth, which are consistent with the IUCN criteria for classification as marine protected areas. This table does not yet include the closures that may be implemented by the Commonwealth as part of their marine planning zones.

IUCN category or equivalent	State Waters only ($65,400\ km^2$)				All Waters ($837,500\ km^2$ (including State waters))			
	Fisheries		Existing MPA		Fisheries		Existing MPA	
	km^2	%	km^2	%	km^2	%	km^2	%
I	0	0	0	0	0	0	1,300	< 1
II	0	0	1,900	3	0	0	1,900	< 1
III	0	0	0	0	0	0	0	0
IV	19,100	29	3,500	6	149,200	18	3,500	< 1
V	0	0	0	0	0	0	0	0
VI	36,800	56	4,100	6	677,500	81	4,100	< 1



NORTH COAST OVERVIEW FIGURE 6

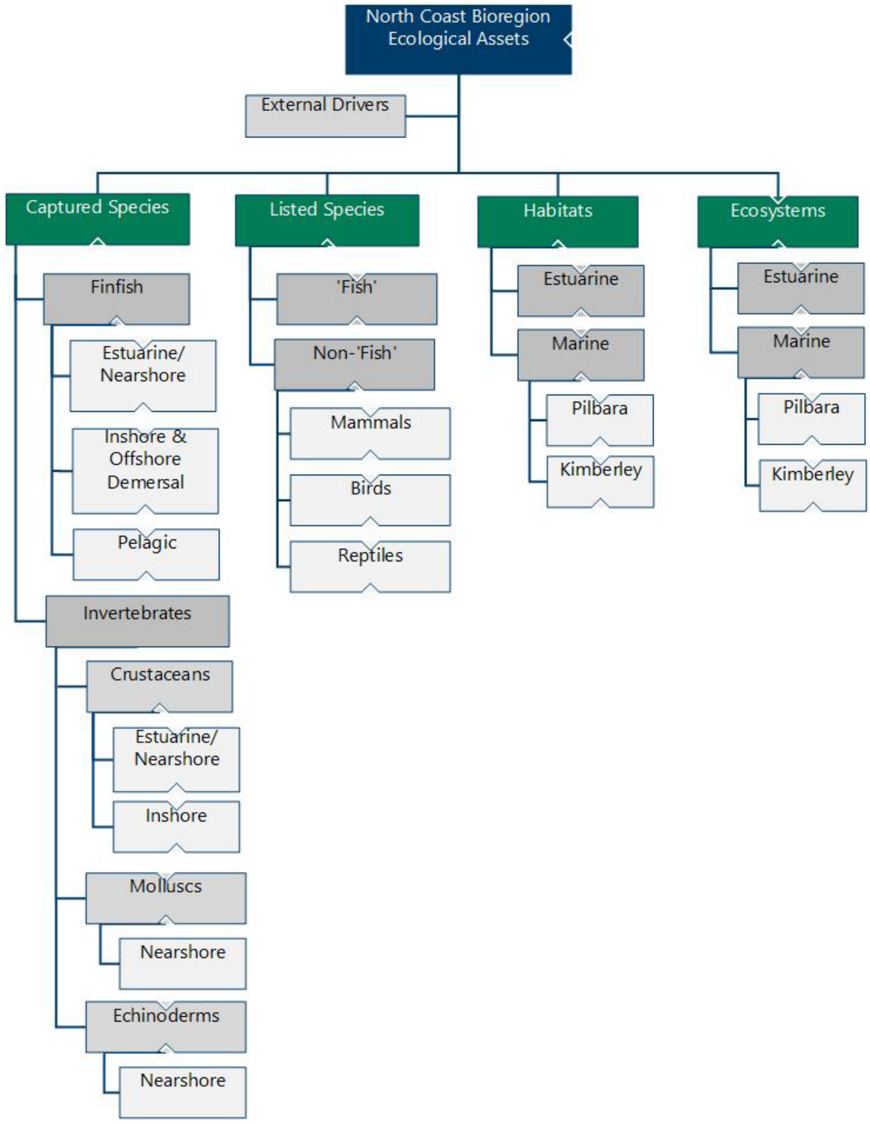
Map showing the North Coast Bioregion and areas closed to all trawling. The areas permanently closed to trawling are consistent with IUCN marine protected area category IV.



NORTH COAST OVERVIEW FIGURE 7
Map showing the North Coast Bioregion and current and proposed state and Commonwealth marine parks and reserves along the northern WA coast.

ECOSYSTEM MONITORING AND STATUS

In order to assess the adequacy of management arrangements aimed at ensuring sustainability of the ecological assets within the North Coast Bioregion, the Department must identify and monitor trends in the condition of these resources. This is achieved through application of an Ecosystem Based Fisheries Management (EBFM) framework (Fletcher, *et al*., 2010) to identify, in a hierarchical manner, the key ecological resources that require ongoing monitoring and assessment. (See How to Use section for more details). These key ecological assets identified for the North Coast Bioregion are identified in North Coast Overview Figure 8 and their current risk status reported on in the following sections.



NORTH COAST OVERVIEW FIGURE 8
Component tree showing the ecological assets identified and separately assessed for the North Coast Bioregion.

External Drivers

External factors include factors impacting at the Bioregional-level that are likely to affect the ecosystem as a whole and may not fall within the direct control of Fishery legislation (e.g. climate change). An understanding of these factors, which are typically environmental (cyclones, ocean currents) is necessary to fully assess the performance of the ecological resource. The main external drivers identified with potential to affect the North Coast Bioregion include climate, introduced pests and diseases[1] and oil and gas development activities.

Climate

External Drivers	Current Risk Status
Climate	MODERATE

The North Coast Bioregion is predicted to have relatively minor impacts from climate change in the coming decade, compared to more southerly Bioregions.

Oil and Gas Development Activity

External Drivers	Current Risk Status
Oil and Gas Development	LOW

While there are a number of specific oil and gas related offshore developments that are proposed in this region, at the overall ecosystem level there is only a low risk that the ecosystem will be altered measurably. In addition, State and Commonwealth marine parks, including totally protected zones, are currently in place or planned.

1 Biosecurity issues are now reported by the Biosecurity pillar of the Department of Primary Industries and Regional Development.

Captured Species

FINFISH

The principal fisheries in the North Coast Bioregion focus on tropical finfish, particularly the high-value emperors, snappers and cods. These species are taken by the Pilbara Demersal Scalefish Fishery (trawl, trap and line sectors) and the Northern Demersal Scalefish Fishery (trap and line). The typical catch is in the order of 3000-5,000 t annually at an estimated annual value of more than $20 million, making these fisheries the most valuable finfish sector in the state. A number of other finfish fisheries operate in the Bioregion, including near-shore beach seining and gillnetting for barramundi and threadfin (the Kimberley Gillnet and Barramundi Managed Fishery) and surface trolling for Spanish mackerel (the Mackerel Managed Fishery).

Indicator species which reflect the characteristics of the broader exploited stocks are monitored in order to assess ecological risk to the ranges of species targeted.

Estuarine/ Nearshore (0-20 m depth)

Captured Species	Aquatic zone	Ecological Risk
Finfish	Estuarine/Nearshore	MODERATE

The Kimberley Gillnet and Barramundi Managed Fishery (KGBF) is the only commercial finfish fishery operating in the nearshore and estuarine zones of the North Coast Bioregion. The primary target species are barramundi and threadfin. Stocks of barramundi and threadfin are considered to be at acceptable levels. Changes to marine reserves in the region are expected, which may affect commercial fishing activities in the region.

Inshore and Offshore Demersal

Captured Species	Aquatic zone	Ecological Risk
Finfish	Inshore and Offshore demersal	MODERATE

There are four State-managed commercial fisheries which use multiple methods to target demersal fish stocks. These fisheries include: The Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF); The Pilbara Trap Managed Fishery (PTMF); The Pilbara Line Fishery (PLF); and The Northern Demersal Scalefish Managed Fishery (NDSF).

These fisheries all target the tropical demersal scalefish suite in the Pilbara and Kimberley Ecosystem and are collectively referred to as the Pilbara Demersal Scalefish Fisheries (PDSF) and Northern Demersal Scalefish Fishery (NDSF). The trawl fishery lands the largest component of the catch, comprising more than 50 scalefish species.

Pelagic

Captured Species	Aquatic zone	Ecological Risk
Finfish	Pelagic	MODERATE

There are a large number of species in the pelagic suite in this Bioregion. Spanish Mackerel are the only species heavily targeted (by the Mackerel Managed Fishery) and this stock is at an acceptable level. Few other pelagic species are exploited at any significant levels and these stocks are lightly impacted by fishing.

INVERTEBRATES

The Pearl Oyster Managed Fishery is a significant commercial invertebrate fishery in this Bioregion which is based on the collection of pearl oysters (*Pinctada maxima*) for use in the aquaculture production of pearls. The North Coast Bioregion also has a number of small, limited-entry trawl fisheries for prawns, typically producing approximately 500 t annually, valued at more than $10 million. Two small trap-based crab fisheries also exist in the Bioregion, targeting blue swimmer crabs in the Pilbara (the Pilbara Developing Crab Fishery) and mud crabs in the Kimberley (the Kimberley Developing Mud Crab Fishery). Sea cucumbers (also known and bêche-de-mer or trepang) are collected by hand by divers and waders throughout the Kimberley region. Catches are mainly comprised of two species, sandfish (*Holothuria scabra*) and redfish (*Actinopyga echinites*). The Trochus Fishery is a small fishery based on the collection of a single target species, *Tectus niloticus* from King Sound and the Buccaneer Archipelago. This fishery is operated by the Bardi Jawi and Mayala Aboriginal Communities, who have traditionally collected trochus in this area.

Crustaceans

Captured Species	Aquatic zone	Ecological Risk
Crustaceans (Crabs)	Estuarine/ Nearshore	LOW
Crustaceans (Prawns)	Inshore	MODERATE

There is a small amount of fishing for mud crabs and blue swimmer crabs in some estuarine and inshore areas and its ecological risk is considered to be low. Stocks of mud crabs are considered to be of significant value to the recreational sector and for social amenity.

There are a number of separate prawn stocks and fisheries within this Bioregion and each has limited entry, seasonal and area closures. Annual recruitment to these stocks is variable, which combined with the higher costs of operating in this region, has resulted in fishing effort being much lower in recent years.

Molluscs

Captured Species	Aquatic zone	Ecological Risk
Molluscs (Pearls)	Nearshore	MODERATE
Molluscs (Trochus)	Nearshore	MODERATE

The pearl oyster fishery only targets a very small section of the pearl oyster stock both spatially and within the available size range. The fishery achieved Marine Stewardship Council certification in 2017. Legislative structures for this fishery are currently being updated with the primary legislative instrument changing from the *Pearling Act* (1990) to the *Aquatic Resources Management Act* (2016).

The North Coast Trochus Fishery in King Sound is an indigenous fishery targeting the commercially important gastropod shell *Tectus niloticus*, commonly known as trochus. It is a hand collection fishery open to nominated fishers from the community.

Echinoderms

Captured Species	Aquatic zone	Ecological Risk
Sea cucumbers	Nearshore	MODERATE

The majority of the effort for sea cucumbers has been expended in the Kimberley region, although there have been several years with substantial effort directed into the Pilbara region. In 2019, the Pilbara portion of the fishery for sandfish (*Holothuria scabra*) and redfish (*Actinopyga echinites*) achieved Marine Stewardship Council certification.

Listed Species

A number of endangered, threatened and protected[1] (ETP) species can be found within the North Coast Bioregion, including cetaceans, dugongs, marine turtles, sea snakes, elasmobranchs, seahorses and pipefish, crocodiles and seabirds and migratory shorebirds. These species are protected by various international agreements and national and state legislation. International agreements include:

Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention);

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES);

The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974 (JAMBA)[2];

The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986 (CAMBA)[1];

The Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007 (ROKAMBA)[1]; and

Any other international agreement, or instrument made under other international agreements approved by the environment minister including the EBPC Act 1999.

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

Fisheries in the region that have reported interactions with ETP species include trawl fisheries (the Onslow Prawn Managed Fishery (OPMF), the Nickol Bay Prawn Managed Fishery (NBPMF), the Pilbara Fish Trawl Fishery (PFTF)) and the Kimberley Gillnet Barramundi Fishery (KGBF). ETP interactions with trawl fisheries are few, due to fishing arrangements, such as the use of bycatch reduction devices and the exclusion of trawling activities from most ETP species' primary habitat. Similarly, fishers in the KGBF actively avoid capturing ETP species; however, a small amount of interactions have been reported with crocodiles and sawfish.

Fish

Listed species	Risk
Fish	MODERATE

The sawfish (Pristidae), speartooth shark (*Glyphis glyphis*) or the northern river shark (*Glyphis garricki*) are incidentally captured in small numbers by net fishing and trawlers in some areas of the Kimberley region. The area of these fisheries in which sawfish are vulnerable to capture is small relative to the total range of each species, suggesting limited impacts on each population. There are requirements for increased resolution regarding the nature and consequence of interactions with ETP elasmobranchs.

Sea horses (syngnathids) and pipefish (solenostomids) are occasionally captured in trawl nets and fish/crab traps. The areas of each fishery in which syngnathids and solenostomids are vulnerable to capture is small relative to the total distribution of the species, which includes waters inshore of the fishery and fishery closed areas, as well as structured habitats where trawling does not occur.

Recent video observations indicate that the potato cod is present in high numbers at discrete

1 A listed species list does not automatically indicate that a species is either threatened or endangered.

2 Further information on the CMS, JAMBA, CAMBA and ROKAMBA is provided at www.environment.gov.au/biodiversity/migratory/index.html

locations within the Kimberley region where the NDSF operates. Potato cod (*Epinephelus tukula*), a totally protected species, rarely enter fish traps due to their large size and girth limiting their capacity to pass through the entrance funnel into fish traps.

Non-Fish

Listed species	Risk
Mammals	LOW
Reptiles and Birds	MODERATE

Dolphins are incidentally captured by the PFTF. To assist in mitigation of shark, reptile and cetacean bycatch, species-specific responses to three bycatch reduction device (BRDs) configurations were investigated using both *in situ* subsurface and onboard observations. The upward inclined exclusion grid significantly improved the escape proportions for most sharks by 21-29 %. BRDs were highly effective in reducing turtles bycatch and moderately so for seasnakes, but ineffective for the few sawfish (n = 13) that became entangled in the anterior of the net. Cetacean (bottlenose dolphins only) interactions with BRDs were very rare (n = 7) despite high levels of attendance and depredation during trawling. Loss of targeted teleosts through the BRDs was also very rare (1.3 % of day trawls)[1]. The study also provided evidence that the subsurface expulsion of megafauna in poor condition is negligible. The Pilbara fish trawl fishery operates under WTO with conditions around dolphin and sawfish interactions and monitoring.

Turtles are encountered occasionally in trawl catches but are typically returned to the sea alive. Grid BRDs are now compulsory on trawl nets, which has largely eliminated the capture of any turtle or other large animal.

Sea snakes are the largest component of the ETP bycatch in the trawl fisheries of this bioregion. Programs for identifying and reporting these interactions are currently in development and implementation stages with these and other fisheries.

Crocodiles are occasionally captured in nearshore/ estuarine fisheries' nets and are typically released alive.

Habitats and Ecosystems

Coastal geography is extremely variable within the North Coast Bioregion and its identified meso-scale ecosystems include a range of key habitats in depths of less than 40 m (where the vast majority of relevant fisheries resources are located and fishing activities are undertaken in this Bioregion) which include:

Mangroves: Mangroves occur throughout the Bioregion, and within the Kimberley, and are considered to be very well developed and relatively pristine. The mangrove communities of Roebuck Bay and Eighty Mile Beach have been listed as Ramsar Wetlands of International Significance mainly due to the numbers of migratory wading birds they support.

Seagrasses: Seagrasses are mainly tropical species. Twelve species have been identified throughout the North Coast Bioregion, including one endemic species (*Cymodocea angustata*). Within the Bioregion, seagrasses are generally found in shallow water environments near the mainland coast and offshore reefs and shoals.

Algae: Algal growth is restricted by the limited presence of hard substrates on the North West Shelf. Throughout the Kimberley, the effects of strong tidal currents and high turbidity result in low macroalgal diversity. Surveys in the Kimberley have identified 72 species of macroalgae in the southern Kimberley and 90 species (not including coralline algae) in the northern Kimberley, most of which are widespread tropical taxa.

Sponges and Filter-Feeding Communities: Sponges are found from tidal areas to the deep waters of the Abyssal Plain and generally occur as part of a mixed filter-feeding community. Species richness varies considerably throughout the Bioregion, with both relatively low-diversity communities (< 25 species, e.g. Rowley Shoals) and exceptionally rich communities (> 250 species, e.g. Dampier-Port Hedland regions). Sponge communities throughout the Bioregion are also broadly different. For example, a study by the Western Australian Museum found more than half the sponges identified at Mermaid, Scott and Seringapatam Reefs were unique to a single reef (WAM, 2006).

Coral Reefs: Coral reefs in the Bioregion fall into two general groups: the fringing reefs around coastal islands and the mainland shore and large platform reefs, banks and shelf-edge atolls on the mid and outer shelf. North of Cape Leveque, the Kimberley supports extensive nearshore reef systems. Areas of fringing reef development include islands in the Buccaneer Archipelago, the Heyward island group, islands of the Bonaparte Archipelago and off mainland shores of Cape Voltaire and Cape Bougainville. Coral diversity is typically high, with surveys of the Buccaneer Archipelago having recorded 280 species of coral from at least 55 genera. Coral reefs are also well developed around offshore island such as Ashmore, Cartier, Hibernia, Seringapatam and Scott Reefs, Browse Island and the Rowley Shoals.

1 Wakefield, C. B., Blight, S., Dorman, S. R., Denham, A., Newman, S. J., Wakeford, J., Molony, B. W., Thomson, A. W., Syers, C. and O'Donoghue, S. 2014. Independent observations of catches and subsurface mitigation efficiencies of modified trawl nets for endangered, threatened and protected megafauna bycatch in the Pilbara Fish Trawl Fishery. Fisheries Research Report No. 244. Department of Fisheries, Western Australia. 40 pp.

Sand/Mud: Embayments along the Kimberley are known to have extensive muddy tidal flats and the majority of the offshore area is dominated by soft sediment seabeds, which are mainly sand/mud with occasional patches of coarser sediments.

In depths beyond 40 m, ecosystems include hard- and soft-bottom benthic communities, sand banks and pelagic communities. Given the low levels of activities in these depths, there is little detailed information on these environments.

A high level of protection of the ecosystems and habitats within the North Coast Bioregion is ensured based on the limited area of the Bioregion that is available to commercial trawl fishing activity (North Coast Bioregion Overview Figures 6 and 7). If areas that are not trawled are taken into account, 89 % of statewide benthic habitats out to the 200 m isobath are protected and may never have been trawled (North Coast Ecosystem Management Table 1). In addition to fisheries-related closures, the North Coast Bioregion has a number of marine protected areas described under the preceding "spatial closures" section.

The Department identifies and monitors trends in the condition of ecosystems and their associated habitats to ensure the long term sustainability of both these key ecological assets and the fisheries that depend on them.

Habitats

Habitats	Aquatic zone	Current Risk Status
North Coast	Estuarine	LOW
Kimberley	Marine	LOW
Pilbara	Marine	MODERATE

The majority of these fishing activities occur in mud/sand habitats in estuaries, tidal creeks and embayments. Trawl activities are considered to have the highest relative impact of the methods used within the bioregion which also includes low impact activities of trap, gillnets and hand collection based fisheries. However, the spatial extent of trawling activities is small, and there are a variety of measures in place to manage any impacts. The spatial distribution of all fishing activities are also managed through the use of seasonal and area closures to protect sensitive habitats.

Ecosystems

Ecosystems	Aquatic zone	Current Risk Status
North Coast	Estuarine	NEGLIGIBLE
Kimberley	Marine	MODERATE
Pilbara	Marine	MODERATE

There are a number of oil and gas related offshore and onshore developments that exist or are proposed in this bioregion. While some specific areas may be locally impacted, these still only pose a low risk to the overall ecosystem of this Bioregion.

Given the large areas closed to both trawling and to all commercial fishing, there is a low risk that the level of fishing in this region is changing the regional-level community structure to an unacceptable level. Assessments of the community structure and trophic level of all commercially caught fish species in the region over the past 30 years found no evidence that there have been any systematic changes (Hall and Wise 2011[1]). The majority of catch from each fishery is comprised of the main target species, and catch compositions have remained stable throughout the history of each fishery. None of the main target species are known to be involved in any strong ecological interactions and their removal at current rates is unlikely to seriously or irreversibly alter community structure. Slight increases to the risk ratings for the Kimberley marine ecosystem are a reflection of increased monitoring and reporting requirements ensuing from changes to marine park management in the region.

1 Hall, N.G. and Wise, B.S. 2011. Development of an ecosystem approach to the monitoring and management of Western Australian fisheries. FRDC Report – Project 2005/063. Fisheries Research Report No. 215. Department of Fisheries, Western Australia. 112 pp.

FISHERIES

NORTH COAST PRAWN RESOURCE STATUS REPORT 2021

M. Kangas, S. Wilkin, M. Shanks, and S. Brown

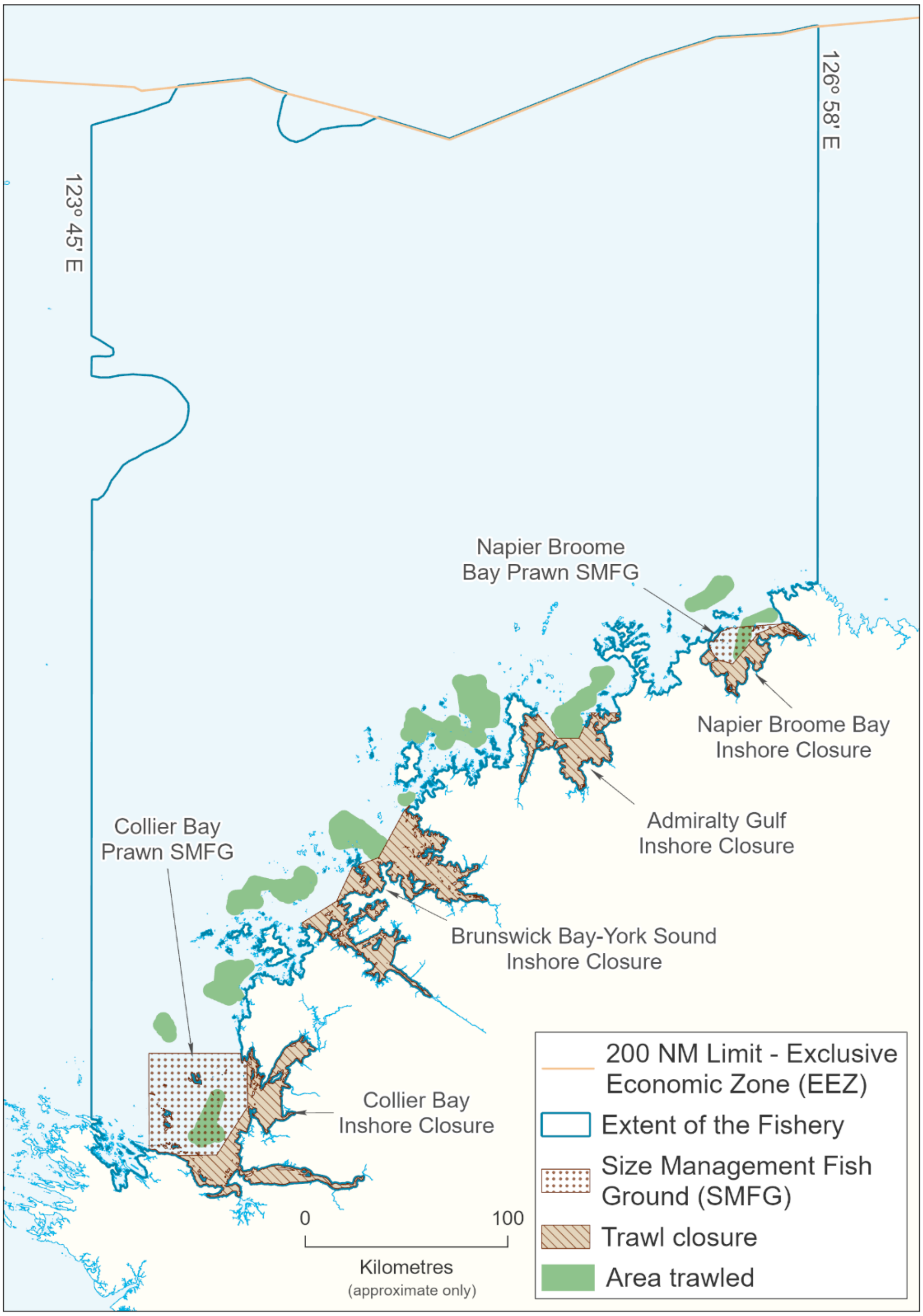
OVERVIEW

The four northern prawn managed fisheries (Kimberley, Broome, Nickol Bay and Onslow) all use low opening, otter prawn trawl systems to target western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), and blue endeavour prawns (*Metapenaeus endeavouri*). High opening, otter trawl systems are also used when targeting banana prawns (*Penaeus merguiensis*) which is the target species for the Kimberley and Nickol Bay fisheries. Management of the north coast prawn managed fisheries is based on input controls, including limited entry, gear controls (maximum headrope units), seasonal and area openings and closures.

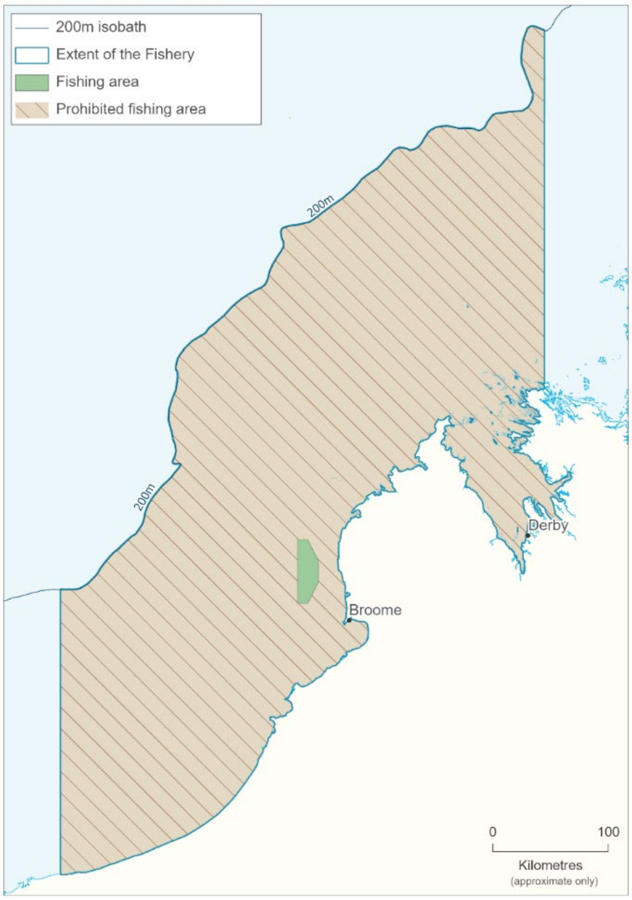
The fisheries have Commonwealth export approval until 2025 (under Part 13 of the *Environment Protection and Biodiversity Conservation Act 1999* [EPBC Act]).

SUMMARY FEATURES

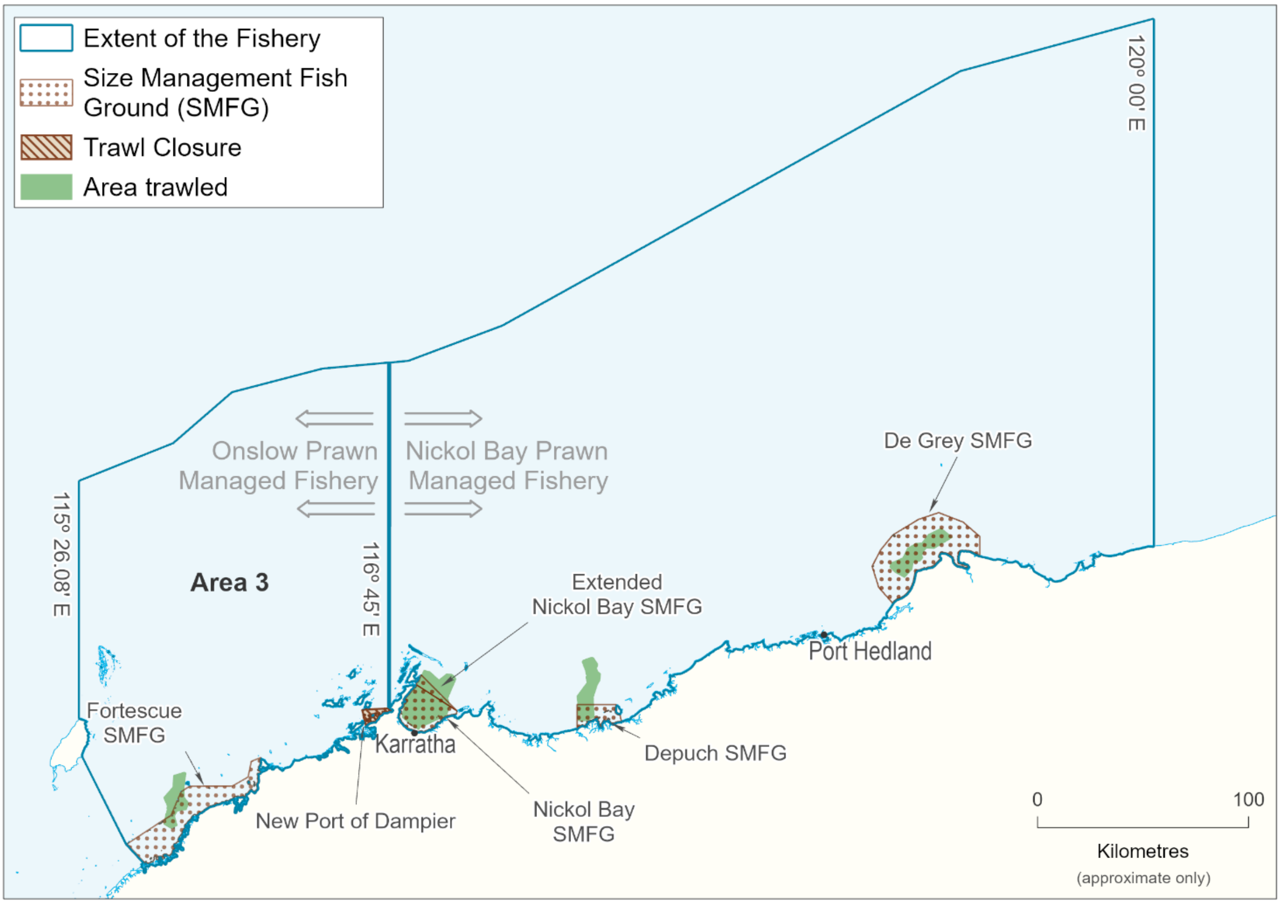
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (2020)	Total Catch: 459 t	Acceptable
Recreational fishery (N/A)		
EBFM		
Indicator species		
Banana prawns (KPMF and NBPMF)	Moderate risk: Catches within predicted ranges	Adequate
Western king prawns (BPMF)	Low risk: Very low effort and catch	Adequate
Brown tiger prawns (OPMF)	Low risk: Low effort and catch	Adequate
Ecological		
Bycatch	Low risk	Adequate
Listed Species	Low risk	Adequate
Habitat	Low risk	Adequate
Ecosystem	Low risk	Adequate
Economic (GVP $4.9m)	High risk	Acceptable
Social (low amenity)	Low risk	Acceptable
Governance	Moderate risk	Acceptable
External Drivers	Moderate risk (climate)	



NORTH COAST PRAWN FIGURE 1.
Map showing boundaries of the Kimberley Prawn Managed Fishery and areas fished in 2020.



NORTH COAST PRAWN FIGURE 2.
Map showing boundaries of the Broome Prawn Managed Fishery

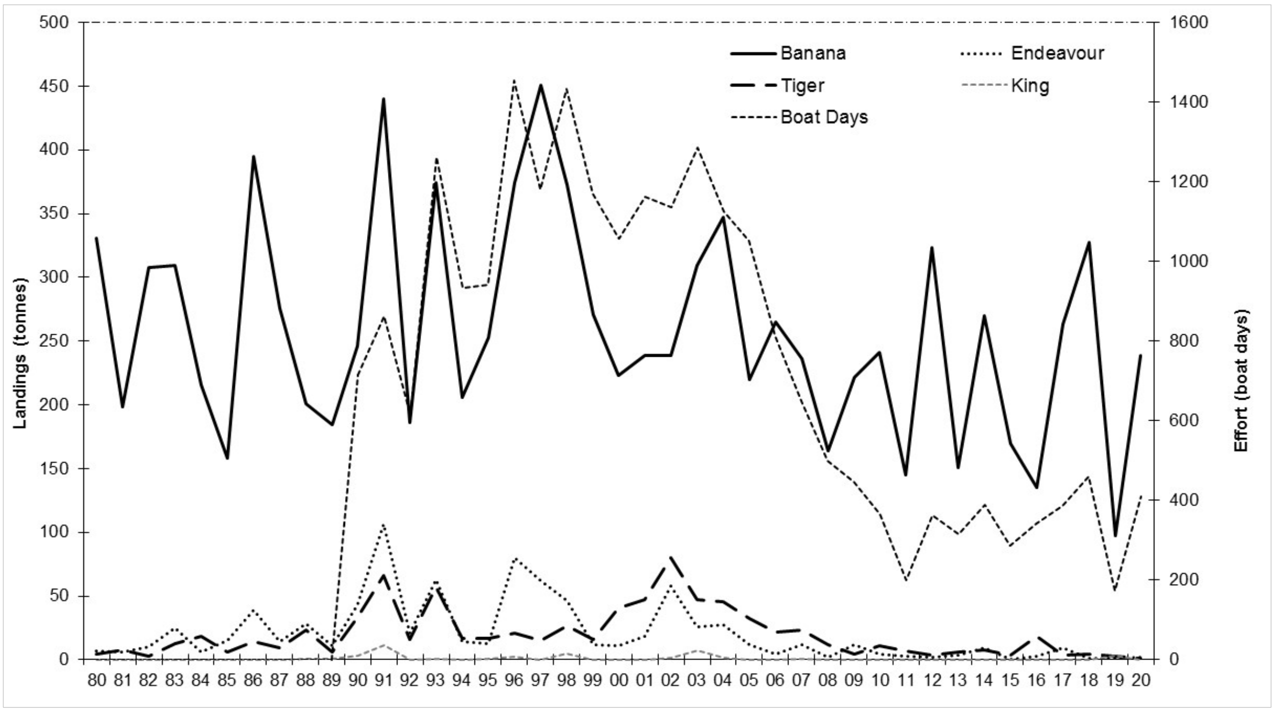


NORTH COAST PRAWN FIGURE 3.
Map showing boundaries of the Nickol Bay Prawn Managed Fishery and areas fished in 2020.

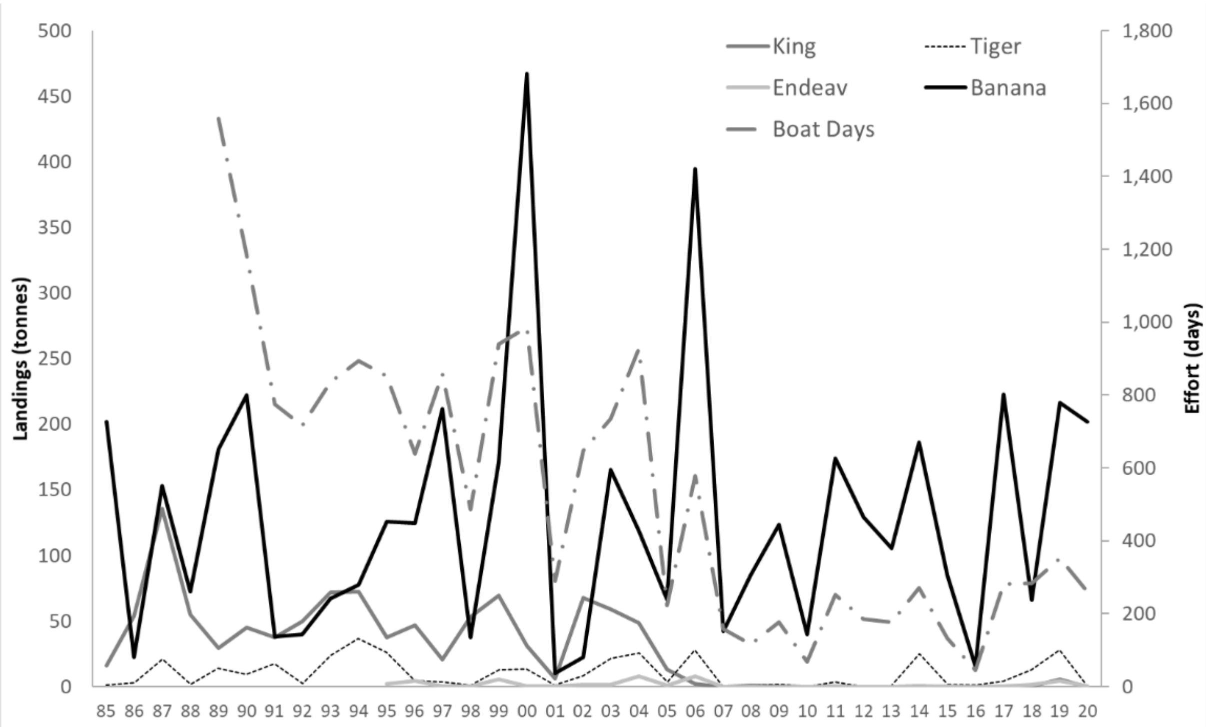
CATCH AND LANDINGS

Kimberley Prawn Managed Fishery (KPMF)

The total prawn landings in 2020 for the KPMF (North Coast Prawn Figure 1) were 253.4 t. The catch was primarily banana prawns (241.8 t), with 9.9 t of brown tiger prawns and 1.6 t of blue endeavour prawns also taken (North Coast Prawn Figure 4). The banana prawn landings were within the target catch range and the catch prediction. There are two fishing periods for the season (April to mid-June, then from August to the end of November) with around 81% of the total landings taken in the first fishing period. Negligible quantities of byproduct were reported.



NORTH COAST PRAWN FIGURE 4.
Annual prawn landings (t) and fishing effort (total adjusted hours) for the Kimberley Prawn Managed Fishery 1980-2020.



NORTH COAST PRAWN FIGURE 5.
Annual prawn landings (t) and fishing effort (total adjusted hours) for the Nickol Bay Prawn Managed Fishery 1985-2020.

Broome Prawn Managed Fishery (BPMF)

Extremely low fishing effort occurred as only one boat undertook trial fishing to investigate whether catch rates were sufficient for commercial fishing. This resulted in negligible landings of western king prawns with no byproduct recorded.

Nickol Bay Prawn Managed Fishery (NBPMF)

The total landings of major penaeids for the 2020 season in the NBPMF (North Coast Prawn Figure 3) were 202.4 t (North Coast Prawn Figure 5) with 99% being banana prawns, which were within the catch tolerance and predicted range (150 – 220 t). Minor landings of other prawn species were recorded. Due to the lower abundance of banana prawns in 2020, fishing effort was reduced to 261 boat days compared to 353 in 2019.

Onslow Prawn Managed Fishery (OPMF)

The total landings in 2020 were less than the target catch range (60 t) with only 13 days of fishing taking place by one boat. Due to data confidentiality a spatial fishing map is not shown for 2020.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Kimberley Prawn Managed Fishery – Banana prawns (Sustainable-Adequate)

On the basis of annual trends in catch, effort, and catch rates, the outputs of preliminary stock production models and a biomass dynamics model, it is considered that the stock is being fished at a sustainable level with the breeding stock is considered **sustainable-adequate**.

Key evidence to support this is: (1) the lack of a marked declining trend in overall landings across the entire time series despite very marked reductions in effort in recent years (with catches typically fluctuating within the lower half of the catch target range); (2) although there has been some decline in catches in recent years, the level of reduction is consistent with that which would be expected given the level of effort reduction, according to the outputs of stock production models; (3) no decline in peak catch rates in recent years in the two main fishing grounds; (4) declining trends in fishing mortality due to low fishing levels, as estimated by a biomass dynamics model; and (5) high levels of spawning biomass relative to the estimated unfished level, in recent years, as determined from the biomass dynamics model.

Broome Prawn Managed Fishery – Western king prawns (Sustainable-Adequate)

No fishing takes place during the breeding season and there is minimal overlap of fishing on the breeding stock due to the widespread nature of this species and the current very low level of fishing effort. Higher average water temperatures appear to be having a negative effect on western king prawn catches in the north coast prawn fisheries in recent years. There was only negligible fishing in Broome and therefore, the breeding stock is considered **sustainable-adequate.**

Nickol Bay Prawn Managed Fishery – Banana prawns (Sustainable-Adequate)

On the basis of annual trends in catch, effort, and catch rates, the outputs of preliminary stock production models and a biomass dynamics model, it is considered that the stock is being fished at a sustainable level with the breeding stock considered **sustainable-adequate**.

Onslow Prawn Managed Fishery – Brown Tiger and Western King Prawns (Sustainable-Adequate)

One boat fished in the OPMF in 2020 whilst the other operators chose to fish elsewhere where catches were likely to be more profitable. So overall this fishery recorded relatively low effort and catch. Therefore, the breeding stocks of banana, brown tiger and western king prawns were protected and are considered **sustainable-adequate**.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

Bycatch levels for all these fisheries are relatively low by tropical trawl fishery standards, with few species of significance to other fishing sectors being taken. In addition to grids, fish escape secondary bycatch reduction devices (FEDs) (square mesh panels) were implemented in all nets in 2005. All boats also use hoppers (in-water catch sorting systems), which adds another level of improvement for bycatch survival and product quality. **Low** risk.

Protected species

While protected species including dugongs, turtles, sawfish and sea snakes occur in the general area, only sea snakes and sawfish and occasionally turtles are encountered in the trawl catches. Most are typically returned to the sea alive. Grids have largely eliminated turtle and other large animal captures. **Low** risk.

Protected species interactions recorded in the daily logbooks for each fishery in 2020 are as follows:

Kimberley: 73 sea snakes were recorded as being caught, with 16 returned dead. Six sawfish were caught with one returned alive and one turtle was caught and returned alive.

Broome: No interations were reported. The fishery operates in relatively deep water, has a restricted trawl area and often has little to no trawl effort, which results in minimal interaction with protected species.

Nickol Bay/Onslow: 35 sea snakes were caught with 31 returned alive and four returned dead, two turtles were caught with one returned alive and one returned dead.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

The trawl gear has relatively little physical interaction with complex benthic environments. Given the predominantly mud and sand habitats of the trawl grounds, the nature of these fisheries and controls on effort, environmental impacts from operations is likely to be low. The total percetage of area fished in the approved boundary extent of the four northern prawn fisheries was 3 % in the KPMF, 1 % in the NBPMF and < 1% in the BPMF and OPMF. **Low** risk.

Ecosystem

The impact of the catch on local food chains is unlikely to be significant in view of the high natural mortality of prawns, the extent of non-trawled nursery areas in each fishery and variable biomass levels of prawns resulting from variable environmental conditions such as cyclone and rainfall events. **Low** risk.

SOCIAL AND ECONOMIC OUTCOMES

Social

The estimated employment in 2020 was 30-60 people, including skippers and other crew, for all north coast prawn fisheries combined for the operational period.

Economic

Ex-vessel (beach) prices for prawns vary, depending on the type and quality of product and the market forces operating at any one time. The total estimated value of the fisheries excluding byproduct are; KPMF - $2.7 M, NBPMF - $2.2 M, BPMF and OPMF - NA.

GOVERNANCE SYSTEM

Harvest Strategy

Management arrangements for all four fisheries are designed to keep fishing effort at levels that will maintain a sufficient spawning biomass of prawns. For the KPMF, an effort cap of 1500 vessel days is set for the season, distributed in two parts. For the NBPMF, a conservative banana prawn resource harvest strategy allowing adequate spawning biomass to survive the key spawning period each year by opening key fishing grounds in May provides protection from recruitment overfishing. For the BPMF, trial fishing is undertaken to assess the stock level of western king prawns prior to commercial fishing commencing, thus retaining spawning biomass. Bycatch reduction devices, including grids and FEDs are mandatory under the EPBC Act.

Annual Catch Tolerance Levels

KPMF: 240 - 450 t (**Acceptable**). Banana prawns within whilst all other prawn species landings were below their allowable ranges.

BPMF: 55 -260 t (**Acceptable**). Minimal fishing occurred in 2020.

NBPMF: 90 - 300 t (**Acceptable**).

Banana prawns were within the allowable and predicted range, all other prawn species were below.

OPMF: 60-180 t (**Acceptable**). Effort and catches were low in 2020.

Compliance

It is a requirement that all vessels in these fisheries are fitted with an Automatic Location Communicator (ALC). The implementation of an ALC enables the Department of Primary Industries and Regional Development (Department) to monitor the fleet using a Vessel Monitoring System (VMS) and manage compliance with temporal and spatial closures. The Department also undertakes regular vessel inspections to ensure fishing is being undertaken in accordance with the governing legislation (e.g. gear requirements, catch reporting).

Consultation

Biannual meetings between the Department, WAFIC and licence holders are held to consider the status of the stocks and recommend the opening and closing dates and fishing arrangements for each season.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives/Outlook

The Department and industry are considering a management review of the KPMF and NBPMF. The review proposes to unitise effort days and introduce an individual transferable effort system. This will provide industry opportunity to consolidate entitlement, addressing latent effort and allow for improvements in the fishery's seasonal management arrangements.

Some members of industry commenced trialling different gear configurations for the Department to assess potential efficiency gains associated with their use.

Formal MSC Fisheries Improvement Projects are being considered for the the KPMF and NBPMF.

EXTERNAL DRIVERS

A positive relationship has been observed with summer rainfall and banana prawn landings, particularly in the NBPMF.

High water temperatures have had a negative effect on western king prawn catches in recent years (Caputi *et al*. 2015a, 2016) which may be impacting those northern prawn fisheries that target western king prawns. Brown tiger prawns were ranked as a **high risk** to climate change effects and western king prawns as **moderate-high** and will need to be monitored (Caputi *et al.* 2015a, 2015b).

REFERENCES

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2015a. *Management implications of climate change effect on fisheries in Western Australia: Part 1*: Fisheries Research and Development Corporation project 2010/535. *Fisheries Research Report*, Western Australian Department of Fisheries, Perth.

Caputi N, Feng M, Pearce A, Benthuysen J, Denham A, Hetzel Y, Matear R, Jackson G, Molony B, Joll L, and Chandrapavan A. 2015b. *Management implications of climate change effect on fisheries in Western Australia, Part 2*: Case studies. FRDC Project 2010/535. *Fisheries Research Report*, No. 261. Department of Fisheries, Western Australia. 156pp.

Caputi N, Kangas M, Hetzel Y, Denham A, Pearce A, and Chandrapavan A. 2016. Management adaptation of invertebrate fisheries to an extreme marine heat wave event at a global warming hotspot. *Ecology and Evolution*. doi: 10.1002/ece3.2137. http://onlinelibrary.wiley.com/doi/10.1002/ece3.2137/full

NORTH COAST NEARSHORE AND ESTUARINE RESOURCE STATUS REPORT 2021

S. Newman, C. Skepper, G. Mitsopoulos and L. Wiberg

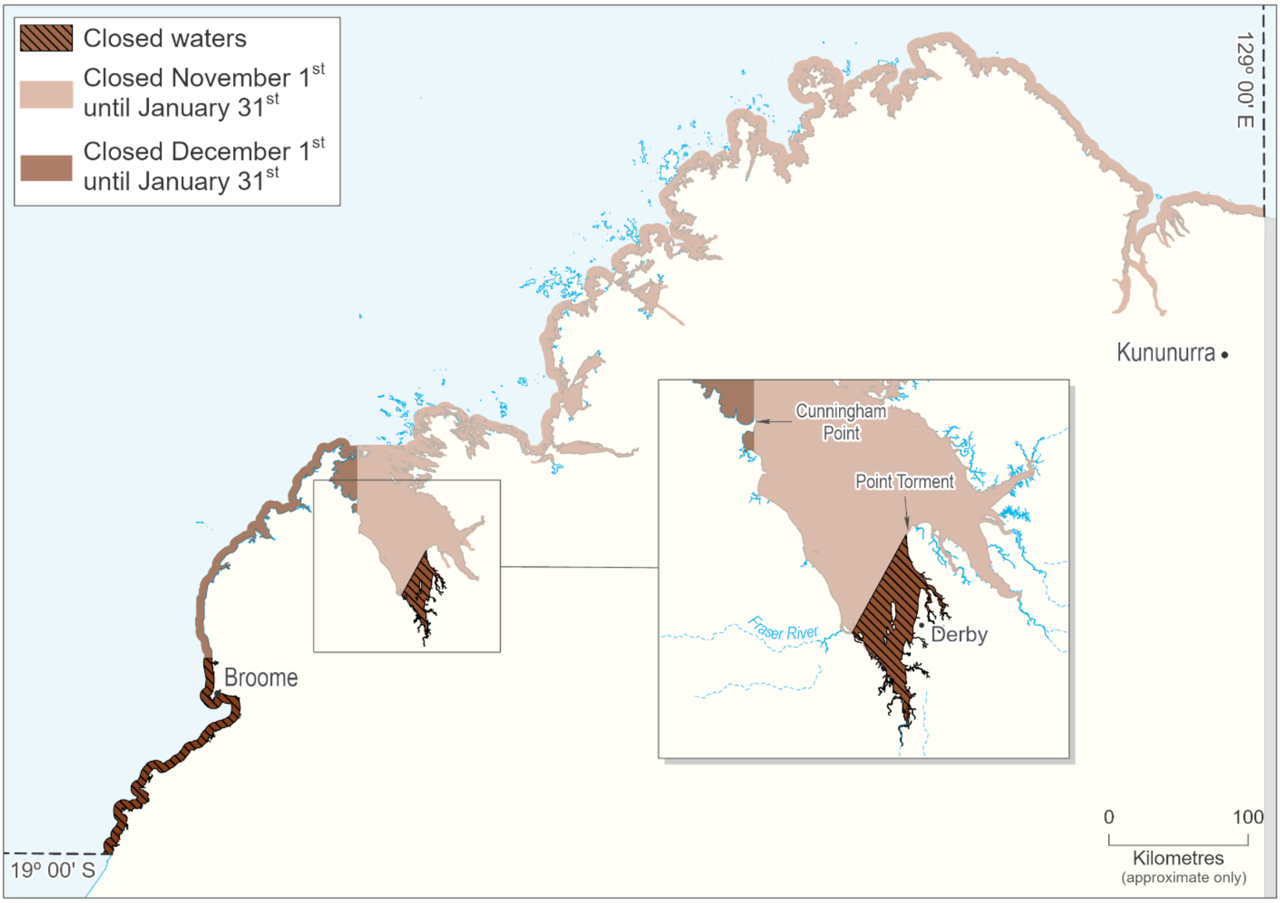
OVERVIEW

The Kimberley Gillnet and Barramundi Fishery (KGBF) operates in the nearshore and estuarine zones of the North Coast Bioregion and extends from the WA/NT border (129ºE) to the top end of Eighty Mile Beach, south of Broome (19ºS; North Coast Nearshore and Estuarine Figure 1). It encompasses the taking of any fish by gillnet in inshore waters and the taking of barramundi (*Lates calcarifer*) by any means. The principal species landed are barramundi (*Lates calcarifer*) and two species of threadfin (king threadfin *Polydactylus macrochir* and blue threadfin *Eleutheronema tetradactylum*). Small quantities of Elasmobranchs (sharks and rays), black jewfish (*Protonibea diacanthus*) and tripletail (*Lobotes surinamensis*) are also landed.

The main areas of operation for the commercial fishery are the river systems and tidal creek systems of the Cambridge Gulf (including Ord River), the Ria coast of the northern Kimberley (six small river systems), and King Sound. Access to the KGBF is limited to four licences. Commercial fishing is now prohibited between the southern boundary of the fishery (19º00′ S) to north of Willie Creek (17º44′ S) and in King Sound South (North Coast Nearshore and Estuarine Figure 1). Fishing is also restricted to within three nautical miles of the high water mark for the remainder of the fishery. There are commercial fishing area closures around major town sites and recreationally important fishing locations, southern King Sound, encompassing Derby and the Fitzroy River, and all its creeks and tributaries south of 17º27′ S, and the lower Ord River upstream of Adolphus Island.

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (Barramundi 33-44t)	Total Catch 2020: 44.6t	Acceptable
Recreational fishery	Total Catch 2017/18: 15–26 t (boat-based only)	Acceptable
EBFM		
Indicator species		
KGBF	Medium Risk	
Barramundi	Above target but within the limit catch range, catch rates remain high, effort is low	Adequate
King threadfin	Catches well below the average of 74.5 t for the 10-year period from 2004–2013	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Negligible Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (GVP $ (<$1 m)	Low Risk	Acceptable
Social (low amenity)	Low Risk	Acceptable
Governance	Moderate Risk	Acceptable
External Drivers	Low Risk	Acceptable



NORTH COAST NEARSHORE AND ESTUARINE
Location and extent of the KGBF within the Kimberley region of Western Australia. Note: this map is indicative only.

CATCH AND LANDINGS

The total reported catch of all species in the KGBF in 2020 was 44.6 tonnes (t) (North Coast Nearshore and Estuarine Table 1). The total landings of barramundi in 2020 were 34t (North Coast Nearshore and Estuarine Table 1, Figure 2), a decrease on the 2019 catch of 47t (60.1t was taken in 2018, the highest recorded catch since since 1987). The 2020 landings of threadfin from the KGBF were 7.3t (North Coast Nearshore and Estuarine Table 1, Figure 2), substantially lower than the 20.7t reported in 2019.

The top 10 nearshore and estuarine species (or species groupings) in the North Coast represented 87% of the boat-based recreational catch (kept by numbers) in 2017/18. The estimated boat-based recreational harvest ranges for the top 10 nearshore and estuarine species in the North Coast were steady at 20 t (95% CI 15–26 t) in 2017/18 compared with 21 t (95% CI 15–28) in 2015/16, 14 t (95% CI 10–18) in 2013/14 and 19 t (95% CI 13–25) in 2011/12 (Ryan *et al*. 2019). No recent estimates of shore-based recreational catches are available.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Barramundi (Sustainable-Adequate)

The barramundi catch in 2020 was 34t, which is at the lower end of the target range. The catch rate increased from 138.6 kg/block day in 2019 to 167.5 kg/block day in 2020 (North Coast Nearshore and Estuarine Figure 3).

The above evidence indicates the biomass of these stocks is unlikely to be depleted and recruitment is unlikely to be impaired and that current levels of fishing mortality (catch) are unlikely to cause the stock to become recruitment impaired. Thus the breeding stock is classified as **sustainable-adequate**.

King threadfin (Sustainable-Adequate)

Threadfin catches are dominated by king threadfin. The catch of king threadfin in 2020 was 6.9t, a substantial decrease from the 17.4t reported in 2019 and well below the average of 74.5t for the 10-year period from 2004–13. This is due to the low effort levels now demonstrated in the fishery, following the removal of two fishing licenses from the Broome coast area, with the area closed to commercial fishing in late-2013. The lower commercial catches in recent years (post closures) are relatively stable. King threadfin are landed by recreational and charter fishers, but only in small quantities (1t). The above evidence indicates the biomass of these stocks is unlikely to be depleted and recruitment is unlikely to be impaired and that current levels of fishing mortality (catch) are unlikely to cause the stock to become recruitment impaired.

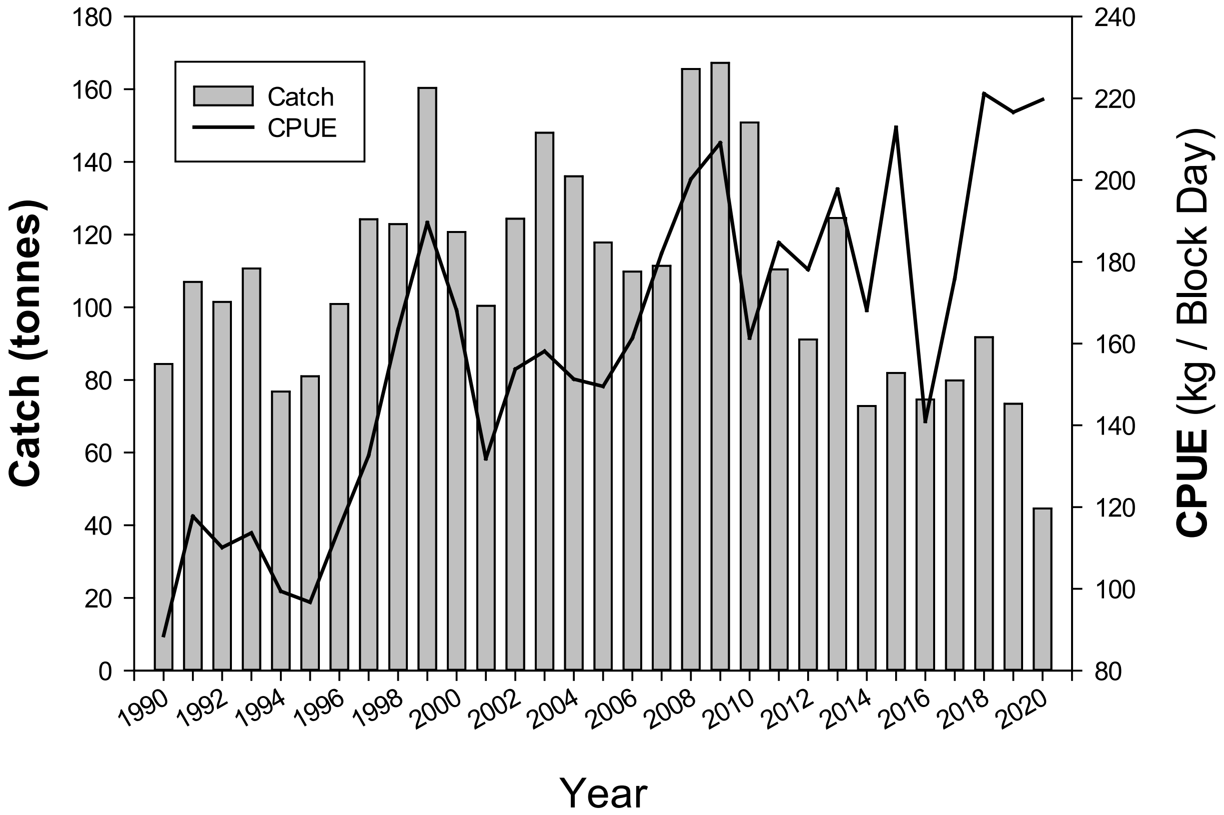
On the basis of the evidence provided above, the breeding stock of King Threadfin is classified as **sustainable-adequate**.

NORTH COAST NEARSHORE AND ESTUARINE TABLE 1

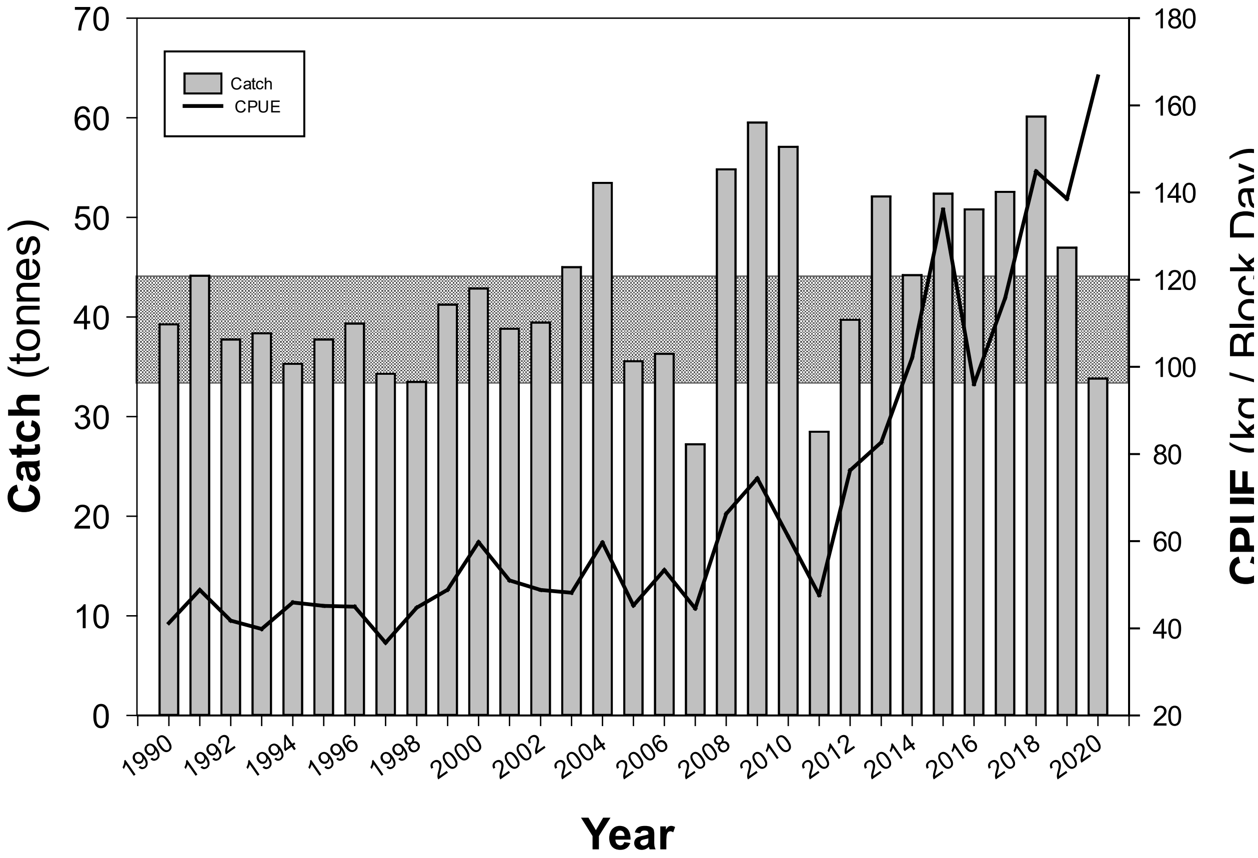
Summary of the reported catch (t) in the Kimberley Gillnet Barramundi Fishery in 2020 and the percentage composition of each of the major species retained.

Species	Catch (tonnes)	Composition %
Threadfin	7.3	16.4
Barramundi	33.8	75.9
Tripletail	0.5	1.2
Black jewfish	1.7	3.8
Sharks*	0.2	0.4
Other fish*	1.0	2.3
Total	44.6	100

*Other fish includes general catfish, Giant queenfish, sea mullet and unspecified species. Shark species are not typically identified.



NORTH COAST NEARSHORE AND ESTUARINE FIGURE 2
The annual total catch and catch per unit effort (CPUE, kg block day^{-1}), from all areas of the KGBF including sharks and rays over the period 1990 to 2020.



NORTH COAST NEARSHORE AND ESTUARINE FIGURE 3
The annual catch and catch per unit effort (CPUE, kg block day^{-1}) for barramundi from the KGBF over the period 1990 to 2020. The upper and lower bounds of the target commercial catch range for barramundi are shown by the shaded catch area between 33 and 44 tonnes.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

The fishery operates at a relatively low intensity over a wide area of the Kimberley region, specifically targeting barramundi and threadfin. The fishing gear uses large mesh sizes, and hence does not generate a significant bycatch of species important to other sectors, but does take some sharks and rays. Where practicable, sharks and rays are released alive. However, there is some mortality of sharks and rays associated with gillnet capture. Because of the low spatial density of fishing effort relative to the widespread distribution of these species and the size-selectivity of the permitted mesh sizes, these impacts impose a negligible risk to the stocks involved. **Negligible** risk.

Protected species

The fishing gear used for this fishery (gillnets) is known to result in the occasional bycatch of protected crocodiles (*Crocodylus porosus*) and sawfish (Family Pristidae). These species are generally released alive or avoided as far as is practicable. Because of the low effort levels and the low spatial intensity of fishing effort, these impacts are unlikely to pose a significant threat to the sustainability of the stocks of these species. In 2020, listed species interactions were reported for both crocodiles and sawfish.

Catches of the speartooth shark (*Glyphis glyphis*) or the northern river shark (*Glyphis garricki*), which are listed under the Environment Protection and Biodiversity Conservation Act 1999 as critically endangered and endangered, respectively, are rare in the KGBF. However, as these species look similar to other whaler shark species, they may be captured but misidentified. Given the fishery's overall low effort levels, particularly inside the freshwater drainages in which these species are most likely to occur, the fishing operations of the KGBF are unlikely to pose a significant threat to the sustainability of the stocks of these species. Effort levels inside freshwater drainages will be monitored. **Low** risk.

HABITAT AND ECOSYSTEM INTERACTIONS

This fishery poses a **negligible** risk on the nearshore and estuarine ecosystem of the Kimberley region due to the low spatial density of fishing effort. The fishing gear has minimal impact on the habitat. The area and habitat fished is subject to extreme tidal currents and associated effects and is typically mud flat areas.

SOCIAL AND ECONOMIC OUTCOMES

Social

During the 2020 season (February to November), three vessels fished in the KGBF with an average crew level of approximately 2 people, with an estimate of at least six people directly employed in the fishery. There was additional employment through local processors and distribution networks. The fishery provides fresh fish for local communities and the tourism industry throughout the Kimberley region.

A significant number of recreational and charter anglers also fished across the region. Recreational fishing attracts many visitors to the North Coast Bioregion, particularly in nearshore areas over the winter dry season (April – October). This provides employment through local charter fishing services and fishing tackle outlets around key population centres, as well as more remote charter operations offering wilderness fishing experiences in the north Kimberley region. The social amenity definition for the KGBF is important (this fishery is an important asset locally and/or the use or existence of the asset is important to the broader community).

Economic

The fishery's score value in 2020 was estimated to be Level 1 (i.e. Risk level – **Low**; Economic value – < $1 million). The establishment of new marine parks may impact on the future economic viability of the KGBF.

Recreational fishers make a significant contribution to Western Australia's economy, and support economic activity in many regional towns on the coast and near inland fishing spots. These resources contribute in part to the $2.4 billion attributed to the value of recreational fishing to the State's economy each year.

GOVERNANCE SYSTEM

Harvest Strategy

The harvest strategy for barramundi in the Kimberley Gillnet and Barramundi Managed Fishery in the Kimberley region of Western Australia is based on a constant commercial catch policy where the annual commercial catches of barramundi are allowed to vary within the target catch range, which is based on an historical catch range during which the fishery was stable and levels of exploitation were considered to be sustainable.

Annual Catch Tolerance Levels (Acceptable)

The target commercial catch range was calculated based on catch information from 1989 – 1999, a period during which the fishery was stable and levels of exploitation were considered to have been sustainable. However, the target catch range for barramundi has recently been revised to be consistent with the reference points and control rules adopted for other fisheries. The current approach specifies this range as the values within the minimum and maximum catches observed during the reference period. The threshold values for the target commercial catch range have been calculated as being within the range of 33 – 44t, with a limit reference range of 23-54t. Monthly catch and effort data from the commercial fishery are used to assess the status of barramundi populations targeted by the fishery. There is a need to further review the catch ranges within the fishery.

Compliance

The KGBF is managed primarily through input controls in the form of limited entry, seasonal and spatial area closures and gear restrictions. There is a closed season in which fishing is prohibited in the KGBF. In the southern KGBF (west of Cunningham Point, 123º08.23´ E longitude) the closure extends from 1 December to 31 January the following year, while in the northern section of the KGBF (east of Cunningham Point) the closure extends from 1 November to 31 January the following year. There are also limits on the length of net and mesh sizes to be used in the fishery.

Recreational fishing activities are concentrated around key population centres, with a seasonal peak in activity during the dry season (winter months). Fish species in the North Coast Bioregion are assigned bag and size limits according to their ecological suite and the risk to sustainability. The bag and size limits are species-specific (e.g. barramundi) or species group specific (e.g. mullet) to ensure that stock levels are maintained. Recreational set and haul netting is prohibited in all waters of the North Coast Bioregion with the exception of haul netting in the waters of the Dampier Archipelago (between Cape Preston and Cape Lambert) with the following restrictions: haul nets must not exceed 30 metres in length; mullet are the only species to be retained and all other species must be returned to the water.

Consultation

The Department undertakes consultation directly with licensees on operational issues. Industry Management Meetings are convened by the Western Australian Fishing Industry Council (WAFIC), who are also responsible for statutory management plan consultation under a Service Level Agreement with the Department. Consultation processes for the recreational fishing sector are facilitated by Recfishwest under a Service Level Agreement with the Department, although the Department undertakes direct consultation with the community on specific issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department’s Stakeholder Engagement Guidelines.

Management Initiatives

New State marine parks are currently being developed for the Kimberley region. The establishment of these new marine parks may impact on the future economic viability of the KGBF. This represents a **moderate** risk, with the Department continuing to monitor the development of marine parks.

EXTERNAL DRIVERS

The barramundi stocks utilising the Kimberley river systems as nursery areas are expected to be reasonably resilient to fishing pressure. However, the impact of increasing exploitation from the charter and tourism sectors on barramundi stocks needs to be monitored.

Furthermore, the smaller, isolated stocks along the arid Pilbara coastline are likely to experience highly variable recruitment due to environmental fluctuations (e.g. the amount of rainfall).

The introduction of new marine parks across the Kimberley region has the potential to concentrate fishing effort from multiple sectors into those areas that remain open to fishing and are easily accessible, increasing risks of local depletion of barramundi and threadfin stocks.

In addition, inter-sectoral conflict between recreational and commercial fishing sectors in the Derby area surrounding access to the barramundi resource have resulted in the introduction of a commercial closure in the south of King Sound between Point Torment and Fraser River. This reallocation of the resource to the recreational fishing sector is reflective of the social value placed on barramundi, and is not due to any stock sustainability concerns.

Low risk.

NORTH COAST DEMERSAL RESOURCE STATUS REPORT 2021

S. Newman, C. Wakefield, C. Skepper, D. Boddington and A. Steele

OVERVIEW

A range of commercial and recreational fisheries target demersal scalefish resources in the North Coast Bioregion (NCB) of Western Australia. The major demersal fish species in the NCB (in order of gross tonnage) are; goldband snapper (*Pristipomoides multidens*), bluespotted emperor (*Lethrinus punctulatus*), red emperor (*Lutjanus sebae*), saddletail snapper (*Lutjanus malabaricus*), crimson snapper (*Lutjanus erythropterus*), rankin cod (*Epinephelus multinotatus*), rosy threadfin bream (*Nemipterus furcosus*), brownstripe snapper (*Lutjanus vitta*), and spangled emperor (*Lethrinus nebulosus*).

Commercial fisheries landing demersal scalefish resources in the NCB include the Northern Demersal Scalefish Managed Fishery (NDSMF) in the Kimberley subregion, and the Pilbara Demersal Scalefish Fisheries (PDSF) in the Pilbara subregion (North Coast Demersal Figure 1). These fisheries are managed in accordance with the *North Coast Demersal Scalefish Resource Harvest Strategy 2017-2021* (NCDSR Harvest Strategy; DPIRD 2017).

The permitted methods in the NDSMF (Area 2 – offshore area) include handline, dropline and fish traps, but since 2002 it has essentially been a trap based fishery which uses gear time access and spatial zones as the primary management measures. The main species landed by this fishery in the Kimberley subregion are goldband snapper and red emperor. The inshore area of the NDSMF (Area 1) permits line fishing only, between the high water mark and a line approximating the 30 m isobath.

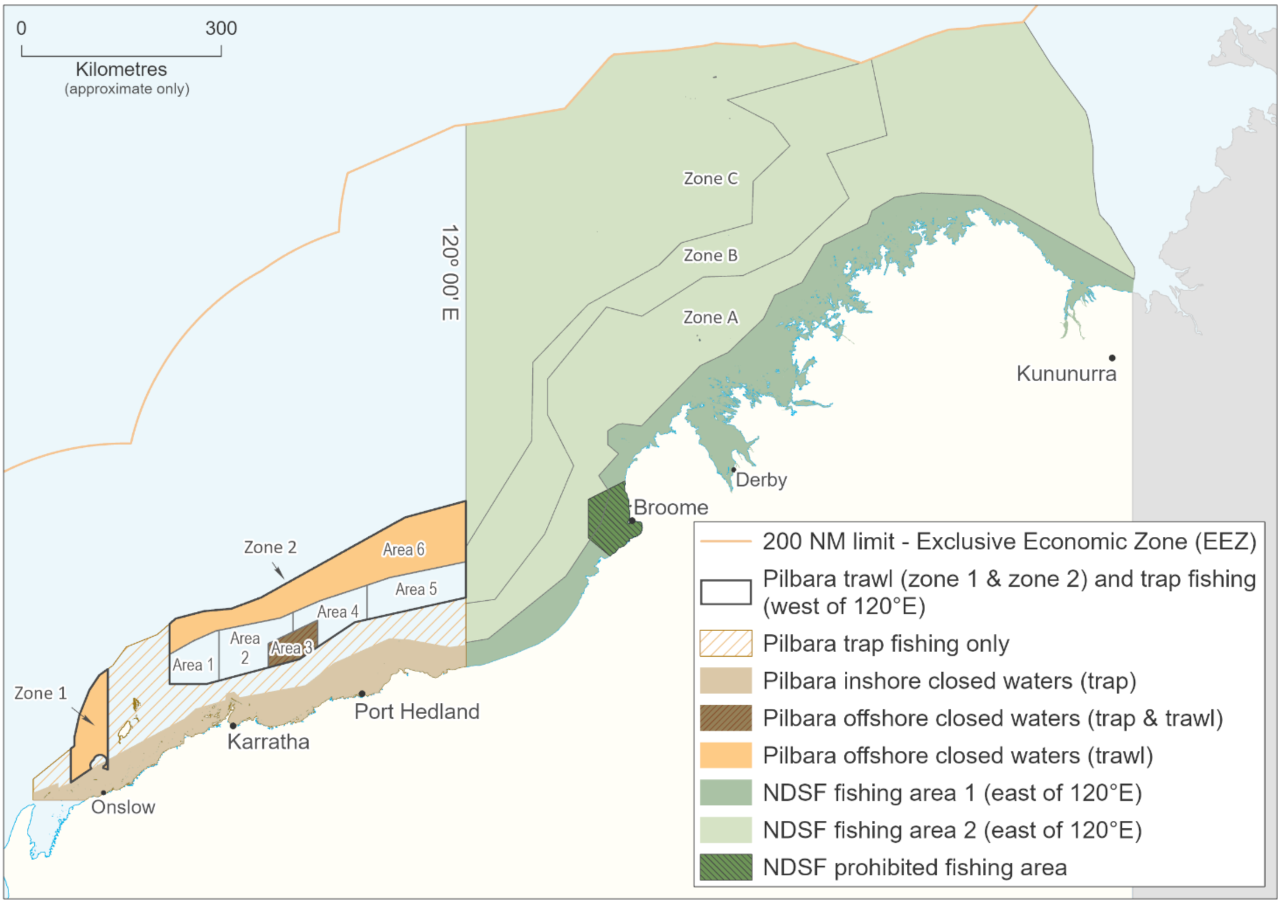
The PDSF includes the Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF), the Pilbara Trap Managed Fishery and the Pilbara Line Fishery. The PDSF collectively use a combination of limited entry, effort allocations (time), gear limits, plus spatial zones (including extensive trawl closures) as management measures. The main species landed by the fisheries in the Pilbara subregion are bluespotted emperor, red emperor and rankin cod.

Recreational fishing activities in the NCB are mostly line-based fishing from private boats and charter vessels with effort concentrated around key population centres. The recreational fishery for demersal fish is managed through the use of input controls (e.g. recreational licences) and output controls (e.g. bag and/or boat limits, size limits). The recreational and charter sectors do not catch significant quantities of most demersal scalefish species targeted by the commercial fisheries.

Further details can be found in the RAR at https://www.fish.wa.gov.au/Documents/resource_assessment/resource_assessment_report_013.pdf

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery: NDSF PDSF	Total Catch 2020: 1,419 t Total Catch 2020: 2,854 t	Acceptable Acceptable
Recreational fishery	Total Catch 2017/18: 63–88 t (boat-based only)	Acceptable
EBFM		
Indicator species		
NDSMF Goldband snapper Red emperor	Medium Risk Biomass above threshold (B_{MSY}) Biomass around target (1.33 B_{MSY})	 Acceptable Acceptable
PDSF Red emperor Rankin cod Bluespotted emperor	Medium Risk Biomass above threshold (B_{MSY}) Biomass above target (1.33 B_{MSY}) Biomass above target (1.33 B_{MSY})	 Acceptable Acceptable Acceptable
Ecological		
Bycatch NDSMF PDSF	 Negligible risk Low risk	 Adequate
Listed Species NDSMF PDSF	 Negligible-Low risk Low-Moderate risk	 Adequate Adequate
Habitat NDSMF PDSF	 Negligible risk Moderate risk	 Adequate Adequate
Ecosystem NDSMF PDSF	 Negligible risk Low risk	 Adequate Adequate
Economic NDSMF (GVP $10-20 m) PDSF (GVP $10-20 m)	 Medium risk Medium risk	 Acceptable Acceptable
Social (low amenity) NDSMF PDSF	 Low-Medium risk Low-Medium risk	 Acceptable Acceptable
Governance NDSMF PDSF	 Low risk Low risk	 Acceptable Acceptable
External Drivers	Low risk	Acceptable



NORTH COAST DEMERSAL FIGURE 1.
Demersal scalefish fisheries of the North Coast Bioregion of Western Australia. In the Pilbara subregion: Areas 1 to 6 refer to the management regions in Zone 2 of the trawl fishery. Zone 1 has been closed to trawling since 1998. In the Kimberley subregion: Zones A, B and C lie in Area 2 of the NDSF.

CATCH AND LANDINGS

Kimberley

Since 2008, NDSMF annual catches have exceeded 1,000 t. The 2020 catch of 1,419 t is the second largest reported catch across the whole fishery, following the 1,507t landed in 2019. The majority of the catch is landed from Zone B, with a catch of 1,249 t in 2020. The level of catch in Zone B is also the second highest (1,313t in 2019) reported since zoning was implemented in 2006. The 2020 reported catch of the jobfish group (*Pristipomoides spp.*) was the highest ever recorded at 657t. Goldband snapper constituted ~93% of the jobfish catch. A breakdown of the landed weight by the major species in the NDSMF is reported in North Coast Demersal Table 1.

Pilbara

The PDSF annual catches from the domestic fish trawl, trap and line fisheries peaked at 3,600 t in 1996. In 2008, following declining catch rates and relatively high levels of fishing mortality for red emperor in the western areas of the PFTIMF, effort was reduced for the PFTIMF in these areas. In 2016, the PDSF annual catches exceeded 2,000 t for the first time since effort reductions in 2008. Of the total commercial catches of demersal scalefish in the Pilbara in 2020 (2,854 t), 74% (2,103 t) were landed by the trawl sector, with 20% (584 t) taken by the trap sector and 6% (167 t) taken by the line sector. A breakdown of the landed weight by the major species in the PDSF is reported in North Coast Demersal Table 1.

Total annual trawl catches have reduced from an annual average of approximately 2,500 t during the period 1995-2004 to an annual average of 1,159 t from 2008-15, in response to the effort reductions imposed on the PFTIMF since 2008. The total demersal scalefish catch in the PFTIMF in 2020, despite having the same annual effort allocations as those imposed since 2008, exceeded the acceptable catch range (i.e. 940-1,416 t). These increasing catch rates (combined with fishing mortality spawning biomass estimates) suggest effort reductions since 2008 have resulted in increased fish abundance and stock rebuilding in the PFTIMF.

The total annual catch taken by the trap and line sectors have remained relatively consistent over the past decade, averaging 489 t and 114 t per year, respectively. The total catch of the trap fishery slightly exceeded the acceptable catch range in 2020 (i.e. 241-537 t), and also exceeded

the acceptable catch range for the line fishery (36-127 t).

The top 10 demersal species in the North Coast represented 79% of the boat-based recreational catch (kept by numbers) in 2017/18. The estimated boat-based recreational harvest range for the top 10 demersal species (or groupings) in the North Coast was higher at 75 t (95% CI 63–88 t) in 2017/18 compared with 40 t (95% CI 34–46 t) in 2015/16, but steady with 55 t (95% CI 46–65) in 2013/14 and 78 t (95% CI 69–87) in 2011/12 (Ryan *et al*. 2019).

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Kimberley (Sustainable-Adequate)

Due to the resource comprising a large number of species, indicator species have been selected from the suite of demersal scalefish (based on their inherent vulnerability, management importance and overall risk to sustainability) for assessing the status of the overall resource. The demersal indicator species for the Kimberley region are red emperor (*Lutjanus sebae*) and goldband snapper (*Pristipomoides multidens*). The annual commercial catches of indicator species from the NDSMF are depicted in North Coast Demersal Figure 2.

A 2018 assessment of the two indicator species in the Kimberley estimated the median relative spawning biomass of both the red emperor stock and the goldband snapper stock to be **around** threshold level (which corresponds to B_{MSY}).

Representative age structure samples of each indicator species in the Kimberley region are scheduled to be collected again in late 2021/2022, and will be processed and used to update the stock assessments. The life history parameters for these species are also currently being reviewed and updated to better inform the assessment model.

The above evidence indicates that the current biomass of these stocks is unlikely to be depleted, recruitment is unlikely to be impaired, and current levels of fishing mortality (catch) are unlikely to cause the stock to become recruitment impaired.

On the basis of the evidence provided above, the biological stocks are classified as **sustainable-adequate**.

Pilbara (Sustainable-Adequate)

Due to the resource comprising a large number of species, indicator species have been selected from the suite of demersal scalefish (based on their inherent vulnerability and overall risk to sustainability) for assessing the status of the overall resource. The three demersal indicator species for the Pilbara region are red emperor (*Lutjanus sebae*), rankin cod (*Epinephelus multinotatus*), and bluespotted emperor (*Lethrinus punctulatus*). The annual commercial catches of these indicator species from the PDSF are depicted in North Coast Demersal Figure 2. The status of ruby snapper (*Etelis* sp) is also used as an indicator species for the offshore demersal scalefish resources targeted by the Pilbara Line Fishery. The stock status of the indicator species is assessed periodically (~ every 5 years) using a weight-of-evidence approach that considers all available information as described above.

A 2020 assessment of the three indicator species in the Pilbara estimated the spawning biomass of red emperor stock to be currently **above** the threshold level (which corresponds to B_{MSY}). The stocks of rankin cod, bluespotted emperor and ruby snapper are **well above** the target spawning biomass levels.

Representative age structure samples of indicator species in the Pilbara region collected in 2015 and 2019 will be processed and used to update the stock assessments in 2020/21. The life history parameters for these species are also currently being reviewed and updated to better inform the assessment model.

The above evidence indicates that the biomass of these stocks is unlikely to be depleted, recruitment is unlikely to be impaired, and current levels of fishing mortality (catch) are unlikely to cause the stock to become recruitment impaired.

On the basis of the evidence provided above, the biological stocks are classified as **sustainable-adequate**.

NORTH COAST DEMERSAL TABLE 1.
Summary of the commercial catches and the relative contribution (% composition of the total NCB demersal catches of each species) of each of the major species taken within the Pilbara and Kimberley subregions of the NCB in 2020.

Species	Pilbara (PDSF) catch		Kimberley (NDSMF) catch		Total catch
	tonnes	% total	tonnes	% total	tonnes
Goldband snapper (all *Pristipomoides* sp.)	176.8	21	657.4	79	834.2
Bluespotted emperor	426.9	90	48.6	10	475.5
Red emperor	210.3	59	144.4	41	354.7
Saddletail snapper	116.4	39	184.1	61	300.5
Crimson snapper	201.8	83	41.4	17	243.2
Rankin cod	171.1	70	72.1	30	243.2
Brownstripe snapper	184.7	93	14.9	7	199.6
Rosy threadfin bream	217.8	100	0.4	<0.1	218.2
Spangled emperor	67.1	78	18.5	22	85.6
Moses snapper	57.9	89	6.9	11	64.8
Frypan snapper	85.1	100	<0.1	<0.1	85.1
Barcheek coral trout	11.7	67	5.7	33	17.4
Ruby snapper	5.7	79	1.5	21	7.2
Longnose emperor	11.5	83	2.3	17	13.8
Other demersal scalefish	909.1	80	220.7	20	1,129.8
Total all demersal scalefish	2,853.9	67	1,419.0	33	4,272.9

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Kimberley Trap / Pilbara Trap

Bycatch

There is a limited quantity of non-retained bycatch in these fisheries. The most common bycatch species is the starry triggerfish (*Abalistes stellaris*), but the numbers taken are considered to pose a **negligible** risk to the sustainability of this species.

Protected species

Using trap gear in continental shelf regions is very unlikely to interact with listed species. Previous video observations indicate that the potato cod (*Epinephelus tukula*), a protected species, can be present in high numbers at discrete locations within the fishery. However, potato cod rarely enter traps because most individuals encountered are large in size and girth which limits their capacity to pass through the entrance funnel into the traps.

The Kimberley and Pilbara trap fisheries regularly capture sea snakes. In 2020, the Kimberley trap fishery reported 100 sea snakes (Daily Log) or 141 (Monthly Returns) sea snakes. Sea snakes are returned to the water alive.

Overall, the level of interactions with listed species is considered a **negligible** risk to their populations.

Pilbara Fish Trawl

Bycatch

Species of teleosts caught as bycatch by the trawl fishery are typically small bodied and/or short lived. Such species are considered less vulnerable compared to longer-lived teleost species based on their population production potential. Thus, the indicator species used in the weight-of-evidence stock assessments for the Pilbara demersal scalefish resources are considered to provide an adequate indication for similar or less vulnerable retained and bycatch species. While a number of species that are caught are not retained during demersal fishing activities (including inedible species and undersized marketable species) may not all survive, this still represents a minor impact to their stocks and therefore a **low** risk.

Protected species

The use of Bycatch Reduction Devices (BRDs) has been mandatory in the PFTIMF since 2006. BRDs are highly effective in reducing reptile (turtles and sea snakes) bycatch. Bottlenose dolphin interactions with BRDs are rare (5.2 per 1,000 trawls) despite high levels of attendance and depredation during trawling. Loss of targeted teleosts through the BRD hatch is also rare (1.3% of fish during day trawls). Based on high levels of

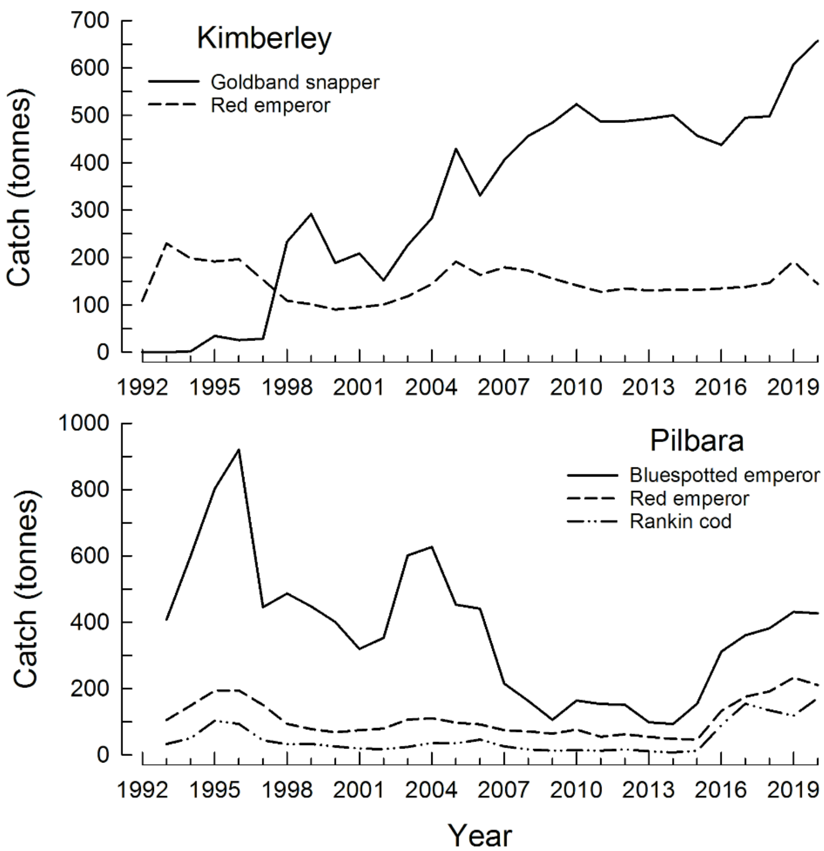
subsurface observer coverage in 2012 (60% of day trawls or 56% of day trawl hours), the subsurface expulsion of megafauna in poor condition was negligible (see Wakefield *et al*. 2014; Wakefield *et al*. 2016). Therefore, electronic monitoring of above deck records accurately reflects megafauna bycatch levels. The level of interactions with listed species is therefore considered **low-moderate** risk to their populations. The reported bycatch of listed species in the PFTIMF in 2020 is listed in North Coast Demersal Table 2.

The PFTIMF was re-accredited a Wildlife Trade Operation (WTO) under the Commonwealth of Australia's *Environmental Protection and Biodiversity Conservation Act 1991* (EPBC) for three years from the end of 2018. The accreditation included specific conditions around the observing, reporting and mitigation of endangered, threatened and protected species interactions.

NORTH COAST DEMERSAL TABLE 2.

Reported bycatch of listed species by skippers in the PFTIMF in 2020. [a]where the condition was not reported the status of the animal was considered to be unknown; [b]where the species of sawfish was not reported the animal was considered to be unknown sawfish.

Species	Number released Alive	Number deceased	Number unknown[a]	Total Reported
Bottlenose dolphins	5	11	0	16
Pipefish	1	29	0	30
Green sawfish	18	25	0	43
Narrow sawfish	7	4	0	11
Unknown sawfish[b]	4	1	0	5
Seahorses	0	3	0	3
Sea-snakes	64	53	0	117
Turtles	1	0	0	1



NORTH COAST DEMERSAL FIGURE 2.

Annual commercial catches of indicator species from the Kimberley and Pilbara demersal scalefish fisheries from 1993 to 2020.

HABITAT AND ECOSYSTEM INTERACTIONS

Kimberley Trap / Pilbara Trap and Line

Habitat

As a result of the gear design, these fisheries have little impact on the habitat overall, although there may be some rare interactions with coral habitats which are not common in areas where these fisheries operate. Trap fishing is the main fishing method used in the NDSMF for demersal species, which has little physical impact on the benthic environment and hence **negligible** risk to benthic habitats.

Ecosystem

Hall and Wise (2011) demonstrated that there has been no reduction in either mean trophic level or mean maximum length in the finfish catches recorded within the Kimberley (i.e. no fishing down of the food web) over the past 30 years. The need to maintain relatively high levels of biomass for the species caught in this fishery to meet stock recruitment requirements results in a **negligible** risk to the overall ecosystem from the fishery.

Pilbara Fish Trawl

Habitat

The PFTIMF is restricted to less than ~2% of the North West Shelf (NWS; Amoroso et al. 2018). Area 3 and the waters inside the 50 m isobath are permanently closed to fish trawling, Zone 1 is closed to fish trawling, and Area 6 has had no fish trawling since 1998.

Within the areas actually trawled, monitoring has indicated that approximately 10% of the sessile benthic fauna (e.g. sponges) are detached per year. Considering effort for the trawl fishery is at historically low levels and the effective area trawled within the managed areas has been greatly reduced, it is likely that the trawl fishery imposes a **moderate** risk to the small amount of habitat in the Areas open to trawling (~2% of NWS) but a **negligible** risk to the total habitat in the North West Shelf.

Ecosystem

The PFTIMF operates with standard stern trawling gear (single net with extension sweeps) within an area previously trawled by foreign vessels. Previous research by CSIRO has suggested that the extensive Taiwanese Pair Trawl Fishery caused a significant decrease in the biomass of finfish on the North West Shelf, and a change in species composition towards smaller (shorter lived) species. The PFTIMF, which developed when the fish stocks had begun to recover, uses a much larger mesh size and much lighter ground gear, and operates at lower exploitation rates and only in restricted parts of the continental shelf. At the present levels of catch and effort by the fish trawl, fish trap, and line fisheries, the broader effect on the trophic levels and community structure of the North West Shelf is considered to be at an acceptable level. Hall and Wise (2011) demonstrated that there has been no reduction in either mean trophic level or mean maximum length in the finfish catches recorded within the Pilbara (i.e. no fishing down of the food web) over the past 30 years and thus represents a **low** risk to the ecosystem.

SOCIAL AND ECONOMIC OUTCOMES

Social

Kimberley: Seven vessels fished in the 2020 fishing season, and at least 23 people (3-4 crew per vessel) were directly employed in the NDSMF. Approximately half the fish from this fishery are supplied to Perth metropolitan markets, while the other half is supplied to east coast metropolitan markets. There is currently a **medium level of** risk to these values.

Pilbara: It is estimated that ~10 fishers on 2 vessels were directly employed during 2020 in the trawl sector, and 8 fishers on 3 vessels in the trap sector, and at least ~15 fishers on 5 vessels in the line sector. Overall, at least ~33 people (e.g. 3-4 crew per vessel) were directly employed in the PDSF. There is currently a **medium level of** risk to these values.

Recreational fishing attracts many visitors to the North Coast Bioregion, particularly in inshore areas over the winter dry season (April – October). This provides employment through local charter fishing services and fishing tackle outlets around key population centres, as well as more remote charter operations offering wilderness fishing experiences in the north Kimberley region, including offshore locations such as the Rowley Shoals.

The annual estimated boat-based recreational fishing effort in the North Coast Bioregion was steady in 2017/18 (32,964 boat days, SE=2,574) compared with 2015/16 (31,375 boat days, SE=2,414), but lower than 2013/14 (45,604, SE=3,603) and 2011/12 (47,721, SE=3,778) (Ryan *et al*. 2019).

The North Coast Demersal Scalefish Resource provides a high social amenity to recreational fishing and diving and to consumers via commercial fish supply to markets and restaurants. There is currently a **low level of** risk to these values.

Economic

Kimberley: The NDSMF principally targets the higher-value species such as the goldband snapper and red emperor resulting in an economic value of $10-20 million (Level 4). The

social amenity value is that this is an important asset locally. There is currently a **medium** risk to this level of return.

Pilbara: Overall, the estimated economic value of the PDSF is $10-20 million (Level 4). The fish trawl demersal scalefish catch is dominated by lower-valued species such as bluespotted emperor and threadfin bream. However, its value is estimated to be $5-10 million (Level 3). For social amenity some of the species may be caught recreationally and/or there is some specific interest in the resource by the broader community. The fish trap and line catches are dominated by valuable species such as red emperor and goldband snapper. The demersal scalefish catch from these sectors was estimated to have an economic value of $1-5 million (Level 2) and they also have social amenity value. There is currently a **medium** risk to this level of return.

Recreational fishers make a significant contribution to Western Australia's economy, and support economic activity in many regional towns on the coast and near inland fishing spots. These resources contribute in part to the $2.4 billion attributed to the value of recreational fishing to the State's economy each year.

GOVERNANCE SYSTEM

Harvest Strategy

The NCDSR Harvest Strategy (DPIRD 2017) focuses on the exploitation and stock status of the indicator species in the Kimberley and Pilbara demersal scalefish fisheries. These indicator species include red emperor and goldband snapper in the Kimberley, and red emperor, bluespotted emperor, and rankin cod in the Pilbara. Periodic assessments of selected non-indicator species are also occasionally undertaken to validate the indicator species approach and ensure that the status of other retained species remains at acceptable levels. The assessment and harvest strategies of these species are primarily based on estimates of spawning stock biomass (or an appropriate proxy for biomass), relative to internationally accepted target, threshold and limit reference levels.

The commercial sectors are managed primarily through input controls in the form of a total allowable effort (TAE) allocation system via individually transferable effort (ITE) allocations. The recreational and charter sector are primarily managed using size limits for some species, and daily bag and possession limits. Recreational fishers operating from a boat are required to have a current Recreational Fishing from Boat Licence (RFBL). Charter operators are required to have a Fishing Tour Operators Licence.Allowable Catch Tolerance Levels (Acceptable)

Kimberley

For the 2020 calendar year, the total allowable effort was set at 986 standard fishing days in Zone B of the fishery, and 616 and 1,100 standard fishing days in Zone A and C of the fishery, respectively. At these levels of total effort and at recent catch rates, the total catch of the fishery is expected to be in the range of 903–1,332 t. The total 2020 catches were above the **acceptable** catch range and this has triggered a review of likely risks to sustainability.

Pilbara

The total catch of the trawl fishery exceeded the acceptable catch range in 2020 despite having the same (reduced) annual effort allocations as those imposed since 2008. This increased catch represents an increase in stock abundance following eleven years of reduced effort in the western trawl managed areas. The total catch in 2020 of the trap fishery also slightly exceeded the **acceptable** catch range, and that of the line fishery was within the acceptable catch range.

Compliance

The primary management measures of gear time usage and spatial zone access for NCB trap and trawl fisheries are monitored and enforced using a satellite-based vessel monitoring system (VMS). The annual fishing effort capacity limits the amount of effort available in the fishery to achieve the notional target total allowable catch. Additional management measures include size limits, and limits on the numbers of fish that can be taken by individual recreational fishers and by recreational fishers fishing from boats.

Consultation

The Department undertakes consultation directly with licensees on operational issues. Industry Management Meetings are convened by the Western Australian Fishing Industry Council (WAFIC), who are also responsible for statutory management plan consultation under a Service Level Agreement with the Department. Consultation processes for the recreational fishing sector are facilitated by Recfishwest under a Service Level Agreement, although the Department undertakes direct consultation with the community on specific issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives/Outlook Status

Kimberley

The Northern Demersal Scalefish Fishery Operators Guide to the Management Arrangements 2016 (DoF 2016) was published in July 2016, and is a plain English guide to the management arrangements, designed to assist licence holders.

Pilbara

In 2021/22, the Department will continue to collaborate with permit holders in the Pilbara Fish Trawl Interim Managed Fishery to address the conditions arising from the re-accredition process for Wildlife Trade Operation (WTO) approval.

In 2020, the Department collaborated with the Commonwealth Department of Agriculture, Water and the Environment and Pilbara Trap licence holders to complete an assessment of the Pilbara Trap Fishery under the EPBC for export approval, for which it was accreditated a new WTO.

EXTERNAL DRIVERS

The Commonwealth's North-west Marine Parks Network came into effect on 1 July 2018 and introduced marine reserves, including sanctuary zones which prohibit fishing. This will restrict access to fishing in parts of the NCB to all sectors, i.e. commercial, recreational and charter.

Under the Offshore Constitutional Settlement, commercial trawl vessels licensed by the Commonwealth may operate in waters outside of a line that represents the 200 m isobath as part of the North West Slope Trawl Fishery (NWSTF).

Climate change and climate variability has the potential to impact fish stocks in a range of ways including influencing their geographic distribution (e.g. latitudinal shifts in distribution). However, it is unclear how climate change may affect the sustainability risks to North Coast demersal fisheries.

Low risk.

REFERENCES

Amoroso RO, Pitcher CR, Rijnsdorp AD, McConnaughey RA, Parma AM, Suuronen P, Eigaard OR, Bastardie F, Hintzen NT, Althaus F, Baird SJ, Black J, Buhl-Mortensen L, Campbell AB, Catarino R, Collie J, Cowan JH, Durholtz D, Engstrom N, Fairweather TP, Fock HO, Ford R, Galvez PA, Gerritsen H, Gongora ME, Gonzalez JA, Hiddink JG, Hughes KM, Intelmann SS, Jenkins C, Jonsson P, Kainge P, Kangas M, Kathena JN, Kavadas S, Leslie RW, Lewis SG, Lundy M, Makin D, Martin J, Mazor T, Gonzalez-Mirelis G, Newman SJ, Papadopoulou N, Posen PE, Rochester W, Russo T, Sala A, Semmens JM, Silva C, Tsolos A, Vanelslander B, Wakefield CB, Wood BA, Hilborn R, Kaiser MJ, and Jennings S. 2018. Bottom trawl fishing footprints on the world's continental shelves. Proceedings of the National Academy of Sciences Oct 23, 2018 115 (43): E10275-E10282.

DoF. 2016. Northern Demersal Scalefish Managed Fishery, An operators' guide to the management arrangements 2016, Version 2.0 (July 2016). Fisheries Occasional Publication No. 120, Department of Fisheries, Western Australia. 36pp.

DPIRD. 2017. *North Coast demersal scalefish resource harvest strategy 2017 – 2021. Version 1.0*. Fisheries Management Paper No. 285. Department of Primary Industries and Regional Development, Government of Western Australia, Perth, Australia. 35p.

Hall NG, and Wise BS. 2011. Development of an ecosystem approach to the monitoring and management of Western Australian fisheries. FRDC Report – Project 2005/063. Fisheries Research Report, No. 215. Department of Fisheries, Western Australia. 112pp.

Langlois TJ, Wakefield CB, Harvey ES, Boddington DK, and Newman SJ. 2021. Does the benthic biota or fish assemblage within a large targeted fisheries closure differ to surrounding areas after 12 years of protection in tropical northwestern Australia? Marine Environmental Research 170: 105403.

Newman SJ, Brown JI, Fairclough DV, Wise BS, Bellchambers LM, Molony BW, Lenanton RCJ, Jackson G, Smith KA, Gaughan DJ, Fletcher WJ, McAuley RB, and Wakefield CB. 2018. A risk assessment and prioritisation approach to the selection of indicator species for the assessment of multi-species, multi-gear, multi-sector fishery resources. Marine Policy 88: 11-22.

Newman SJ, Skepper CL, Mitsopoulos GEA, Wakefield CB, Meeuwig JJ, and Harvey ES. 2011. Assessment of the potential impacts of trap usage and ghost fishing on the Northern Demersal Scalefish Fishery. Reviews in Fisheries Science 19 (2): 74-84.

Newman SJ, Steckis RA, Edmonds JS, and Lloyd J. 2000. Stock structure of the goldband snapper, *Pristipomoides multidens* (Pisces: Lutjanidae) from the waters of northern and western Australia by stable isotope ratio analysis of sagittal otolith carbonate. Marine Ecology Progress Series 198: 239–247.

Newman SJ, Wakefield CB, Williams AJ, O'Malley JM, Taylor BM, Nicol SJ, Nichols RS, Hesp SA, Hall NG, Hill N, Ong JJL, Andrews AH, Wellington CM, Harvey ES, Mous P, Oyafuso ZS, Pardee C, Bunce M, DiBattista JD, and Moore BR. 2017. International workshop on advancing methods to overcome challenges associated with life history and stock assessments of data-poor deep-water snappers and groupers. Marine Policy 79: 78-83.

Newman SJ, Williams AJ, Wakefield CB, Nicol SJ, Taylor BM, and O'Malley JM. 2016. Review of the life history characteristics, ecology and fisheries for deep-water tropical demersal fish in the Indo-Pacific region. Reviews in Fish Biology and Fisheries 26 (3): 537-562.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia.

Stephenson PC, Edmonds JS, Moran MJ, and Caputi N. 2001. Analysis of stable isotopes to investigate stock structure of red emperor and Rankin cod in northern Western Australia. Journal of Fish Biology 58: 126–144.

Wakefield CB, Blight S, Dorman SR, Denham A, Newman SJ, Wakeford J, Molony BW, Thomson AW, Syers C, and O'Donoghue S. 2014. Independent observations of catches and subsurface mitigation efficiencies of modified trawl nets for endangered, threatened and protected megafauna bycatch in the Pilbara Fish Trawl Fishery. Fisheries Research Report, No. 244, Department of Fisheries, Western Australia. 40 p.

Wakefield CB, Hesp SA, Blight S, Molony BW, Newman SJ, Hall NG. 2018. Uncertainty associated with total bycatch estimates for rarely-encountered species varies substantially with observer coverage levels: informing minimum requirements for statutory logbook validation. Marine Policy 95: 273-282.

Wakefield CB, Santana-Garcon J, Dorman SR, Blight S, Denham A, Wakeford J, Molony BW, and Newman SJ. 2017. Performance of bycatch reduction devices varies for chondrichthyan, reptile and cetacean mitigation in demersal fish trawls: assimilating subsurface interactions and unaccounted mortality. ICES Journal of Marine Science 74 (1): 343-358.

Santana-Garcon J, Wakefield CB, Dorman SR, Denham A, Blight S, Molony BW, and Newman SJ. 2018. Risk versus reward: interactions, depredation rates, and bycatch mitigation of dolphins in demersal fish trawls. Canadian Journal of Fisheries and Aquatic Sciences 75 (12): 2233–2240.

PEARL OYSTER MANAGED FISHERY RESOURCE STATUS REPORT 2021

A. Hart, D. Murphy, L. Wright

OVERVIEW

The Western Australian pearl oyster fishery (fishery) is the only remaining significant wild-stock fishery for pearl oysters in the world. It is a quota-based dive fishery, operating in shallow coastal waters along the north coast bioregion and targets the silver lipped pearl oyster (*Pinctada maxima)*. The fishery is currently managed under the *Pearling Act 1990* and uses output controls in the form of a Total Allowable Catch (TAC) divided up into individually transferable quotas (ITQs).

Fishing for *P. maxima* is one component of the pearling industry's activities, along with seeding and grow-out of pearl oysters to produce pearls.

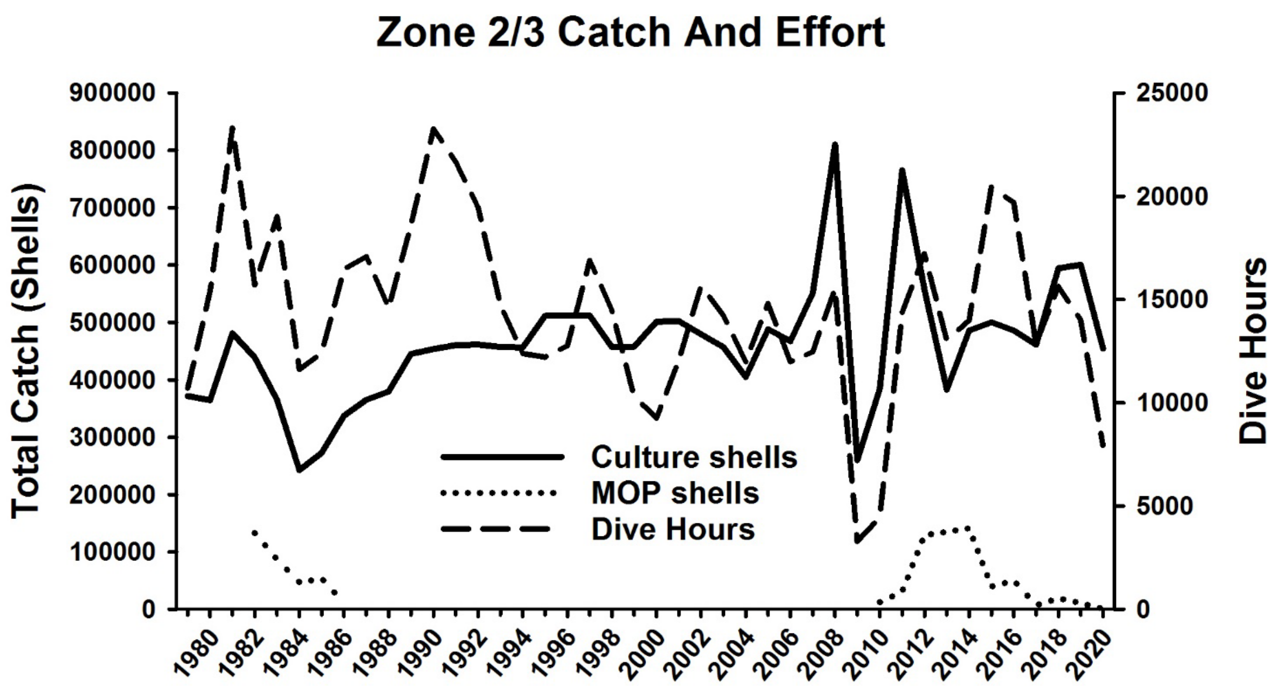
This fishery has been accredited for export under the EPBC Act for a period of ten years (re-assessment in 2025) and was certified under the MSC certification process in 2017. Further information can be sourced from Hart *et al*. (2016).

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total catch 2020: 455,980 shells	Acceptable
Recreational fishery	NA	NA
EBFM		
Assessment Indicator		
Silver lipped pearl oyster (*Pinctada maxima*)	Performance indicator above Target	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Negligible Risk	Adequate
Habitat	Negligible Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (Level 4: GVP $57 M)	Moderate Risk	Acceptable
Social	Low Risk	Acceptable
Governance	MSC certification	Acceptable
External Drivers	Moderate Risk	Acceptable

CATCH AND LANDINGS

In 2020, catch was taken in Zone 2 only with no fishing in Zones 1 or 3. The number of wild-caught pearl oysters was 455,980 (a decrease of 25% from 2019), comprising 454,487 culture shells and 1,173 Mother of Pearl (MOP) shells (oysters ≥175 mm) (Pearl Figure 1). Total effort was 9,942 dive hours (Pearl Figure 1), a decrease of 30% from the 2019 effort of 14,022 hours. No fishing has occurred in Zone 1 from 2017 to 2020 with only 4,594 culture shells taken in 2016.



PEARL FIGURE 1:
Total pearl shell catch (all areas) and effort (Zone 2/3). ‘Culture shells’ are pearl oysters ≥100 and <175 mm shell length, ‘MOP shells’ are pearl oysters ≥175 mm.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Zone 1 *Pinctada maxima* (Sustainable - Adequate)

Based on the information and analyses available, there is currently a **Low** risk to pearl oysters in Zone 1. The low risk reflects the negligible levels of fishing mortality. All the lines of evidence are consistent with a low level of risk; hence the overall weight of evidence assessment indicates the status of the Zone 1 pearl oyster stock is adequate and that current management settings are maintaining the level of risk at acceptable (low) levels.

Zone 2 *Pinctada maxima* (Sustainable - Adequate)

Based on the information and analyses available, there is currently a **Medium** risk to pearl oysters in Zone 2. The medium risk reflects the controlled levels of fishing mortality. Current lines of evidence show an increasing abundance due to higher-than-average recruitment, catch rates are above the threshold level, and the size-structure of harvested oysters has returned to the long-term average. Overall, the weight of evidence assessment indicates the status of the Zone 2 pearl oyster stock is adequate and that current management settings are maintaining the level of risk at acceptable (medium) levels.

Zone 3 *Pinctada maxima* (Sustainable - Adequate)

Based on the information and analyses available, there is currently a **Low** risk to pearl oysters in Zone 3. The low risk reflects the negligible levels of fishing mortality. All the lines of evidence are consistent with a low level of risk; hence the overall weight of evidence assessment indicates the status of the Zone 3 pearl oyster stock is adequate and that current management settings are maintaining the level of risk at acceptable (low) levels.

BYCATCH and PROTECTED SPECIES INTERACTIONS (Negligible Risk)

Divers have the ability to target pearl oysters. Pearl oysters brought to the vessel after hand collection are young and have relatively little epiphytic growth (fouling organisms). A small number of over-sized or under-sized pearl oysters are returned to the substrate. Therefore, bycatch impact imposes a **negligible** risk.

There is no interaction between the pearl oyster fishing operation and protected species (Hart *et al*., 2016).

HABITAT and ECOSYSTEM INTERACTIONS (Negligible Risk)

The fishery removes only a small proportion of the biomass of pearl oysters on the fishing grounds and is considered to have negligible impact on the food chain in the fishing area. Pearl divers have minimal contact with the habitat during fishing operations. The main habitat contact is by pearl oysters held in mesh panels on holding sites following capture. However, these sites cover a very small proportion of the habitat and the activity concerned is unlikely to cause any lasting effect.

Similarly, the pearl farming operation, which uses longline systems in areas of high tidal flow to culture pearls, has limited impact on the environment. Physical effects are limited to static anchoring systems in typically sand/mud habitats. Environmental management research has demonstrated that pearl farming has **negligible** impacts on habitat and environment.

Based on the information available, there is currently a **negligible** risk to the ecosystems from pearling operations.

SOCIAL AND ECONOMIC OUTCOMES

Social effects (Low Risk)

Pearl oyster fishing vessels operate from the Lacepede Islands north of Broome to Exmouth Gulf in the south. The number of vessels in the fishing fleet has been slowly reducing from the peak of 16 in 1997 (overall), mostly due to increased fleet efficiency and increased reliance on hatchery-produced pearl oysters. The number of vessels fishing in 2020 was five. Most vessels presently operate 10 – 14 crew for the fishing of pearl oysters between March and August each year. These vessels also support pearl oyster operations and a number of other pearl oyster farm functions throughout the year.

Personnel employed in the pearling industry and current full-time FTEs is estimated to be around 300.

Economic (Moderate Risk)

A precise estimate of the total industry value is difficult to achieve, owing to the variable time lags that occur between harvesting and sale to offshore buyers, and the costs incurred in marketing before sales take place. Based on information provided by the industry, the value of cultured pearls and by-products in 2020 was considered to be approximately $56.5 million.

GOVERNANCE SYSTEM

Annual Catch Tolerance Levels (Acceptable)

The overall TAC for the fishery for 2020 was 786,170 pearl oysters. This was comprised of a Zone 1 TAC of 54,970 pearl oysters and a Zone 2/3 TAC of 731,200 pearl oysters. The Zone 2/3 TAC is further broken down into an industry maximum harvest level of no more than 699,210 pearl oysters between 100 – 175mm and 31,990 MOP oysters.

Catch tolerance levels used in 2020 are for the Zone 2/3 “culture” fishery only.

TAC (699,210 “culture pearl oysters” in Zone 2/3 in 2020) to be caught in 14,071-20,551 dive hours.

Commercial catch (pearl oysters) for season 2020: 455,980 oysters at 7,942 dive hours.

Both the catch and effort levels were acceptable. The reduced catch and effort was due to COVID-19 related issues.

Harvest Strategy (Formal)

The harvest strategy for *P. maxima* is a constant exploitation approach, operationalised through an annual TAC, divided into ITQs. The TAC is set in proportion to overall stock abundance. Harvest control rules determine the TAC according to the relationship of predicted catch rates in comparison to target, threshold, and limit reference levels (DoF, 2016).

The control rules in place ensure that the catch is reduced when predicted recruitment is low. This is in order to provide increased protection to the stock, but also allows the catch to be raised in years when the predicted abundance is high.

Compliance

The pearling industry is highly regulated by the Department. Access to the wildstock pearl oysters is limited to holders of the relevant pearling (wildstock) licence and attached quota.

Companies who produce hatchery-reared pearl oysters must hold the appropriate hatchery licence(s); if they intend on seeding these pearl oysters, they must also hold a pearling (seeding) licence with appropriate hatchery quota.

Seeded pearl oysters, whether from the wild or hatchery-reared, must be held on a pearl oyster farm lease. Applications for a pearl oyster farm lease are reviewed and approval determined by the Department. The total area a company can hold is linked to the pearl oyster quota and/or stock holding held by that company.

Health certification and transport approvals also apply for certain activities within the fishery.

Consultation

The Department undertakes consultation directly with the Pearl Producers Association (PPA) and licensees on operational issues. Formal licence holder engagement is convened by the Western Australian Fishing Industry Council (WAFIC) under a Service Level Agreement with the Department. The stock assessment and sustainable harvest levels are discussed by the Stock Assessment Working Group (SAWG) and with licence holders, the Pearl Producers Association (PPA) and WAFIC at the Annual Management Meeting (AMM) each year. SAWG advice, a summary of discussions at the AMM and a PPA letter are provided to the Director General when determining the annual TAC for the pearl oyster fishery.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department’s Stakeholder Engagement Guidelines.

Management Initiatives

The *Aquatic Resource Management Act 2016* is a new State Act of Parliament to ensure the sustainability and management of all WA’s aquatic resources. When the new Act commences, it will replace both the *Fish Resources Management 1994* and the *Pearling Act 1990.* The Department is reviewing the current legislative framework ahead of the commencement of the new Act to transition the pearl oyster fishery and activities associated with pearl culture.

EXTERNAL DRIVERS

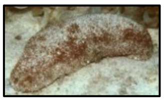
External influences include other activities and factors that occur within the pearl oyster fishery that may or may not impact on the productivity and sustainability of fisheries resources and their ecosystems. The main external influences included here are catch from other fisheries, environmental factors (i.e., cyclones and climate variation), market influences, tourism, liquid natural gas (LNG) exploration, disease and introduced species. Pearl oysters were ranked as a moderate-high risk to climate change effects due to environmental factors affecting the abundance of piggyback spat settlement.

REFERENCES

DoF (2016). Western Australian silver-lipped pearl oyster (Pinctada maxima) resource harvest strategy 2016-2021. Version 1.0. Pearl Oyster Fishery. Fisheries Management Paper No 276. 28 p.

Hart A, Travaille KL, Jones R, Brand-Gardner S, Webster F, Irving A, Harry AV (2016). Marine Stewardship Council Report Series No 5: Western Australian silver-lipped pearl oyster (Pinctada maxima) Industry. Department of Fisheries, Western Australia. 316pp.

SEA CUCUMBER RESOURCE STATUS REPORT 2021



A. Hart, D. Murphy

OVERVIEW

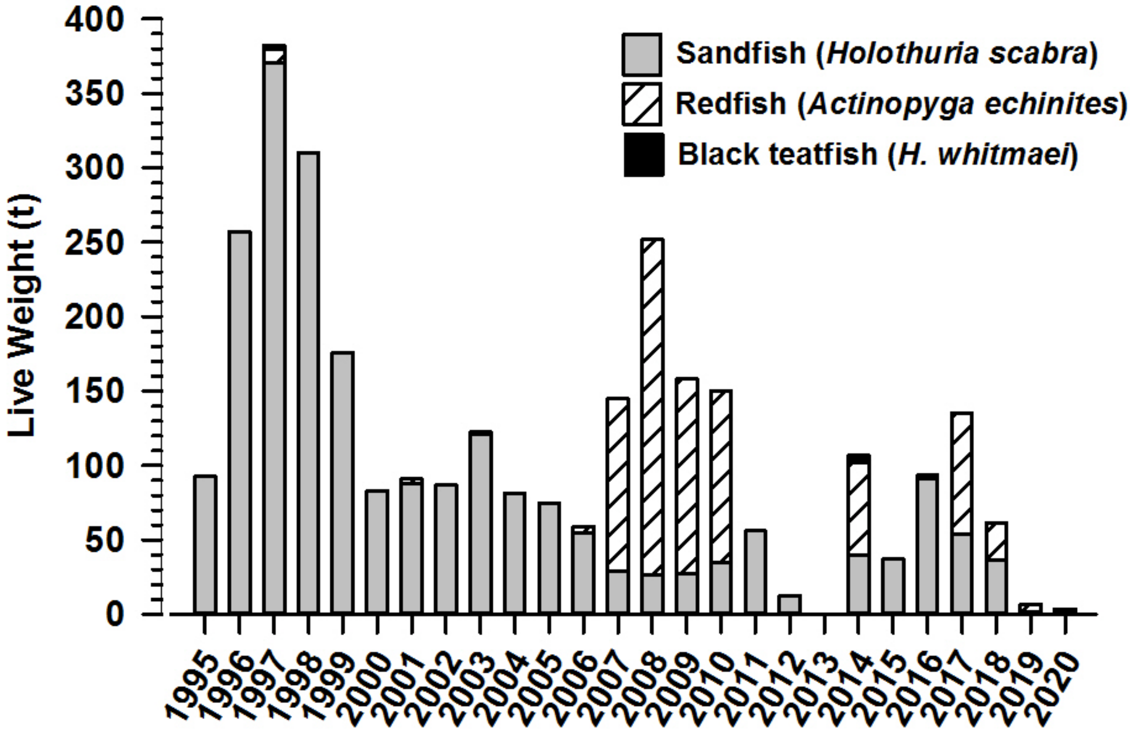
The Western Australian Sea Cucumber fishery is a commercial only fishery, with animals caught principally by diving, and a smaller amount by wading. It targets two main species: sandfish (*Holothuria scabra)* and redfish (*Actinopyga echinites)*. Fishing occurs mostly in the northern half of the State from Exmouth Gulf to the Northern Territory border, however Shark Bay was fished for the first time in 2020. Access is managed under Ministerial Exemptions. The WA Sea Cucumber Fishery (WASCF) is subject to input controls including limited entry, maximum number of divers, spatial closures, and gear restrictions. The Pilbara area of this fishery has achieved Marine Stewardship Council certification.

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2020: 3.6 t	Acceptable
Recreational fishery	Total Catch 2020: NA	
EBFM		
Assessment Indicator		
Sandfish Catch (Kimberley): 0-100 t Sandfish Catch (Pilbara): 0-80 t Redfish Catch (Pilbara): 0-150 t	0 t 0 t 0 t	Adequate Adequate Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Negligible Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (Level 1 GVP <$1 million)	Low Risk	Acceptable
Social (low amenity)	Low Risk	Acceptable
Governance	Stable	Acceptable
External Drivers	Medium Risk	Acceptable

LANDINGS

In 2020, 3.7 tonnes of sea cucumber was harvested (Sea Cucumber Figure 1). This catch comprised 3.6 t of deepwater redfish (*Actinopyga echinites*) and 0.1 t of black teatfish (*Holothuria whitmaei*). Both species were taken from Shark Bay, under an exemption license granted to Aboriginal native title holders, and it is the first time this stock has been fished. The commercial industry did not fish in 2020, and have adopted a rotational fishing strategy for the main species (sandfish – *H. scabra*), and redfish (*A. echinites*).



SEA CUCUMBER FIGURE 1:
Annual total retained catches (tonnes) in the Western Australian Sea Cucumber Fishery (WASCF) between 1995 and 2020.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Kimberley Sandfish (Sustainable - Adequate)

Based on the information and analyses available, the current risk level for Kimberley sandfish was estimated to be MEDIUM. This is consistent with previous assessments of the fishery. Therefore, the overall Weight of Evidence assessment indicates the status of the Kimberley sandfish stock is adequate and that current management settings are maintaining risk at acceptable (medium) levels.

Pilbara Sandfish (Sustainable - Adequate)

Based on the information and analyses available, the current risk level for Pilbara sandfish was estimated to be MEDIUM. Therefore, the overall Weight of Evidence assessment indicates the status of the Pilbara sandfish stock is adequate and that current management settings are maintaining risk at acceptable levels.

Pilbara Redfish (Sustainable - Adequate)

Based on the information and analyses available, the current risk level for Pilbara redfish was estimated to be MEDIUM. This is consistent with previous assessments of the fishery. Therefore, the overall Weight of Evidence assessment indicates the status of the Pilbara redfish stock is adequate and that current management settings are maintaining risk at acceptable levels.

Shark Bay was fished lightly for the first time in 2020, and no stock status assessment is currently available. This will be undertaken in 2021.

BYCATCH and PROTECTED SPECIES INTERACTIONS

Given the hand only method of fishing no bycatch is taken by the fishery and there are no known protected species interactions.

Negligible risk.

HABITAT and ECOSYSTEM INTERACTIONS

Habitat

Divers collect sea cucumber as they drift over the bottom of the seabed; there is minimal impact on the habitat as divers are highly selective in their fishing effort and no fishing gear or lines contact the seabed.

Negligible risk.

Ecosystem

This fishery harvests only a small amount of sandfish and redfish per annum. The effect from this harvesting on the rest of the ecosystem, given that the catch is spread over a wide region, would be insignificant. Due to the toxins present in their body tissues, it is highly unlikely they are a major diet for higher-order predators.

Negligible risk.

SOCIAL AND ECONOMIC OUTCOMES

Social effects

Generally, 4 to 6 crew are employed on a vessel, comprising a master, deckhand and divers. Additional individuals are employed for the processing of the product. These activities are mostly located in the Northern Territory and Victoria where the fishing fleet is based.

Low risk.

Economic

The estimated annual value for 2020 was <$100,000, based on a total live weight of 3.7 tonnes and $4.25 per kg. This is only a beach-price value and the processing sector adds significant value.

Low risk.

GOVERNANCE SYSTEM

Annual Catch Tolerance Range (Acceptable)

Commercial: Sandfish(Kimberley): 0-100 t; Sandfish(Pilbara): 0-80 t; Redfish(Pilbara): 0-150 t.

The catch of sea cucumber was within the tolerance ranges for all species. This indicates the status of sea cucumber stocks is adequate and that current management settings are maintaining risk at acceptable levels.

The recent fishing in Shark Bay occurred in areas for which populations are not well understood. A biomass survey of these stocks is planned for 2021 and results will be available in the 2021 assessment.

Harvest Strategy

The Western Australian Sea Cucumber fishery is managed under a formal harvest strategy, with specified performance indicators, threshold levels, and control rules. Currently all stocks are above the target reference point.

Compliance

There are no current issues.

Consultation

Industry Management Meetings are convened by the Western Australian Fishing Industry Council (WAFIC), under a Service Level Agreement with the Department.

Management Initiatives (MSC Assessment)

The WA Sea Cucumber Fishery has been formally assessed against Marine Stewardship Council (MSC) sustainability standards. Sea cucumber stocks in the Pilbara Unit of Certification have passed the assessment, and the first audit year. Inclusion of the Kimberley region in the assessment is planned for the 2nd audit in 2021.

EXTERNAL DRIVERS

The remoteness of the currently fished stock and the large tidal ranges where it occurs are natural barriers to the uncontrolled expansion of fishing. Marine park planning has to date restricted this fishery from general use zones of some MPAs. Currently, a lack of experienced fishers and suitable vessels is restricting catch to low levels.

Climate change could have positive or negative impacts on sea cucumber populations. It has been reported that higher sea temperatures will have a positive effect (i.e. higher production and yields) given the expected faster growth rates leading to larger sizes and increased fecundity. Sea cucumber were ranked as a **medium** risk to climate change effects.

NORTH COAST CRAB RESOURCE STATUS REPORT 2021

D. Johnston, D. Yeoh and S. Blazeski

OVERVIEW

Blue swimmer crabs are targeted by the Pilbara Crab Managed Fishery (PCMF) using hourglass traps, primarily within inshore waters around Nickol Bay (North Coast Crab Figure 1). Recreational fishers for this species use drop nets or scoop nets, with diving for crabs becoming increasingly popular.

Mud crabs are harvested by the Kimberley Crab Managed Fishery (KCMF) using crab traps between Broome and Cambridge Gulf (North Coast Crab Figure 2). There is an allocation of 1200 units (currently equivalent to 600 traps) to holders of a Managed Fishery Licence under the *Kimberley Crab Managed Fishery Management Plan 2018*. The Minister for Fisheries has also provided an equivalent allocation of 600 traps for commercial purposes to allow for Aboriginal economic development. This is provided through the granting of non-transferable Instruments of Exemption under the *Fish Resources Management Act 1994* to Aboriginal groups.

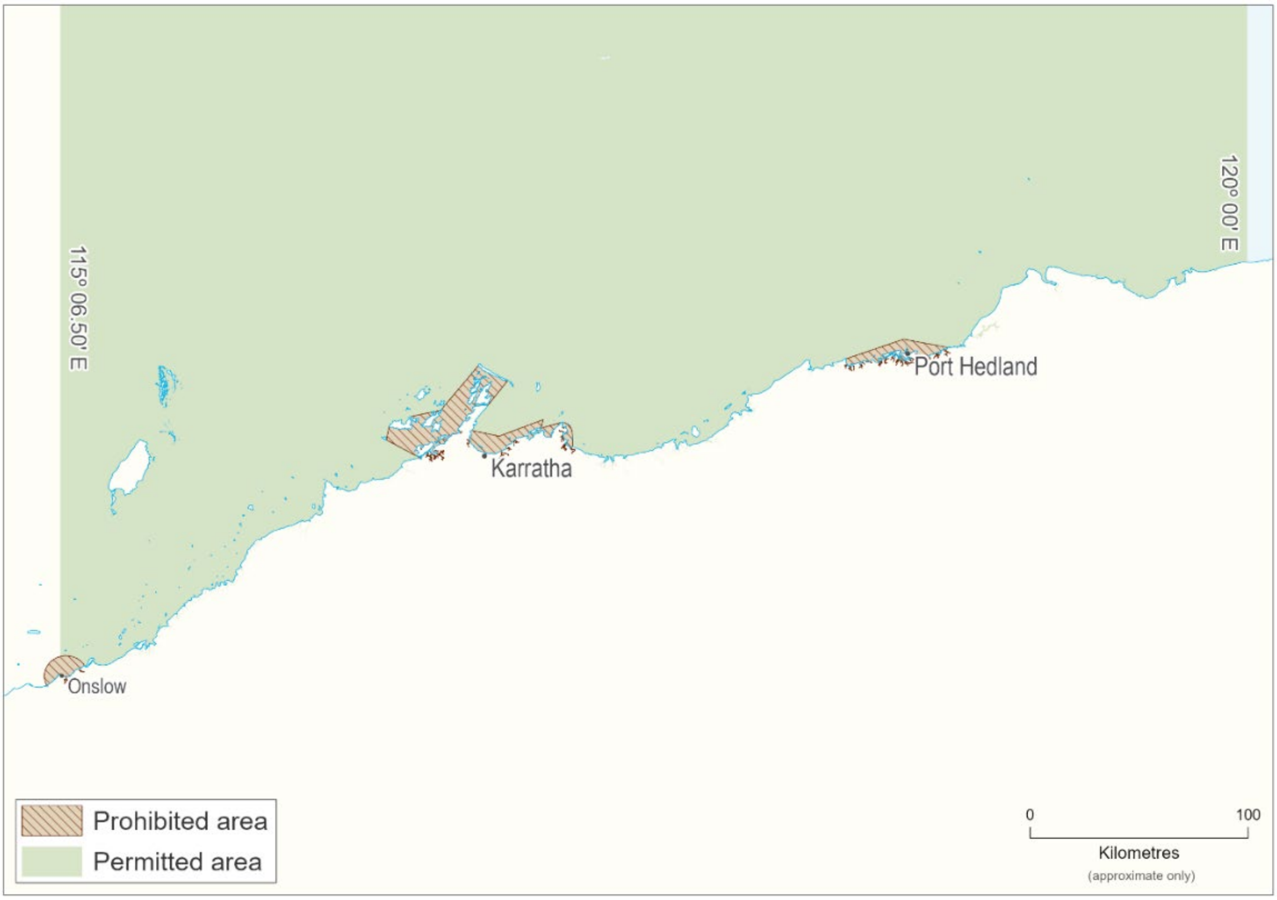
These Exemption holders use crab traps and drop nets in waters adjacent to their native title lands. There is also a small, but socially important, recreational fishery for mud crabs in the North Coast Bioregion where fishers use drop nets, wire hooks or scoop nets.

Management arrangements for commercial and recreational crab fisheries in the North Coast include minimum size limits and protection of breeding females, along with effort controls and spatial and temporal closures for the commercial fishery.

Further information regarding blue swimmer crab and mud crab biology and the North Coast crab fisheries can be sourced from Johnston et al. (2020; http://www.fish.wa.gov.au/Documents/research_reports/frr306.pdf).

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2020 Blue swimmer crab: 0.6 t Mud crab: 1.5 t	Acceptable Acceptable
Recreational fishery	Total Catch 2017/18 (boat-based only) Blue swimmer crab: 1–2 t Mud crab: 2–3 t	Acceptable Acceptable
EBFM		
Indicator species		
Pilbara Blue Swimmer Crab	Catch rate: Above threshold	Adequate
Kimberley Mud Crab	Catch rate: Above threshold	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Low Risk	Adequate
Ecosystem	Low Risk	Adequate
Economic (GVP <$1 m)	Low Risk	Acceptable
Social (high amenity)	Low Risk	Acceptable
Governance	Low Risk	Acceptable
External Drivers	Moderate Risk	Acceptable



NORTH COAST CRAB FIGURE 1.
Map showing the boundaries of the Pilbara Managed Crab Fishery.

NORTH COAST CRAB FIGURE 2.
Map showing the boundaries of the Kimberley Crab Managed Fishery.

CATCH AND LANDINGS

Commercial Sector

The total commercial catch of blue swimmer crabs and mud crabs in the North Coast Bioregion for 2020 was 2.1 t, a substantial decrease from the 29.5 t landed in 2019 and is the lowest landed catch in 20 years.

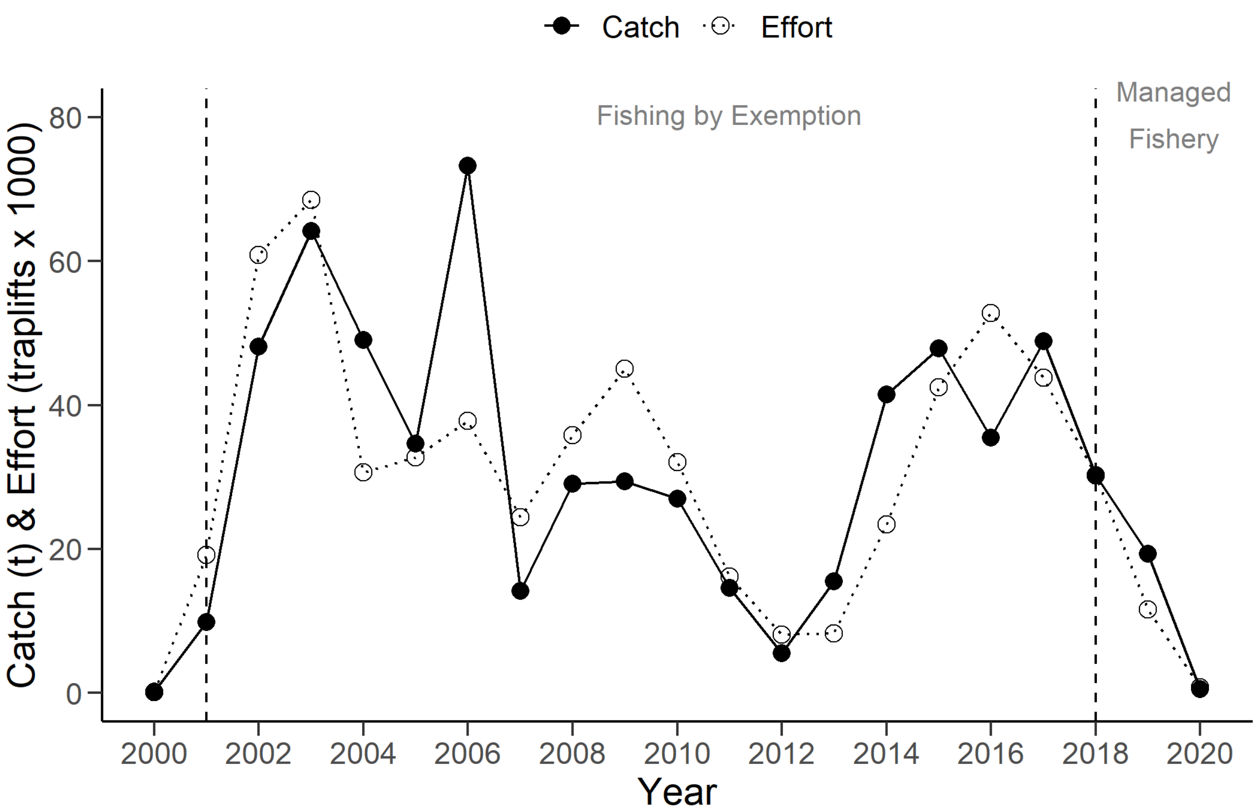
The 2020 North Coast blue swimmer crab catch of 0.6 t accounted for <0.1% of the State commercial catch of 713.5 t for that year, with all catch taken from the PCMF (North Coast Crab Figure 3).

The KCMF catch of 1.5 t (North Coast Crab Figure 4) represented the entire commercial mud crab catch reported in WA in 2020. The majority of this catch was recorded as green mud crab, with a small proportion recorded as brown mud crab.

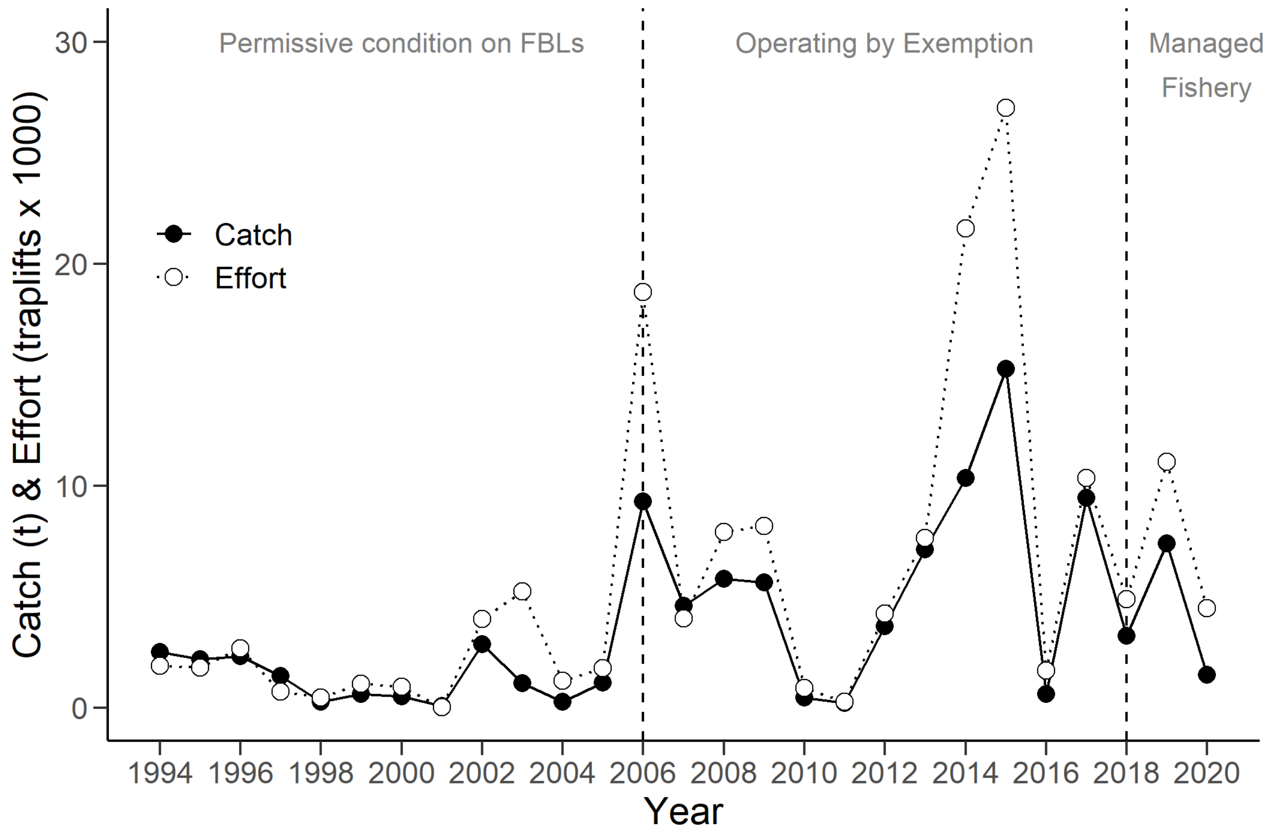
Recreational Sector

The estimated boat-based recreational catch of blue swimmer crab in the North Coast for 2017/18 represented approximately 3% of the statewide boat-based recreational catch (kept crabs by number) for that period. The catch was steady at 1.6 t (95% CI 1–2), compared with 1.7 t (95% CI 1–3) in 2015/16, 4 t (95% CI 2–6) in 2013/14 and 3 t (95% CI 2–5) in 2011/12 (Ryan *et al*. 2019).

The estimated boat-based recreational catch of mud crab in the North Coast represented 92% of the statewide boat-based recreational catch (kept by numbers) in 2017/18. The catch was steady at 2.5 t (95% CI 2–3) in 2017/18 compared with 2.5 t (95% CI 2–3) in 2015/16, but lower than the 6.5 t (95% CI 5–8) reported in 2013/14 and 7 t (95% CI 5–9) reported in 2011/12 (Ryan *et al*. 2019).



NORTH COAST CRAB FIGURE 3.
Annual commercial blue swimmer crab catch (tonnes) and fishing effort (traplifts × 1000) for the Pilbara Crab Managed Fishery between 2000 and 2020, including the developing (2001-18) and managed (since 2018) phases of the fishery. Prior to 2001, fishing occurred via permissive condition on Fishing Boat Licences.



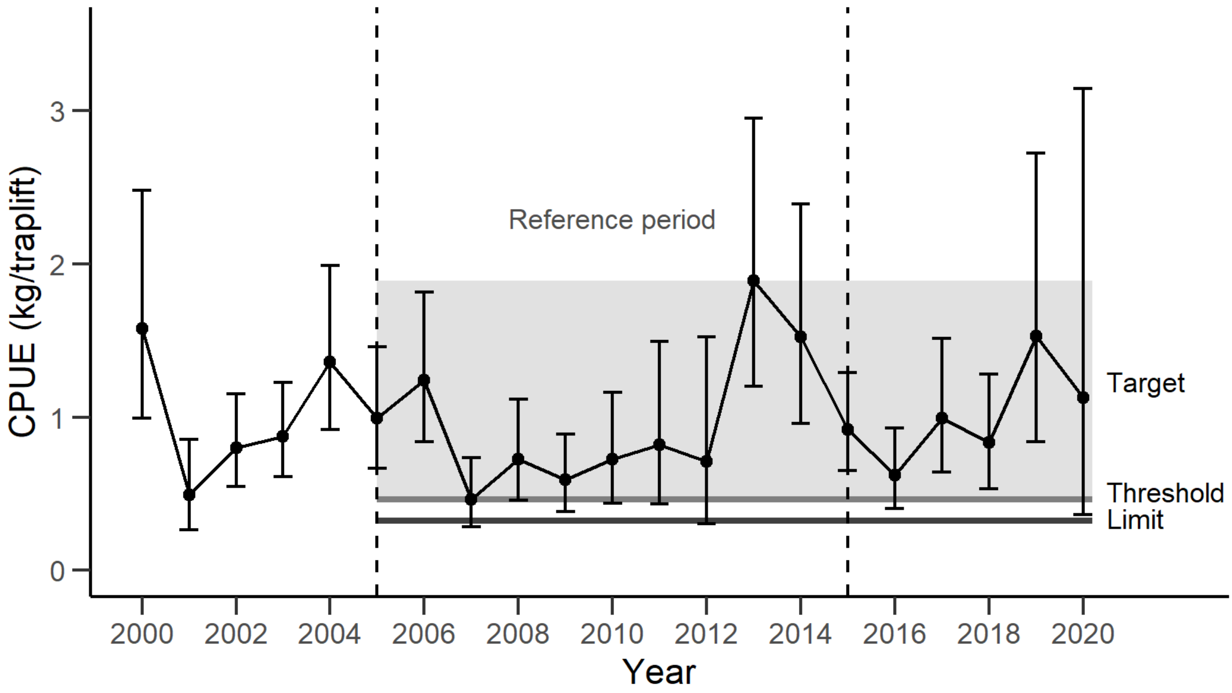
NORTH COAST CRAB FIGURE 4.
Historical annual commercial catch (tonnes) and fishing effort (traplifts × 1000) for trap fishers capturing mud crab in the Kimberley Crab Managed Fishery between 1994 and 2020, including the developing (2006–18) and managed (since 2018) phases of the fishery. Prior to 2006, fishing occurred via permissive condition on Fishing Boat Licences.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Blue Swimmer Crabs (Sustainable-Adequate)

The annual standardised catch rate from the PCMF provides an index of abundance that can be used to assess fishery performance. After significant increases in 2013 (1.9 kg/traplift), and 2014 (1.5 kg/traplift), the annual catch rate declined to 0.6–1.0 kg/traplift during 2015–18 (North Coast Crab Figure 5).

Standardised catch rates then increased to 1.5 kg/traplift in 2019, before declining slightly to 1.1 kg/traplift in 2020 (North Coast Figure 5). The 2020 catch rate is well above the preliminary (draft) harvest strategy threshold of 0.46 kg/traplift, indicating there should be adequate egg production under typical environmental conditions. As such the status of the blue swimmer crab stock is adequate and current management settings are maintaining the level of risk at acceptable (low) levels. Therefore, the blue swimmer crab stock in the PCMF is considered **sustainable-adequate**.



NORTH COAST CRAB FIGURE 5.
The primary performance indicator, annual standardised commercial catch rate (kg/traplift) of blue swimmer crabs, for the Pilbara Crab Managed Fishery between 2000 and 2020, relative to the associated reference points (target, threshold and limit) for a proposed harvest strategy. The reference period (2005-15) covers the years when the fishery was considered to be operating under relative stability following an initial exploratory period (2000-04).

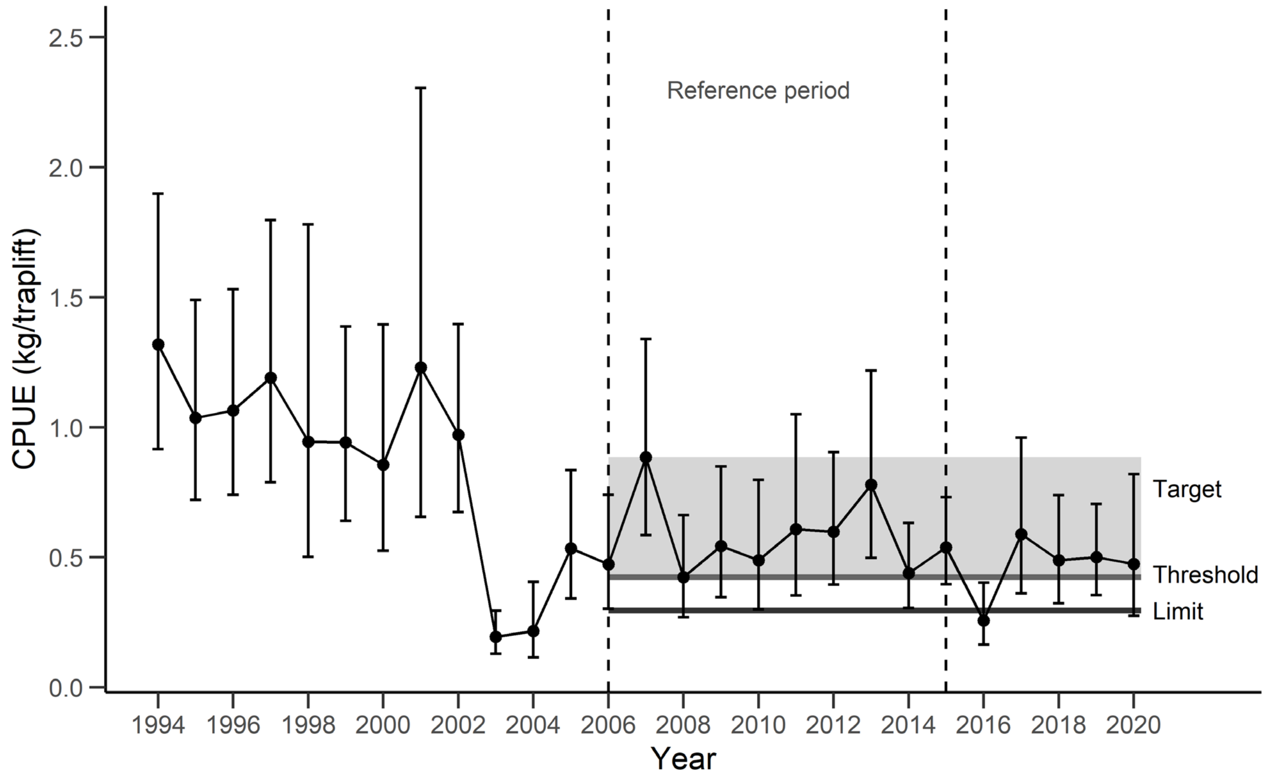
Mud Crab (Sustainable-Adequate)

Four species of mud crab (Scylla spp.) have been identified in the Indo-West Pacific region, of which the green mud crab (*Scylla serrata*) and brown mud crab (*Scylla olivacea*) occur in Western Australia (Keenan et al., 1998). The green mud crab is predominantly found in estuarine habitats in north-western Australia from the Northern Territory border to Shark Bay. The brown mud crab has a more restricted distribution limited to northern embayments, with most catches from King Sound, 200 km northwest of Broome.

The minimum legal size is 150 mm CW for green mud crab (*Scylla serrata*) and 120 mm CW for brown mud crab (*Scylla olivacea*). These are set well above the size at first maturity of 90–120 mm CW for green and 86–96 mm CW for brown mud crab in the North Coast Bioregion. Consequently, breeding stock levels are expected to be adequate to maintain stocks in all current fishing areas under normal environmental conditions.

The annual standardised catch rate from the KCMF provides an index of abundance that can be used to assess this fishery’s performance. Annual standardised catch rates fell below the limit of the harvest strategy during 2016 (0.3 kg/traplift), but increased and remained relatively constant at 0.5–0.6 kg/traplift from 2017 to 2019, within the harvest strategy target range (North Coast Crab Figure 6). In 2020 catch rates declined slightly to 0.47 kg/traplift, but remained above both the threshold and limit level of the harvest strategy (0.4 and 0.3 kg/traplift, respectively; North Coast Crab Figure 6). Minimal effort due to a lack of fishing in 2020 is most likely to be the cause of the drop in catch rate, rather than a decline in stock abundance. COVID impacts on fishing generally and a new entrant who fished in 2020 is likely to have caused this decline in catch rates. For this reason we believe sustainability is not at risk and management action is not required. Nevertheless, catch and effort in this fishery will be closely monitored in 2021.

In addition, the relatively small catch by commercial and recreational fishers, the wide distribution of the species throughout the region, and the minimum legal size being set well above the size at first maturity, indicate that the status of the mud crab stock is adequate and that current management settings are maintaining the level of risk at acceptable (low) levels. The mud crab stock is considered **sustainable-adequate**.



NORTH COAST CRAB FIGURE 6.
The primary performance indicator, annual standardised commercial catch rate (kg/traplift), for the Kimberley Crab Managed Fishery since 1994 (when permissive conditions of fishing boat licenses were issued), relative to the associated reference points (target, threshold and limit) for a proposed harvest strategy. The reference period spans 2006–15 when the fishery was considered to have operated under relative stability following initial exploratory fishing (2000–05).

BYCATCH and PROTECTED SPECIES INTERACTIONS

Blue Swimmer Crab

Bycatch

The shift from using set nets to traps in most blue swimmer crab commercial fisheries has resulted in a substantial reduction in bycatch from dedicated crab fishing. Pots are purpose-designed to minimise the capture of non-target species and are therefore an inefficient way to capture fish, the majority of which are able to escape through the entrance gaps when the pot is soaking or being hauled. Small numbers of fish are infrequently captured in crab pots, but the fishers are not permitted to retain them. The low number of fish caught and returned by crab fishers is considered to pose a **low** risk to these stocks.

Discarded bycatch from trawl fisheries taking crabs as a by-product is dealt with in the status reports that are specific to each trawl fishery.

Protected Species

The crab trap longline system used in the targeted crab fisheries has little possibility of interacting with listed species. The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities and is considered a **negligible** risk.

Mud Crab

Bycatch

Commercial mud crab traps are purpose built to effectively target larger (legal-sized) mud crabs. The overall trap design and mesh size allows sub-legal mud crabs and non-targeted bycatch species the opportunity to escape the trap, preventing them from being retained, therefore posing a **negligible** risk to bycatch species. The gear is required to be pulled (hauled) regularly, and undersized and berried crabs must be returned to the water.

Protected Species

As commercial mud crab traps are purpose built to target mud crab species and are set for relatively short periods of time, the possibility of causing harm to listed species is minimal and is considered a **negligible** risk.

HABITAT and ECOSYSTEM INTERACTIONS

Habitat

Blue Swimmer Crab

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

Mud Crab

Trap fishing in the shallow waters of associated mangrove tidal creeks and near shore embayments results in limited habitat disturbance. The large mesh size prevents the capture of benthic organisms and only minor dragging of traps on the sea floor occurrs during trap retrieval. The sheltered shallow mangrove environment is protected from wind and waves where the majority of traps are deployed, resulting in minimal habitat damage, posing a **low** risk to benthic habitat.

Ecosystem

As the commercial take of blue swimmer and mud crabs represents a relatively small portion of the biomass, which is effectively renewed annually and subject to high levels of natural variation in abundance, secondary food chain effects are likely to be minimal in these fisheries and are a **low** risk to the ecosystem.

SOCIAL AND ECONOMIC OUTCOMES

Social

Blue Swimmer Crab

North Coast blue swimmer crab fisheries provide a high social amenity to recreational fishing and diving and to consumers via commercial crab supply to markets and restaurants. It is classified as a low risk. During 2020, two people were employed as skippers and crew on vessels fishing for blue swimmer crabs along the Pilbara coast, although minimal fishing effort occured. Additional employment for several workers has been created in Point Samson through the development of post-harvest processing of the crab catch.

Mud Crab

The North Coast mud crab fishery provides a high social amenity to recreational fishing and to consumers via commercial mud crab supply to markets and restaurants. It is classified as a low risk. Commercial fishers travel vast distances due to the remoteness of their operations and stay at sea for several weeks before returning to unload the catch. In this scenario crabs are frozen and generally sold to local and interstate markets, although live product may also be sold at premium prices. During 2020, six people were employed as skippers and crew on vessels fishing for mud crab in the KCMF, with effort occuring between April and September.

Economic

The estimated gross value of product (GVP) for the crab fishery within the North Coast Bioregion for 2020 was approximately $68 k (**Level 1** <$1million). The value for blue swimmer crabs was approximately $5 k and mud crabs was approximately $63 k.

Blue Swimmer Crabs: The average beach price for trap-caught blue swimmer crabs across all Western Australian fisheries for the 2019/20 financial year was around $8.40 /kg. Price data was generated by collecting monthly returns recording prices paid to fishers by fish processors. A weighted average price is then calculated for the financial year from the monthly data. The crab catch from the Pilbara region was sold through local and interstate markets.

Mud Crabs: The average beach price for green and brown mud crabs (uncooked) in the Kimberley during the 2019/20 financial year was approximatley $45 and $30/kg, respectivley. However, prices do fluctuate seasonally depending on product availability,Queensland, Northern Territory fisheries production and demand from the Sydney and Melbourne fish markets. Aboriginal corporations may also trade and barter product adding value to the local communities that cannot be estimated.

GOVERNANCE SYSTEM

Harvest Strategy

The breeding stock of crab fisheries are protected by effort controls, legal minimum sizes well above the size at maturity, and spatial and temporal closures.

Blue Swimmer Crab

A preliminary harvest strategy has been determined for the PCMF where the primary performance indicator is the standardised annual commercial catch rate, specifically within the Nickol Bay area as the majority of fishing historically occurred in this area. The reference period spans 2005 to 2015, defined by the period

when the developing fishery status commenced following a period (2001–04) of exploratory fishing.

As the primary performance indicator was above the threshold in 2020, no changes to the management of the fishery were introduced for the 2021 season.

Mud Crab

A preliminary harvest strategy has been determined for the KCMF where the primary performance indicator is the standardised annual commercial catch rate. The reference period spans 2006-15 when the fishery was considered to have operated under relative stability following initial exploratory fishing (2000–05).

No changes to the management of the fishery were introduced for the 2021 season. However, given that the harvest strategy indicator (catch rate) fell below reference levels, the performance of the fishery will be closely monitored during 2021 to determine if aditional management action is required (see explanation in stock status section above).

Annual Catch Tolerance Levels

Pilbara BSC:	20–73 t
Kimberley Mud Crab:	5–30 t

Blue Swimmer Crab

Annual catch tolerance levels have recently been developed for the PCMF (see DPIRD, 2020) based on historical catch information relative to estimates of MSY derived from a preliminary production model to indicate the reference period in which the fishery has been operating sustainably (2005–2015).

Although the 2020 catch for the PCMF of 0.6 t was considerably below the lower Catch Tolerance level (20 t), this can be attributed to substantially reduced fishing effort. Due to the COVID-19 pandemic and associated changes in market demands, fishing only occurred for one month of the year. Consequently, changes to management were considered unnecessary for the 2021 season.

Mud Crab

The current catch tolerance ranges used to assess annual fishery performance in the KCMF are based on the current stock status, and control rules have been calculated from the fishery's maximum and minimum catches between 2006 and 2015 including an additional 10% (of minimum catch) to generate the tolerance range. If the status of the resource changes such that the control rules trigger additional management adjustments, the tolerance range for this fishery will be adjusted accordingly.

The 2020 mud crab catch for the KCMF (1.5 t) was substantially below the lower Catch Tolerance level (5 t). However, the COVID-19 pandemic substantially reduced demand during the peak mud crab season and effort was reduced. There were also difficulties with retaining crew at this time. Therfore, no further management action was considered necessary for the 2021 season.

Compliance

Current risks to enforcement are low for North Coast Bioregion crab fisheries.

Consultation

The Department undertakes consultation directly with licensees on operational issues and processes. Industry Management Meetings are convened by the Western Australian Fishing Industry Council (WAFIC), who are also responsible for statutory management plan consultation under a Service Level Agreement with the Fisheries.

Consultation processes relating to recreational fishing are now facilitated by Recfishwest under a Service Level Agreement although the Department undertakes direct consultation with the community on specific issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

A harvest strategy for the Portunidae crab resource (blue swimmer crab and mud crab) in the North Coast and Gascoyne bioregions of Western Australia is currently being developed. Consultation with key stakeholders and the community is planned for 2021/22.

EXTERNAL DRIVERS

Levels of recruitment to many crab fisheries fluctuate considerably. These are considered most likely due to environmental influences (e.g. water temperature) both on spawning success and larval survival through to recruitment. The relationship between environmental factors, recruitment and catch is being evaluated as further data become available. Climate change implications associated with these environmental variables are also under consideration. Blue swimmer crabs were rated a **high** risk to climate change due to their sensitivity to water temperature changes.

REFERENCES

Department of Primary Industries and Regional Development — DPIRD 2020. Portunidae crab resource of the Pilbara-Kimberley region. Harvest Strategy 2020–2025. Fisheries Management Paper No. XXX. Department of Primary Industries and Regional Development, Western Australia. In Press.

Johnston, D., Yeoh, D., Harris, D. and Fisher, E. 2020. Blue Swimmer Crab (*Portunus armatus*) and Mud Crab (*Scylla serrata and Scylla olivacea*) Resources in the North Coast and Gascoyne Coast Bioregions, Western Australia. Fisheries Research Report No. 306. Department of Primary Industries and Regional Development, Western Australia. 156pp.

Keenan, CP, Davie, PJF and Mann, DL. 1998. A revision of the genus *Scylla* de Hann, 1833 (Crustacea: Decapoda: Brachyura: Portunidae). Raffles Bulletin of Zoology. 46 (1): 217-245pp.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS. 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia.

SOUTH COAST BIOREGION

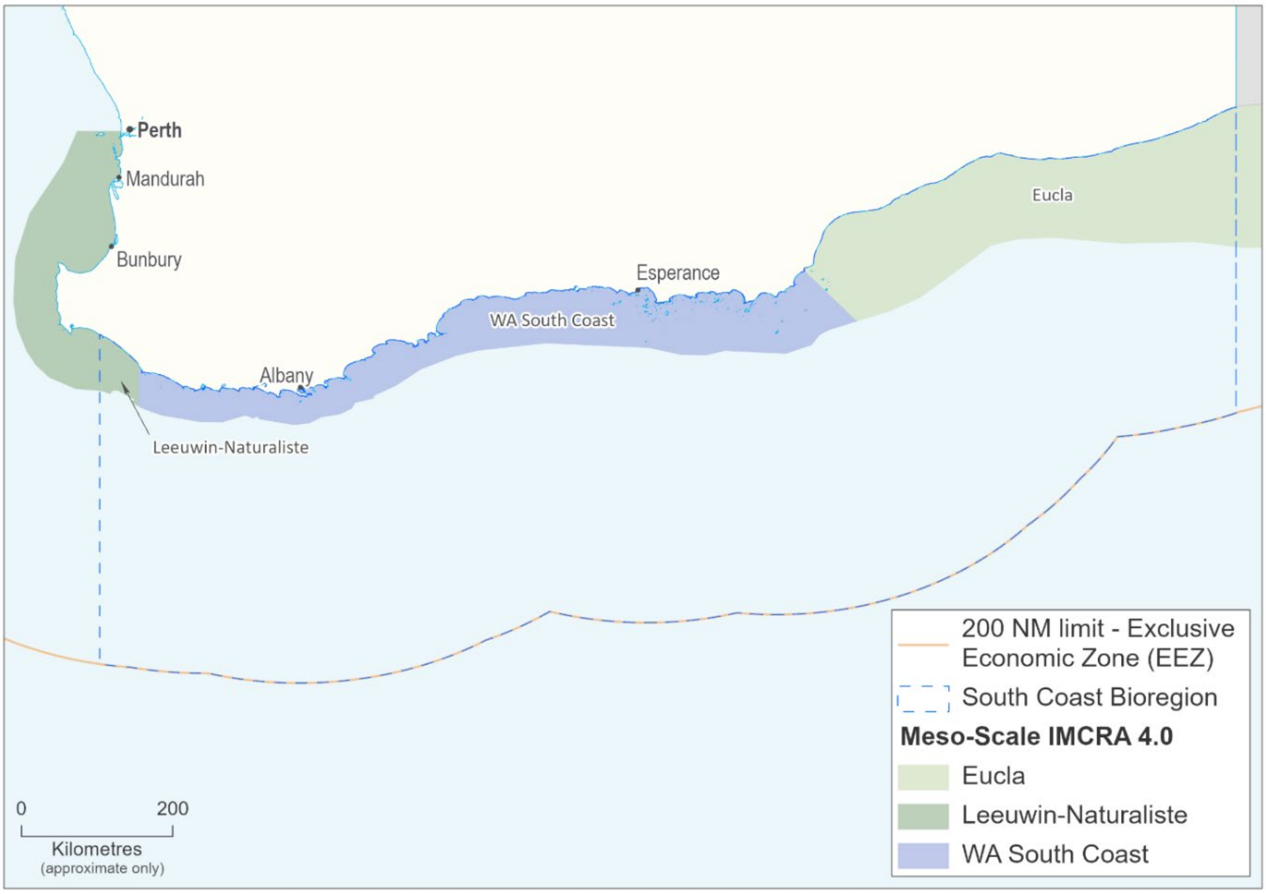
ABOUT THE BIOREGION

The continental shelf waters of the South Coast Bioregion (South Coast Overview Figure 1) are generally temperate but low in nutrients, due to the seasonal winter presence of the tail of the tropical Leeuwin Current and limited terrestrial run-off. Sea surface temperatures typically range from approximately 15°C to 21°C, which is warmer than would normally be expected in these latitudes due to the influence of the Leeuwin Current. The effect of the Leeuwin Current, particularly west of Albany, limits winter minimum temperatures (away from terrestrial effects along the beaches) to approximately 16°C to 17°C.

Fish stocks in this region are predominantly temperate, with many species' distributions extending right across southern Australia. Tropical species are occasionally found, which are thought to be brought into the area as larvae and they are unlikely to form local breeding populations.

The South Coast is a high-energy environment, heavily influenced by large swells generated in the Southern Ocean. The coastline from Cape Leeuwin to Israelite Bay is characterised by white sand beaches separated by high granite headlands. East of Israelite Bay there are long sandy beaches backed by large sand dunes, an extensive length (160 km) of high limestone cliffs and mixed arid coastline to the South Australian border. There are few large areas of protected water along the South Coast, the exceptions being around Albany and in the Recherche Archipelago off Esperance.

Along the western section of the coastline that receives significant winter rainfall, there are numerous estuaries fed by winter-flowing rivers. Several of these, such as Walpole/Nornalup Inlet and Oyster Harbour, are permanently open, but other estuaries are closed by sandbars and open seasonally after heavy winter rains. The number of rivers and estuaries decreases to the east as the coastline becomes more arid. While these estuaries, influenced by terrestrial run-off, have higher nutrient levels (and some, such as Oyster Harbour and Wilson Inlet, are experiencing eutrophication), their outflow to the ocean does not significantly influence the low nutrient status of coastal waters.



SOUTH COAST OVERVIEW FIGURE 1
Map showing the South Coast Bioregion and IMCRA (V 4.0) meso-scale regions: Leeuwin-Naturaliste, South Coast and Eucla.

The marine habitats of the South Coast are similar to the coastline, having fine, clear sand sea floors interspersed with occasional granite outcrops and limestone shoreline platforms and sub-surface reefs.

A mixture of seagrass and kelp habitats occurs along the South Coast, with seagrass more abundant in protected waters and some of the more marine estuaries. The kelp habitats are diverse but dominated by the relatively small *Ecklonia radiata*, rather than the larger kelps expected in these latitudes where waters are typically colder and have higher nutrient levels.

The ecosystem boundaries as defined by IMCRA (V 4.0) in the bioregion are depicted in South Coast Overview Figure 1. The potential threats and risks to these ecosystems are often similar. For simplicity, risk ratings were allocated by grouping the ecosystems into two broad groups, estuarine or marine. However, if a particular ecosystem is unique and/or is exposed to different or significant threats, risk was allocated to these ecosystems separately.

SUMMARY OF ACTIVITIES POTENTIALLY IMPACTING THE BIOREGION

Climate Change

Some of the key environmental trends that may be affecting ecosystems in WA include:

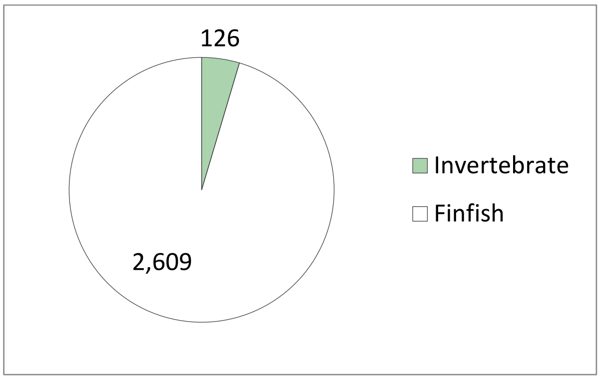
- Increasing frequency of *El Niño*/Southern Oscillation (ENSO) events;
- More years with a weaker Leeuwin Current;
- Increases in water temperature off the west coast of WA, particularly the lower west coast;
- Increase in salinity, which includes some large annual fluctuations;
- Change in the frequency and location of storms (and rainfall) affecting the lower west coast; and
- Change in the frequency of cyclones (and summer rainfall) affecting the north-west coast which can influence rainfall along the south coast.

The South Coast Bioregion is predicted to be at enhanced risk from the effects of climate given that it spans a transitional zone between tropical and temperate regions. The variables expected to drive climate change impacts include changes in water temperature, ocean currents, winds, rainfall, sea level, ocean chemistry and extreme weather conditions.

It is apparent that climate change will impact the biological, economic, and social aspects of many fisheries, and both positive and negative impacts are expected. Climate change can influence biological systems by modifying the timing of spawning, range and distribution of species, composition and interactions within communities, exotic species invasions and impacts, and the structure and dynamics of communities, including changes in productivity. Species distribution shifts are the most commonly reported changes and are often the easiest to recognise and measure. Changes in the distribution of key species are monitored in a national citizen-science program (www.redmap.org.au) in which the Department is a collaborator.

Commercial Fishing

The major commercial fisheries of the South Coast Bioregion are the abalone fishery (which achieved Marine Stewardship Council certification in 2017), a trap fishery targeting southern rock lobsters and deep-water crabs, the purse seine fishery targeting pilchards and other small pelagics, and the demersal gillnet fishery for sharks and scalefishes. Other smaller commercial fisheries include the long-standing beach seine fishery for Western Australian salmon, and the intermittent scallop trawl fishery. There are also commercial net fisheries for finfish operating in a number of South Coast estuaries and beaches. Commercial fishers also target demersal scalefish offshore with droplines and handlines. South Coast commercial fishing vessel operators often hold a number of licences to create a viable year-round fishing operation.

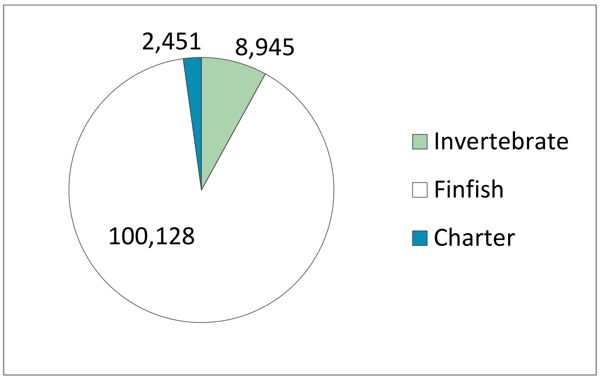


SOUTH COAST OVERVIEW FIGURE 2
Contribution of finfish and invertebrates to the total commercial wild fishery catch originating from the South Coast Bioregion. Numbers represent total catch (in tonnes) based on all major assessed fisheries identified in the Overview section of this report (South Coast Overview Table 1).

Recreational Fishing

As much of the South Coast is remote or difficult to access, recreational beach and boat fishing tends to be concentrated around major population

and holiday centres. The major target species for beach and rock anglers are West Australian salmon, Australian herring, whiting and trevally, while boat anglers target snapper, queen snapper, Bight redfish and King George whiting. The third major component of the recreational fishery is the dinghy and shoreline fishing in estuaries and rivers, focused in the western half of the bioregion where the main angling targets are black bream and whiting (including King George whiting). Recreational netting, primarily targeting mullet, also occurs in these estuaries.



SOUTH COAST OVERVIEW FIGURE 3
Recreational catches (by number) in the South Coast Bioregion. Finfish and invertebrate catches were as assessed in the statewide survey of boat-based recreational fishing in 2017/18[1]. Charter boat catch is for the same period. Estimates of shore based recreational catch are unavailable.

Aquaculture

The predominant aquaculture activity undertaken on the south coast is the production of mussels and oysters from Oyster Harbour and Mistaken Island in King George Sound at Albany. This activity is restricted to these areas, where there are sufficient nutrient levels related to terrestrial run-off to provide the planktonic food necessary to promote growth of filter-feeding bivalves. This is supported by a government supported shellfish hatchery in Albany. Other private hatcheries exist, including for abalone.

Other forms of aquaculture (e.g. sea cage farming) are restricted on the South Coast by the high-energy environment and the very limited availability of protected deep waters typically required by this sector. Most recent development activity in the invertebrate sector has focused on land-based ‘raceway’ culture of abalone, using pumped sea water. The Albany Aquaculture Development Zone – Oyster Harbour Area was declared in August 2020, and it is the first marine shellfish aquaculture development zone established in Western Australia. When fully declared, the Albany Aquaculture Development Zone will likely encompass four separate areas. In addition, offshore abalone farms near Augusta and Esperance are growing out abalone using purpose-built concrete structures located on the sea bed (See Aquaculture Regional Research and Development Overview section in this chapter).

Tourism

Tourism is a regionally-important industry across the South Coast Bioregion, with much of the industry spread across rural areas and away from the major population centres of Albany and Esperance. Tourist infrastructure and development are generally small-scale and focussed on natural and wilderness experiences, thus tourism activities have a relatively low environmental impact, particularly in relation to the extensive length of coastline, which is only accessible via a limited number of four-wheel drive tracks. A significant portion of the bioregion’s coastline is encompassed by national parks and nature reserves, particularly to the east of Bremer Bay. Whale watching, including expeditions to the largest known group of killer whales in the Southern Hemisphere at the head of the Bremer Canyon, and other marine wildlife experiences are also popular tourist activities.

Shipping and Maritime Activity

Significant volumes of bulk commodities such as iron ore, grain, other agricultural products and wood chips are exported from commercial port facilities in Albany and Esperance. Cruise vessels also visit the Ports of Albany and Esperance, providing significant economic input into the local community and surrounding regions during their visits. In addition, many international shipping routes to and from eastern Australia, traverse the South Coast Bioregion, often without coming to port in WA. Seismic surveys have been undertaken in the east of the bioregion to inform prospective oil and gas exploration in the western Great Australian Bight. However, exploratory drilling has yet to occur in this area.

Given that the impacts from vessels and ships tend to be concentrated around ports and favoured anchorage areas, the Department has surveillance in place for marine pests in key port areas to aid in the early detection of any unwanted aqautic species from other locations.

1 Ryan KL, Hall NG, Lai EK, Smallwood CB, Taylor SM, Wise BS 2017. Statewide survey of boatbased recreational fishing in Western Australia 2015/16. Fisheries Research Report No. 287, Department of Primary Industries and Regional Development, Western Australia. 205pp.

BIOREGIONAL SPECIFIC ECOSYSTEM MANAGEMENT

Within each Bioregion there are a range of management measures that have been implemented to manage the potential impact of activities (See Chapter 3 for an overview). Management measures specific to the South Coast Bioregion include:

Spatial Closures

Extensive fisheries closures in coastal and offshore waters have been introduced to manage trawling by Australian vessels (South Coast Overview Figure 4). Trawling is currently only permitted in 1% of shelf waters (South Coast Ecosystem Management Table 1).

The inshore marine habitats of the South Coast are relatively unaffected by human activities due to their remoteness, low population density across the bioregion and the extent of coastal management (national parks, nature reserves, etc.). While there are few permanent closures to demersal fishing methods in this region, the geographic footprint of demersal fishing activities is very small with about 98% of the region not affected by these methods.

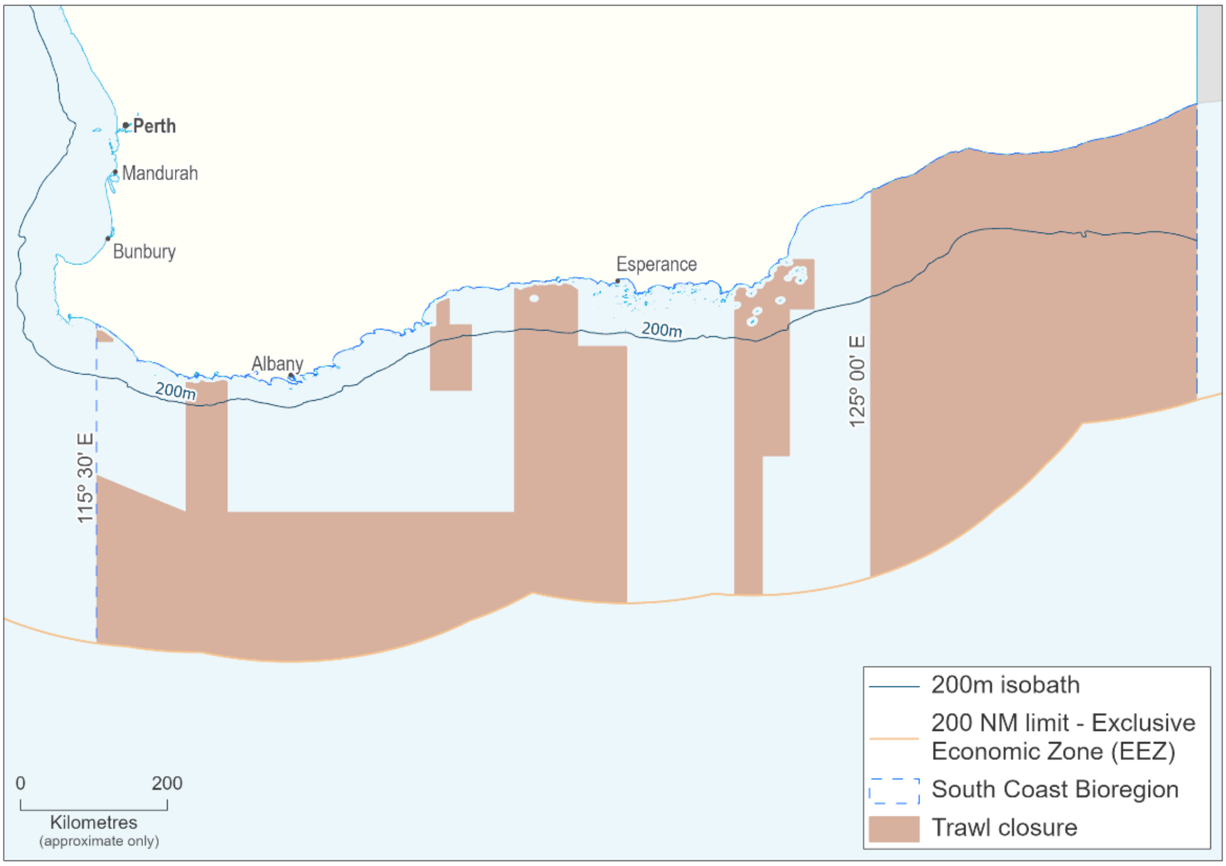
The Walpole–Nornalup Marine Park was declared on the 8th May 2009 and is the first marine protected area on the South Coast. The Department currently undertakes research and monitoring within the Walpole-Nornalup Marine Park, based on the Department's identified risks in conjunction with the Marine Park Management Plan priorities set by the Department of Biosecurity, Conservation and Attractions (DBCA). This work includes the support and supervision of studies on the finfish community to assess current trends, movement ecology and development of a long term monitoring program for the finfish community within the marine park. Additional access restrictions in the bioregion include closures under s.43 of the Fish Resources Management Act 1994 surrounding the wreck of the 'Perth' (Albany), wreck of the 'Sanko Harvest' (east of Esperance) and Esperance Jetty.

The Commonwealth Government's Marine Bioregional Planning process for the South-West marine region (between Kangaroo Island, South Australia and Shark Bay) was implemented in July 2018. This has resulted in a number of Marine Protected Areas off the South Coast of WA (South Coast Overview Figure 5).

SOUTH COAST ECOSYSTEM MANAGEMENT TABLE 1

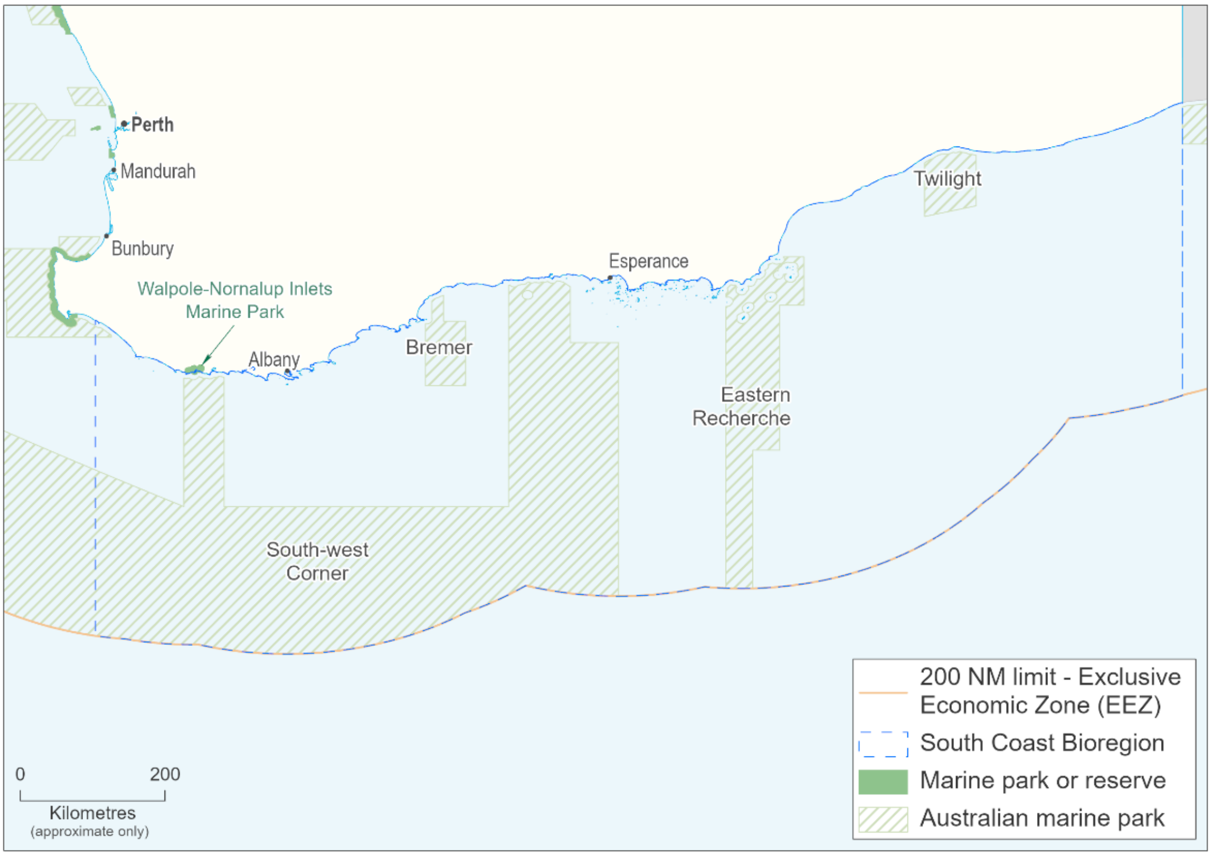
The areas and proportions of the South Coast Bioregion making up State Waters and all continental shelf waters, out to 200 m depth, which meet the IUCN criteria for classification as marine protected areas. This table does not yet include the closures that may be implemented by the Commonwealth as part of their marine planning zones.

IUCN category or equivalent	State Waters only ($17,116\ km^2$)				All Waters ($534,016\ km^2$ (including State Waters))			
	Fisheries		Existing MPA		Fisheries		Existing MPA	
	km^2	%	km^2	%	km^2	%	km^2	%
I	0	0	0	0	0	0	0	0
II	1	< 1	0	0	1	< 1	0	0
III	0	0	0	0	0	0	0	0
IV	2,400	14	15	< 1	2,400	< 1	15	< 1
V	0	0	0	0	0	0	0	0
VI	14,700	86	0	0	531,600	99	0	0



SOUTH COAST OVERVIEW FIGURE 4

Map showing the South Coast Bioregion and areas closed to trawling. The areas permanently closed to trawling are consistent with IUCN marine protected area category IV.

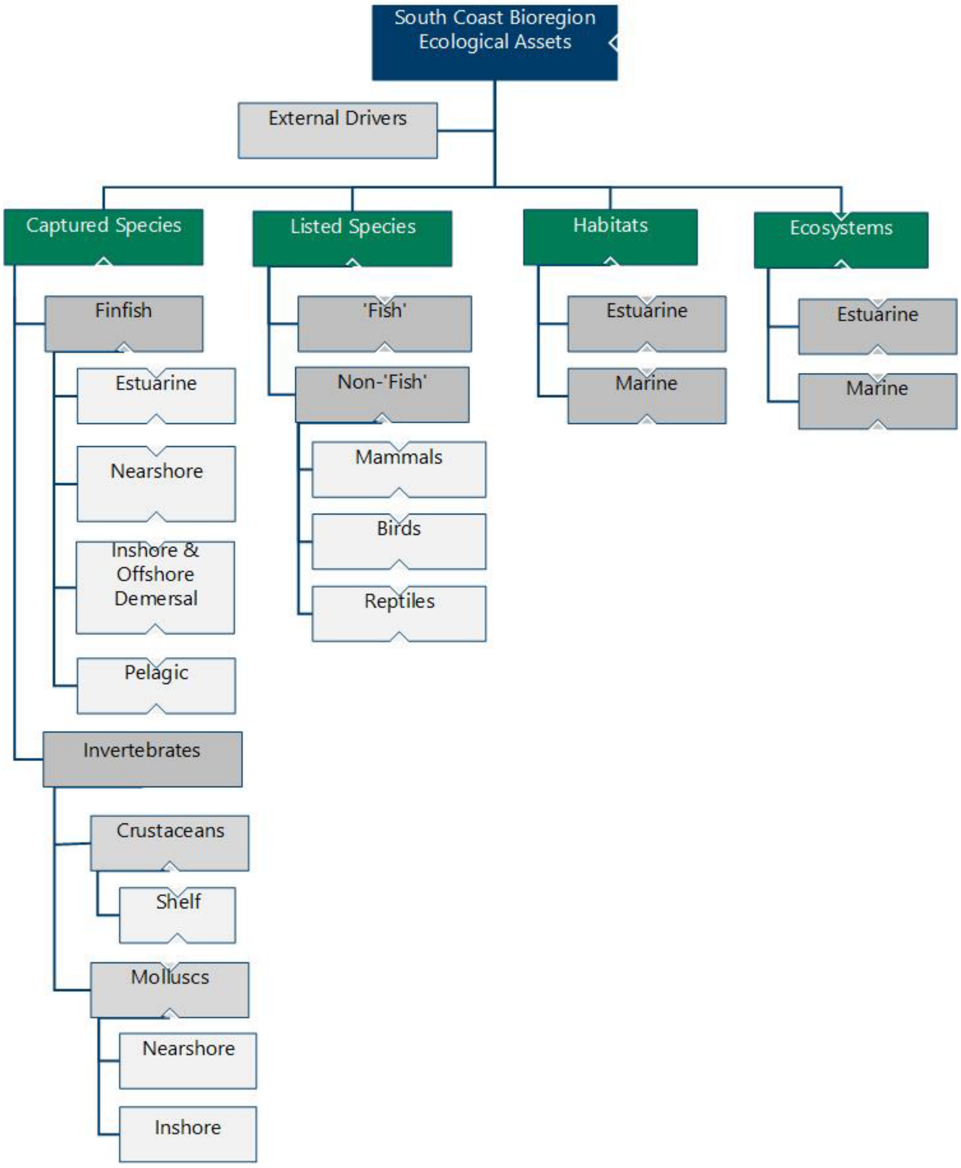


SOUTH COAST OVERVIEW FIGURE 5

Map showing the South Coast Bioregion and current and proposed State and Commonwealth marine parks and reserves along the southern WA coast.

ECOSYSTEM MONITORING AND STATUS

In order to assess the adequacy of management arrangements aimed at ensuring sustainability of the ecological assets within the South Coast Bioregion, the Department must identify and monitor trends in the condition of these resources. This is achieved through application of an Ecosystem Based Fisheries Management (EBFM) framework (Fletcher *et al*., 2010) to identify, in a hierarchical manner, the key ecological resources that require ongoing monitoring and assessment (See How to Use section for more details). These key ecological assets identified for the South Coast Bioregion are identified in South Coast Overview Figure 6 and their current risk status reported on in the following sections.



SOUTH COAST ECOSYSTEM MANAGEMENT FIGURE 6
Component tree showing the ecological assets identified and separately assessed for the South Coast Bioregion.

External Drivers

External factors that potentially impact marine and estuarine ecosystems at the bioregional-level may not fall within the direct control of Fishery legislation (e.g. climate change). An understanding of these factors, which are typically environmental (storms, ocean currents, rainfall, etc.) is necessary to properly assess the risks to ecological resources. The main external drivers identified with potential to affect the South Coast Bioregion include climate change and introduced pests and diseases[1].

1 Biosecurity issues are now reported by the Biosecurity pillar of the Department of Primary Industries and Regional Development.

Climate

External Drivers	Current Risk Status
Climate	LOW

While the current risk is Low, the south west of Western Australia is predicted to be heavily influenced by the impacts of climate change (e.g. increasing sea temperatures, declines in rainfall). Further information is required to examine potential impacts on this bioregion.

Captured Species

FINFISH

Estuarine

Captured Species	Aquatic zone	Ecological Risk
Finfish	Estuarine	HIGH

There is concern for some estuarine fish stocks such as cobbler mainly due to external (non-fishing) factors such as changing rainfall and associated environmental factors.

Nearshore (0-20 m depth)

Captured Species	Aquatic zone	Ecological Risk
Finfish	Nearshore	MODERATE

Catches of many nearshore indicator species (e.g. Australian salmon) have been declining since the mid-late 1990s mainly as a result of reduced market demand.

Inshore and Offshore Demersal

Captured Species	Aquatic zone	Ecological Risk
Finfish	Demersal	MODERATE

Norriss et al. (2016[1]) assessed the risks to inshore demersal indicator species as low (western blue groper) to moderate (bight redfish, snapper and blue morwong). Targeted fishing effort in deeper offshore areas is low and intermittent.

Pelagic

Captured Species	Aquatic zone	Ecological Risk
Finfish	Pelagic	NEGLIGIBLE

While the spawning biomass of sardines has returned to appropriate levels, their catches and those of other pelagic fish do not appear to have returned to pre-virus levels.

INVERTEBRATES

Crustaceans

Captured species	Aquatic zone	Ecological Risk
Crustaceans	Shelf	HIGH

There are concerns for lobsters and deep sea crabs, due to declining catch rates. A transition to quota management will assist in addressing the ecological risks for these crustaceans.

Molluscs

Captured species	Aquatic zone	Ecological Risk
Molluscs (Abalone)	Nearshore	HIGH
Molluscs (Scallops)	Inshore	NEGLIGIBLE

Management action has been taken to address concerns for stocks of abalone in some areas. The abundance of scallops varies inter-annually due to recruitment fluctuations and fishing only occurs when stocks are sufficiently robust.

Listed species

A variety of endangered, threatened and protected[2] (ETP) species can be found within the South Coast Bioregion, including cetaceans, pinnipeds, elasmobranchs, seahorses and pipefish and sea/shore birds. These species are protected by various international agreements and national and state legislation. Primary pieces of legislation include the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999, the *Western Australian Wildlife Conservation Act* 1950, and the *Fish Resources Management Act* 1994.

Fish

Listed species	Risk
Fish	NEGLIGABLE

There are few risks to the listed fish species in this region. This includes the white shark (*Carcharodon carcharias*), which is protected under State and Commonwealth legislation throughout this and all bioregions.

Non-Fish

Listed species	Risk
Mammals	MODERATE
Birds and Reptiles	MODERATE

1 J.V. Norriss, E.A. Fisher, S.A. Hesp, G. Jackson, P.G. Coulson, T. Leary and A.W. Thomson. 2016. Status of inshore demersal scalefish stocks on the South Coast of Western Australia. Fisheries Research Report No. 276, Department of Fisheries, Western Australia. 116 pp.

2 Note that being on the listed species list does not automatically indicate that a species is either threatened or endangered.

Although captures of Australian sea lions are rare and significantly fewer than they were historically due to substantial reductions in levels of demersal gillnet fishing effort, small numbers have intermittently been reported from demersal and nearshore/estuarine gillnets (see Appendix 2). In addition, concerns about potential captures of juvenile sea lions in South Coast Crustacean Managed Fishery pots have led to the requirements for Sea Lion Excluder Devices to be fitted to pots when they are fished in proximity to breeding colonies.

Reported captures of shearwaters in purse seine operations have declined in recent years (Appendix 2) following mitigation measures implemented through a code of conduct. These measures, which apply during a "special mitigation period" (March and April) when entanglement rates historically peaked, include a dawn closure, measures to prevent slack and folds occurring in nets, communication and avoidance protocols and gear modification trials. Further monitoring was undertaken using observers in 2017 and 2018.

Habitats and Ecosystems

The South Coast Bioregion, extends from Black Point (east of Augusta) to Israelite Bay (east of Esperance) (South Coast Overview Figure 1).

South Coast Bioregional ecosystems are generally temperate, although the tropical Leeuwin Current maintains temperatures above those normally expected at such latitudes, especially under *La Niña* conditions. Tropical species can therefore occur across much of the bioregion, although they are unlikely to form breeding populations. Due to the influence of the Leeuwin Current and limited freshwater discharge, South Coast Bioregion ecosystems are relatively oligotrophic, although localised upwelling along the outer edge of the continental shelf may be locally-important sources of productivity, e.g. the head of the Bremer Canyon is a recognised biodiversity hotspot in the region.

The key habitats occurring in depths of less than 40 m (where the vast majority of relevant fisheries resources are located and fishing activities are undertaken in this bioregion) include:

Rocky shores: The most conspicuous of the marine habitats in the South Coast Bioregion are the rocky shores. The south coast is exposed to the most extreme wave energy of the entire Australian coastline, due to the narrow continental shelf and lack of protection from offshore reefs and islands. Along this coast, granitic and gneissic slopes exposed to heavy wave action are usually smooth and populated with moderate to large numbers of gastropod molluscs, barnacles and macrophytes showing distinct vertical zonation.

Algae: Macroalgae along the southwestern and southern coasts of Australia are highly diverse, with an estimated 62% of macroalgal species endemic to the south coast. Algal assemblages are important as a food source, nursery grounds and shelter for a variety of organisms. Macroalgae also contribute to marine nutrient and carbon cycling in the Bioregions.

Sand: The South Coast Bioregion seabed is largely composed of soft, unconsolidated sediments. These sediments provide an important habitat for benthic infauna, with sediment structure an important influence on the distribution, abundance and community of these species.

Seagrasses: The diversity of seagrasses in temperate south-western Australia is the highest for any temperate region in the world and reflects the broad distribution of seagrasses in estuaries, coastal embayments and nearshore sheltered environments through to exposed coastal nearshore and offshore areas that are exposed to ocean swells. Seagrasses perform the following important ecosystem functions: primary production, nutrient cycling, stabilising sediments and habitat provision.

Sponges: In southwestern Australia, sponges are found in areas where algae are less dominant, which includes areas deeper than 30 m and caves.

The IMCRA ecosystem boundaries are illustrated in South Coast Overview Figure 1. The risk status for ecosystems and habitat is simplified into two broad categories: estuarine and marine.

Habitats

Habitats	Aquatic zone / category	Current Risk Status
South Coast	Estuarine	MODERATE
South Coast	Marine	NEGLIGIBLE

The footprint and intensity of demersal fishing methods (i.e. trawling, gillnetting, potting, droplining and longlining) on benthic habitats is extremely low (<1%) relative to the geographic scale of the bioregion. Trawling and demersal gillnetting also take place away from potentially sensitive hard-substrate habitats due to target species' distributions and to avoid damage to fishing gear. Some estuaries (e.g. Wilson and Hardy Inlets) are in poor condition due to reduced rainfall, eutrophication and other environmental factors.

Ecosystems

Ecosystems	Aquatic zone / category	Current Risk Status
South Coast	Estuarine	MODERATE
South Coast	Marine	LOW

An assessment by Hall and Wise (2011)[1] of finfish community structure using commercial fishery data for the past 30 years, concluded that trends mean trophic level, mean length and a Fishery-In-Balance indicator had stabilised in the South Coast Bioregion and that there were no concerning trends in available ecosystem-based indices.

The most likely cause of any changes to community structure in estuarine regions is changing rainfall levels (potentially due to climate change) and changes in tidal exchange due to opening and closing of sand-bars at river mouths.

1 Hall, N.G. and Wise, B.S. 2011. Development of an ecosystem approach to the monitoring and management of Western Australian fisheries. FRDC Report – Project 2005/063. Fisheries Research Report No. 215. Department of Fisheries, Western Australia. 112pp.

FISHERIES

SOUTH COAST CRUSTACEAN RESOURCE STATUS REPORT 2021

J. How and G. Baudains

OVERVIEW

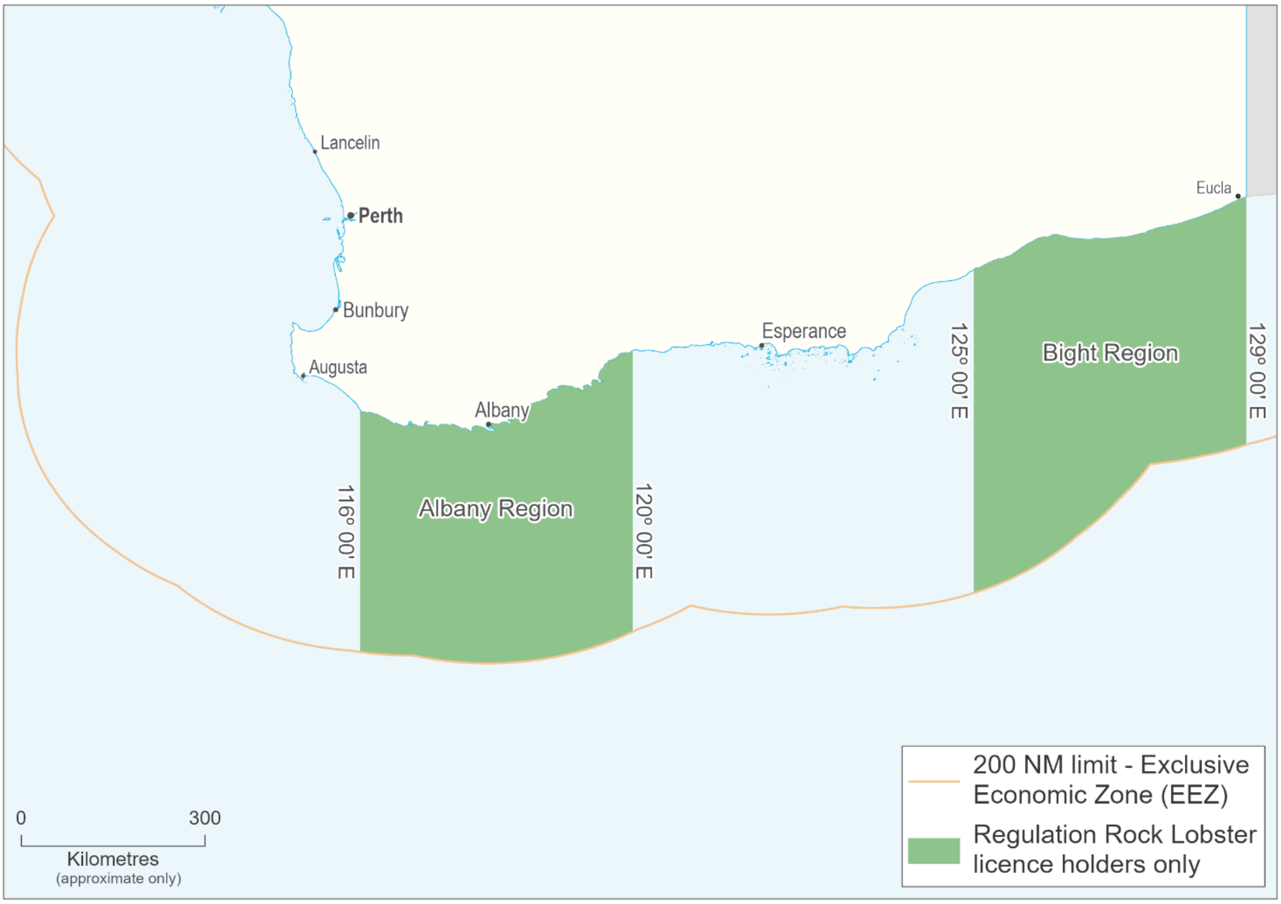
The South Coast Crustacean Managed Fishery (SCCMF) is a multi-species, effort-controlled pot based fishery, which includes catches of southern rock lobster (*Jasus edwardsii*) and western rock lobster (*Panulirus cygnus*), as well as deep-sea crab species, primarily, giant crab (*Pseudocarcinus gigas*), crystal crab (*Chaceon albus*) and champagne crab (*Hypothalassia acerba*).

A stock assessment was not undertaken for the 2019-20 season due to resourcing issues and a shift in catch and effort reporting. As such the stock status is based on the 2018-19 season's assessment. Detailed information on the fisheries biology of the deepwater carb species can be found in see How *et al*. (2015).

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (1977 pots)	Total Catch 2019-20: 52.5 t	Unacceptable: Management Action Required
Recreational fishery	Total Catch 2019-20: <5 t	N/A
EBFM		
Indicator species*		
Southern Rock Lobster	Below threshold, Above limit	Adequate
Crystal Crab	Below limit	Inadequate
Western Rock Lobster	Above threshold	Adequate
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Low Risk	Adequate
Ecosystem	Low Risk	Adequate
Economic (GVP $2.9 m; 2019/20)	Medium Risk	Acceptable
Social (Moderate amenity)	Medium Risk	Acceptable
Governance	Medium Risk	Unacceptable: Management Action Required
External Drivers	Medium Risk	Acceptable

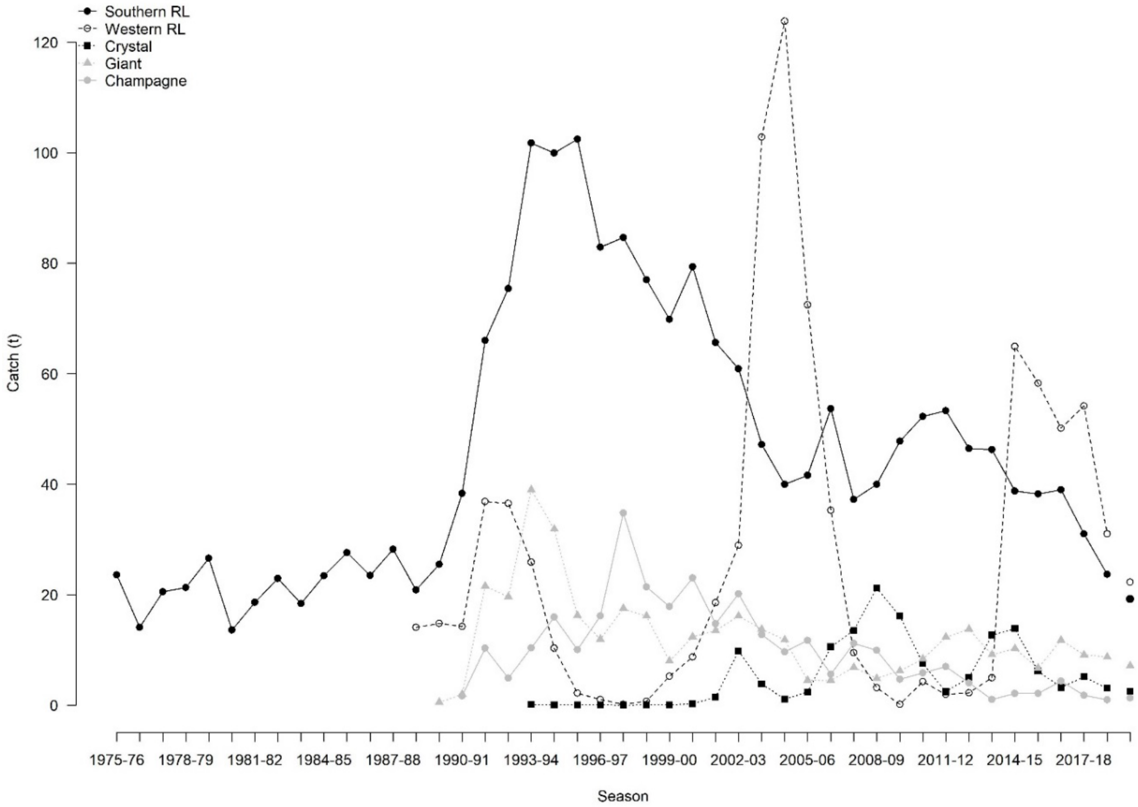
* based on the 2018-19 season assessment



SOUTH COAST CRUSTACEAN FIGURE 1.
Map showing boundaries of the South Coast Crustacean Managed Fishery.

CATCH AND LANDINGS

The total crustacean landings accessed by the SCCMF in 2019/20 from this resource was 52.5 t, comprising 19.2 t of southern rock lobster, 22.3 t of western rock lobster, and 2.5 t of crystal crabs, 7.1 t giant crabs and 1.3 t of champagne crabs (South Coast Crustacean Figure 1). There was a voluntary catch limit in place for crystal crab in Zone 3 which limited their catch to 2 t.



SOUTH COAST CRUSTACEAN FIGURE 2.
Total landings in the South Coast Crustacean Fishery by species.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Zone 1 – Augusta / Windy Harbour (Western rock lobster-Sustainable-Adequate)

The dominant species retained in the catch from this zone is western rock lobster. The western rock lobster in this zone represents the southern edge of the distribution of the stock. The catches and catch rates from 2014/15 to 2018/19 have been above their historic averages (South Coast Crustacean Figure 2 and 3a). Evidence suggests that the source of recruitment for western rock lobsters in the SCCMF is the West Coast Rock Lobster Managed Fishery (WCRLMF), which was assessed as **sustainable-adequate**.

Zone 2 – Albany (Crystal Crab-Inadequate)

Crystal crab, which is found on the west and south coasts of Western Australia (WA), is the indicator species within this zone. It is a deep water species typically caught between 500 – 800 m (for more details see How *et al*. 2015).

Landings of crystal crabs in Zone 2 decreased from 3.1 tonnes in 2018/19 to 2.3 tonnes in 2019/20 (South Coast Crustacean Figure 2). A voluntary memorandum of understanding limited the catch to approximately 2 t of crystal crab in Zone 2 which resulted in the decline in the landed catch during the 2019/20 season.

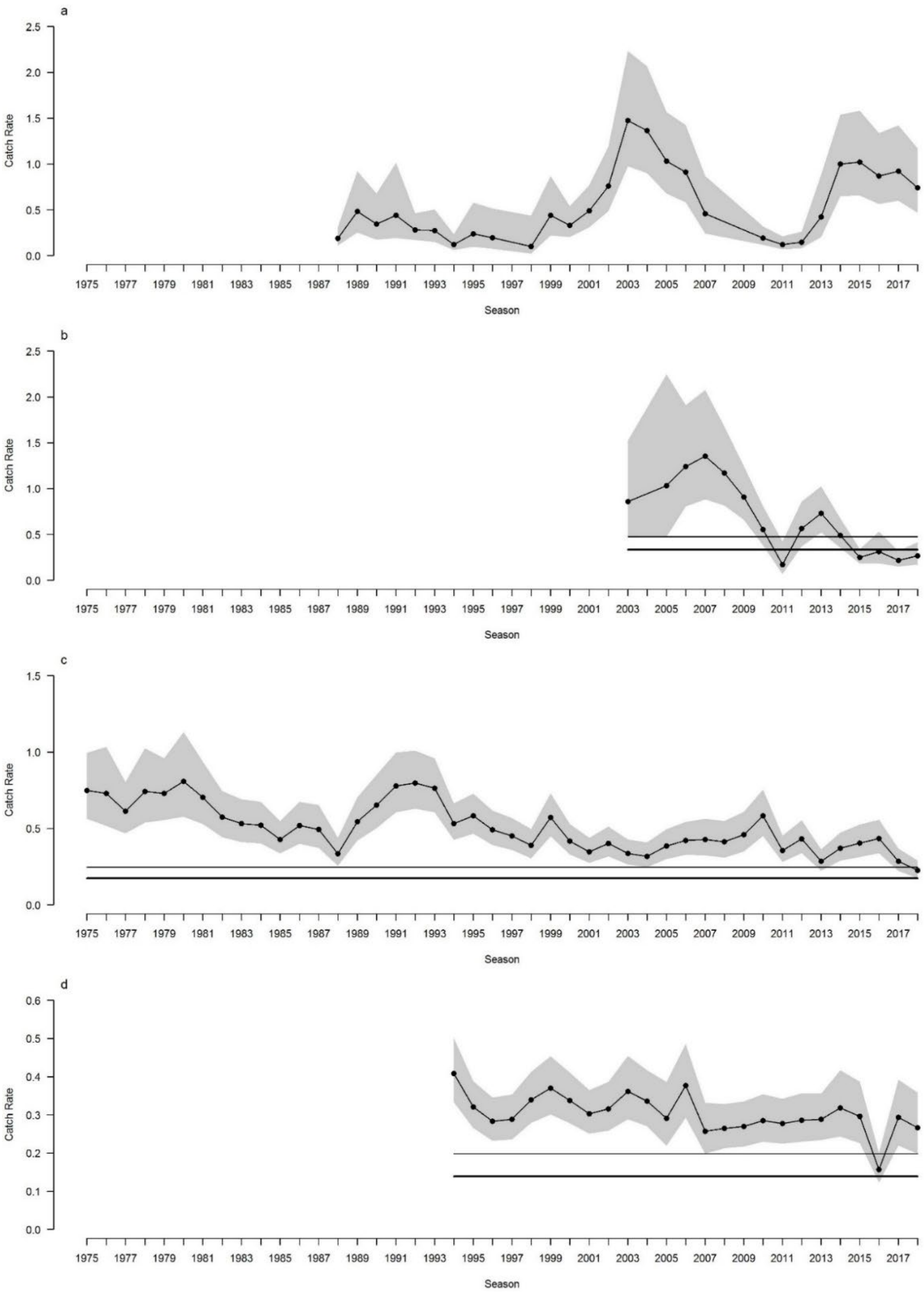
Catch rate data (standardised) from monthly returns, and (nominal) from volunteer logbook returns showed a decline in both metrics, resulting in the standardised catch rate being below the proposed limit reference point for crystal crab in Zone 2 (South Coast Crustacean Figure 3b). The 2018/19 catch rate levels are similar to those of the last three seasons. The assessment indicates that it is likely that the overall level of stock depletion is **unacceptable** (i.e. overall a moderate-high sustainability risk) and is therefore **inadequate**.

Zone 3 – Esperance and Zone 4 – Bight (Southern Rock Lobster- Sustainable-Adequate)

The assessment for these zones is determined using southern rock lobster as the indicator species. Southern rock lobster is considered to be a single genetic stock across the southern waters of Australia where it is harvested (Ovenden *et al*. 1992). This is a major commercial species for a number of southern Australian states with a national stock assessment showing the overall status of the stock as being sustainable (Linnane *et al*. 2020), and that the catches of southern rock lobster from WA are very low relative to the other southern states. For more details see Linnane *et al*. (2018).

Catches of southern rock lobsters in the SCCMF have declined in recent seasons, with catch landings outside of the target catch range of 50-80 tonnes (South Coast Crustacean Figure 2).

Standardised commercial catch rates have declined to record-low levels in Zone 3 (Esperance) and are below the threshold reference level, but above the limit reference level (South Coast Crustacean Figure 3c). The Zone 4 (Bight) standardised commercial catch rate for 2018/19 was similar to that of the 2017/18 season, which is an improvement from the very low catch rate in the 2016/17 season. The 2018/19 standardised catch rate remains above the threshold level for this zone (South Coast Crustacean Figure 3d). It is therefore likely that the current level of overall stock depletion is **acceptable** (i.e. overall a moderate-high sustainability risk) and the SCCMF stock biomass is above its limit level and is therefore **sustainable-adequate**.



SOUTH COAST CRUSTACEAN FIGURE 3.
Seasonal standardised catch rate (line and closed circles with grey 95 CI) for a) western rock lobster in Zone 1 (Windy Harbour-Augusta), b) crystal crab in Zone 2 (Albany) c) southern rock lobster in Zones 3 (Esperance), and d) southern rock lobster in Zones 4 (Bight). Proposed threshold (thin horizontal line) and limit (heavy horizontal line) reference points are presented when applicable. The season is denoted by the first year of the season (e.g. 2017 reflects the 2017/18 season).

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

The gear used in this fishery generates minimal bycatch and the design of the pots is such that their potential to 'ghost fish' if lost is negligible.

Low risk.

Protected Species

The SCCMF operates in areas adjacent to Australian Sea Lion (ASL) colonies. Pots fished in areas potentially frequented by juvenile ASLs are required to be fitted with a Sea Lion Exclusion Device (SLED). These devices are designed to stop the entrance and accidental drowning of ASLs. An exemption was granted in the 2015/16 season to assess the impact of SLEDs on catch composition and catch rate in Zone 3. The outcomes of this assessment showed that SLEDs have no impact on catch composition and catch rates. Statutory consultation was undertaken between the Department of Primary Industries and Regional Development and licence holders to establish suitable mitigation measures to reduce potential ASL interactions and minimise any impact on fisher catches. SLEDs were implented in the 2019/20 fishing season. In the 2019/20 season there were no ASL interactions attributed to the SCCMF.

In the 2019/20 season, there were no whale entanglement attributed to the SCCMF.

Turtles can also get caught in the float rigs of lobster pots. In 2019/20 no turtles were reported to have been entangled in fishing gear from the SCCMF.

Low risk.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

Potting is considered to have a low impact on the habitat over which the SCCMF operates. **Low** risk.

Ecosystem

The effect of the removal of lobster and deep sea crabs has been assessed for the West Coast Deep Sea Crustacean Fishery and WCRLMF on the state's west coast. The removal of crabs and lobsters by both of these fisheries have been assessed as having negligible effects on the food chain. Therefore, at current catch levels, it is unlikely that removal of lobster and crabs on the south coast are likely to result in food chain effects. **Low** risk.

SOCIAL AND ECONOMIC OUTCOMES

Social

The SCCMF is based on mobile vessels that employ a skipper and two or three crew. The product is landed live at ports between the South Australian / West Australian border and Augusta, generating some additional economic activity and benefits. There is a small recreational fishery for rock lobsters on the south coast of WA. **Medium** risk.

Economic

The beach value of the fishery was about $2.9 million in 2019/20 with the majority of the catch being sold live to Asian markets both locally and internationally. **Medium** risk.

GOVERNANCE SYSTEM

Annual Catch Tolerances

Southern Rock Lobster – 50-80 t

Current fishing level –Unacceptable

Under the SCCF Management Plan, the SCCMF is managed through limited entry, input controls (including limiting the number of pots that can be used), size limits and seasonal closures. Through the establishment of the SCCMF, the large amount of latent effort which existed in Zones 2 and 4 was dramatically reduced. The re-structuring which occurred as part of the SCCMF's establishment has also seen a reduction in effort in Zone 4, which combined with COVID market impacts may have contributed to the lower 2019/20 southern rock lobster catch.

While the standardised catch rate of Crystal Crabs in Zone 2 (Albany) is below the limit reference point, this reference level may not be appropriate. A review of the assessment technique and harvest strategy is planned. The overall assessment of the SCCMF fishing levels is unacceptable.

Compliance

Enforcement effort is either opportunistic or targeted. Practices include on-land and at-sea inspection of vessels, gear, authorisations and catch.

Consultation

Consultation occurs between the Department and the commercial sector through Annual Management Meetings convened by WAFIC. Consultation with Recfishwest and other interested stakeholders is conducted through specific meetings and the Department's website.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives (Major)

Management initiatives are focusing on the transition of the fishery from input to output control, which is envisaged to be in place for the start fo the 2022/23 season. Quota working group meetings and broader consulation is currently underway.

EXTERNAL DRIVERS

Given a large export market, fluctuation in the Australian dollar can have impacts on the economic performance of the fishery. The southern and western rock lobsters are near the edge of their distributional range and hence could be influenced by environmental conditions. **Medium** risk.

REFERENCES

de Lestang S, Caputi N, and How J. 2016. Resource Assessment Report: Western Rock Lobster Resource of Western Australia. Department of Fisheries, Western Australia.

How JR, Webster FJ, Travaille KL, Nardi K, and Harry AV. 2015. West Coast Deep Sea Crustacean Managed Fishery, Western Australian Marine Stewardship Council Report Series No. 4. Department of Fisheries, Western Australia.

Linnane A, McGarvey R, Gardner C, Hartmann K, de Lestang S. 2020. Southern Rock Lobster, *Jasus edwardsii,* in: Status of Key Australian Fish Stock Reports. Fisheries Research and Development Corporation (http://fish.gov.au/Pages/SAFS_Report.aspx).

Ovenden JR, Brasher DJ, and White R. 1992. Mitochondrial DNA analyses of the Red Rock Lobster Jasus edwardsii supports an apparent absence of population subdivision throughout Australasia. Marine Biology, 112: 319–326.

SOUTH COAST GREENLIP/BROWNLIP ABALONE RESOURCE STATUS REPORT 2021

L. Strain, F. Fabris and R. Jones

OVERVIEW

The Greenlip/Brownlip Abalone Fishery is a dive fishery that operates in the shallow coastal waters off the south-west and south coasts of WA. The fishery targets two large species of abalone: Greenlip abalone (*Haliotis laevigata*) and Brownlip abalone (*H. conicopora*), both of which can grow to approximately 20 cm shell length. The commercial Greenlip/Brownlip Abalone Fishery is managed primarily through Total Allowable Commercial Catches (TACCs) for each species in four management areas (Greenlip/Brownlip Abalone Figure 1), which are allocated annually as Individually Transferable Quotas (ITQs).

Recreational fishing only occurs in the Southern Zone (Greenlip/Brownlip Abalone Figure 1) with management arrangements that include a specific abalone recreational fishing licence, size limits, daily bag and possession limits, and temporal closures.

Further information on the fishery can be sourced from Hart *et al*. (2017) and Strain *et al.* (2021) at www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_8.pdf. and http://www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_8_addendum_4.pdf.

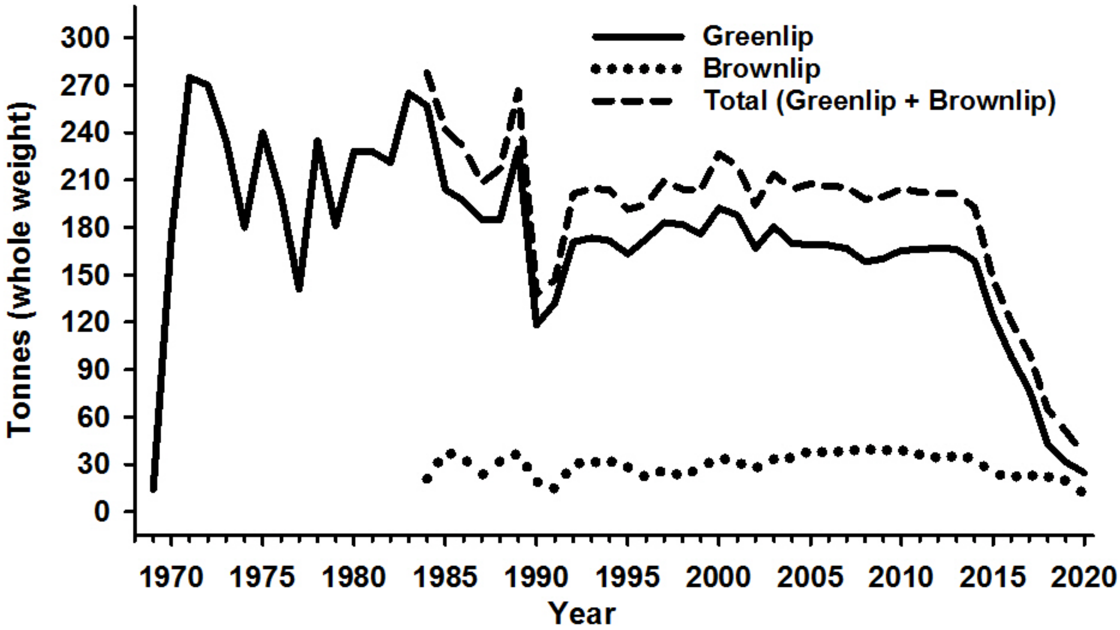
SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (53.8 t)	Total Catch 2020: 36 t	Management Action
Recreational fishery (not formal)	Total Catch 2020: 8 t	Acceptable
EBFM		
Indicator species		
Greenlip abalone (*Haliotis laevigata*)	Area 2 – PI below threshold but above limit Area 3 – PI below threshold but above limit in open regions. Spatial closures enforced in 2020.	Inadequate
Brownlip abalone (*Haliotis conicopora*)	Area 2 – PI below threshold but above limit Area 3 – PI above target	Adequate
Ecological		
Bycatch	Negligible risk	Adequate
Listed Species	Negligible risk	Adequate
Habitat	Negligible risk	Adequate
Ecosystem	Negligible risk	Adequate
Economic (GVP $2.2 m)	High risk	Management Action
Social (amenity)	Medium risk	Acceptable
Governance	High risk	Management Action
External Drivers	High risk	Management Action

GREENLIP/BROWNLIP ABALONE FIGURE 1.
Map showing the boundaries of the management areas for Greenlip/Brownlip Abalone in the commercial Abalone Managed Fishery in Western Australia. Also showing the boundaries of the three zones within the Western Australian Recreational Abalone Fishery; the Western Zone, the Northern Zone and the Southern Zone.

CATCH AND LANDINGS

In 2020 the total commercial Greenlip/Brownlip abalone catch was 36 t whole weight (Greenlip 24.7 t and Brownlip 11.3 t), which was 67% of the combined TACC (53.8 t whole weight) and represents the lowest catch in 51 years (Greenlip/Brownlip Abalone Figure 2). The reduced catch in 2020 was due to the reduction in the Greenlip abalone TACC by 8 t whole weight in Area 2, and a commercial industry decision to catch below the Brownlip abalone TACC in Area 2. The combined recreational catch of both species is estimated at 8 t, which was derived from a 2007 telephone diary survey, is still considered sufficiently accurate.



GREENLIP/BROWNLIP ABALONE FIGURE 2.
Commercial Greenlip and Brownlip abalone catch (t, whole weight) by season as recorded against the nearest calendar year.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

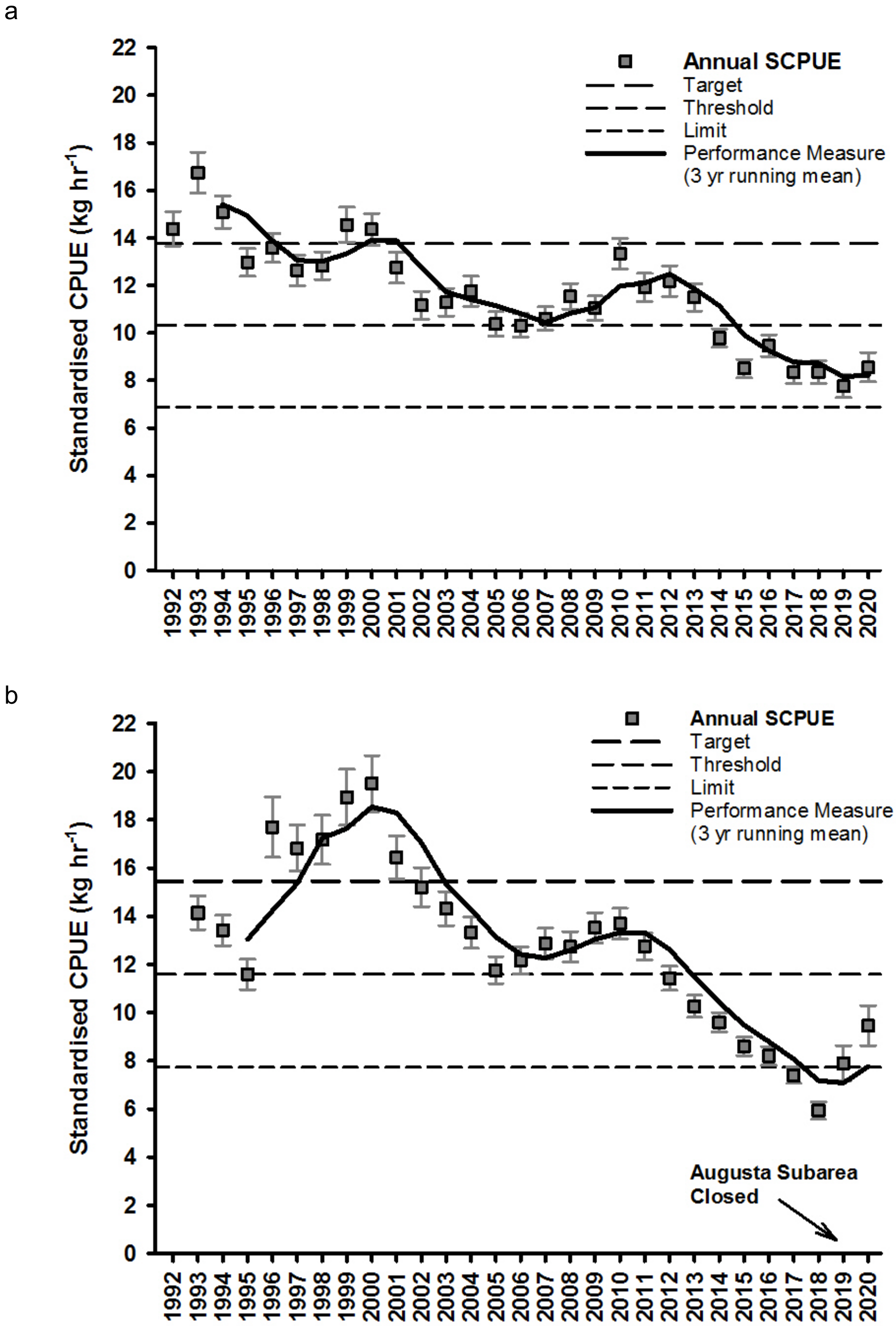
Greenlip abalone (Inadequate)

Greenlip abalone are distributed from south-west WA across southern Australia to Victoria and Tasmania. A recent genomic study suggests the existence of one single Greenlip abalone population along the WA coast, but with five adaptive populations (Sandoval-Castillo *et al*. 2018). The fishery has a legal minimum length of 14.5 cm in Area 2 and 15 cm in Area 3, which allows 2–5 years of spawning to occur before recruitment to the fishery.

To determine the TACCs for each management area the stock status is assessed by, the performance indicator (PI) of standardised catch per unit effort (SCPUE) as a 3-year mean which uses commercial catch and effort statistics, and other measures such as fisheries-independent sampling. In Management Area 2 (Esperance) there was a declining trend in annual SCPUE and PI since 2012, but in recent seasons (2017-2020) this decline has been arrested. The PI is currently below the threshold level but above the limit reference level (Greenlip/Brownlip Abalone Figure 3a).

In Management Area 3 (Albany) the annual SCPUE and PI declined between 2010 and 2018. In 2018, both the annual SCPUE and PI were below the limit reference level (Greenlip/Brownlip Abalone Figure 3b). In 2019, the major component of Area 3 (Augusta) has been closed to fishing and the TACC reduced to 4 t (whole weight). The increase in SCPUE over the last 2 seasons represents only the open regions of Area 3. Analysis of raw catch rate, average meat weight per individual and length-frequency trends also support evidence of the declining trend (2010-2018). However, increases in meat weight per individual have occurred over the last 3 to 4 seasons. Fishery-independent surveys in the Augusta region indicate the total density of Greenlip abalone to be at record low levels for the last 6 years, while there has been a slight increase in the densities of juvenile animals (4 – 8 cm shell length) in the last 3 years after it was at record low levels between 2014 and 2017.

Stock status of Greenlip abalone is considered **inadequate**.



GREENLIP/BROWNLIP ABALONE FIGURE 3.
The standardised CPUE (kg.hr^{-1}) for Greenlip abalone with the performance indicator (3 year running mean) and reference levels (target, threshold and limit) in Management Area 2 (a) and Area 3 (b).

Brownlip abalone (Adequate)

Brownlip abalone are limited to WA and distributed from the south-west to the WA/SA border. There is evidence to suggest Brownlip abalone are genetically similar to, and potentially considered conspecific with, Blacklip abalone (*Haliotis rubra*) (Brown and Murray 1992), which are distributed east from the WA/SA border to northern NSW and Tasmania. Estimates of Brownlip abalone biological characteristics can be found in Strain *et al*. (2017), and given the fishery has a legal minimum length of 14.5 cm in Area 2 and 15 cm in Area 3, it allows 2–4 years of spawning to occur before recruitment to the fishery.

The stock status is assessed using commercial catch and effort statistics, and an integrated model. Trends in the PI (3 year mean of SCPUE) were used for the assessment of the 2020 TACC for each management area. In Management Area 2 (Esperance) the annual SCPUE and PI for Brownlip abalone were relatively stable above the target reference level between 1999 and 2011. However, over the next four seasons they declined markedly before levelling off below the threshold level but above the limit reference level.

The annual SCPUE and PI then increased over the next two seasons (to threshold) before declining again during 2019 and 2020 towards the limit reference level. In Management Area 3 (Albany) the annual SCPUE and PI for Brownlip abalone fluctuated greatly during 1999 to 2012 (above the threshold). A relatively stable, increasing trend from the threshold to the target has been observed from 2011 to 2017. Over the last three seasons the annual SCPUE and PI has fluctated above the target reference level.

An integrated length-based model has been fitted to commercial catch and catch rate data, length composition data and modelled growth of Brownlip abalone from Management Areas 2 and 3 combined (Strain *et al*. 2017). The integrated model estimated the spawning biomass (relative to that for an unfished stock) was above the target reference level in 2018. Consequently, the stock status of Brownlip abalone is considered to be **adequate**.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Divers have the ability to target abalone of choice (species, sizes and quality of abalone) and do not inadvertently harvest bycatch in their normal fishing activities. The only potential listed species interaction is with the white shark (*Carcharodon carcharias*), which has been known to attack divers. Most divers now use diving cages and/or electronic shark deterrent devices for their personal protection, and are recording their encounters with white sharks. **Negligible** risk.

HABITAT AND ECOSYSTEM INTERACTIONS

The fishing activity makes minimal contact with the habitat, which typically consists of hard rock surfaces in a high wave-energy environment. As abalone are drift algae feeders, their removal is unlikely to result in any change to the algal cover in fished areas, and hence it is considered unlikely that the fishery has any significant effect on the food chain in the region. **Negligible** risk.

SOCIAL AND ECONOMIC OUTCOMES

Social

There are 17 vessels registered to operate in the commercial Greenlip/Brownlip Abalone Fishery, but given the low catches in 2020 only a proportion of these were active. The dispersed nature of the Greenlip/Brownlip Abalone Fishery means that small coastal towns from Busselton to the WA/SA border receive income from the activity of divers. Recreational diving for Greenlip and Brownlip abalone is a small but active sector, with dive shops and vessel manufacturers benefiting from this activity. The recreational fishery provides a major social benefit to those community members that appreciate abalone as a delicacy. There were 18,328 recreational abalone licenses issued in 2020 that would have allowed fishers to participate in the recreational abalone fishery, although most of these would have targeted the Roe’s Abalone Fishery in the Perth metropolitan area. **Medium** risk.

Economic

Estimated annual value (to commercial fishers) for 2020 was $2.2 million, based on the estimated average price received by commercial fishers of $170.23/kg meat weight ($63.83/kg whole weight) for Greenlip abalone and $134.65/kg meat weight ($53.86/kg whole weight) for Brownlip abalone. Greenlip and Brownlip abalone prices increased again in 2020 and the price for Greenlip abalone is well above the then high prices of 20 years ago (e.g. $146/kg meat weight in 2001). **High** risk.

GOVERNANCE SYSTEM

Harvest Strategy (Formal)

The harvest strategy (DoF 2017) uses SCPUE as a proxy for biomass as the key performance indicator, which are assessed against specified biological reference levels for both species in each management area. The TACCs (whole weight) have been set for the 2021/22 season using the harvest strategy, for Greenlip abalone they are 3 t in Area 1, 16 t in Area 2 and 11 t in Area 3, while for Brownlip abalone they are 150 kg in Area 1, 7.5 t in Area 2 and 11 t in Area 3.

Annual Catch Tolerance Levels Commercial – Not Acceptable Recreational – Acceptable

Commercial: 53.8 t (TACC) (3,440 – 5,270 fishing hours).

Recreational: Not formal.

Commercial catch was below the TACC due to commercial industry decisions. The commercial fishing effort (1421 hours) was also below the expected range. Greenlip abalone stock indicator is below the threshold reference level for Area 2 and the open regions of Area 3. The TACC was reduced to 48.8 t and spatial closures enforced in Area 3 for the 2021 season (Greenlip abalone TACC at 17% of long-term levels). Recreational catch levels are relatively small and not considered a risk to stocks.

Compliance

The Department conducts regular inspections of commercial catch at both the point of landing and

processing facilities to ensure the commercial industry is adhering to the governing legislation. The recreational fishery has a level of enforcement appropriate to the distribution of recreational fishing effort.

Consultation

The Department undertakes consultation directly with the Abalone Industry Association of Western Australia (AIAWA), the Southern Seafood Producers Association WA (SSPA) and licensees on operational issues. The Department convenes Annual Management Meetings through the Industry Consultation Unit at the West Australian Fishing Industry Council (WAFIC), who are also responsible for undertaking statutory management plan consultation under a Service Level Agreement with the Department. Recreational consultation processes are facilitated by Recfishwest under a Service Level Agreement, although the Department undertakes direct consultation with the community on specific issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

A Recovery Strategy for Area 3 Greenlip abalone has been finalised, while the Department has reviewed the Harvest Strategy for the Western Australian Abalone Resource and is currently finalising consultation and approvals.

The commercial Greenlip/Brownlip abalone fishery has undergone full MSC assessment and achieved certification in 2017, with the 3rd surveillance audit completed during 2020 (https://fisheries.msc.org/en/fisheries/western-australia-abalone-fishery/@@view).

EXTERNAL DRIVERS

In the last few years there have been a number of changes which impact on fishery governance, and particularly on catch rates. Lease divers and using 2 divers per fishing day are more common, and industry size limits have been varied substantially above the legal minimum lengths. Fishery management arrangements may need to be reviewed over the next few years with commercial fishers in Area 3 considering a different industry management model. In addition, environmental effects such as weather conditions, and the effect of technology changes, continue to have significant impacts on diver efficiency.

The effect of above-average water temperatures on the abalone stocks including the marine heatwave period of 2011-2013, needs to be investigated further. Greenlip and Brownlip abalone have been assessed as a high risk to climate change effects. **High** risk.

REFERENCES

Brown LD, and Murray ND. 1992. *Genetic relationships within the genus Haliotis*. In: Abalone of the World: Biology, Fisheries and Culture. Shepherd SA, Tegner MJ, and Guzman del Proo SA. (eds). Blackwell Scientific Publications Ltd, Oxford, pp.19-23.

DoF. 2017. Abalone Resource of Western Australia Harvest Strategy 2016 - 2021. Fisheries Management Paper No. 283. Department of Fisheries, Western Australia. 36p.

Hart A, Strain L, Hesp A, Fisher E, Webster F, Brand-Gardner S, and Walters S. 2017. *Marine Stewardship Council Full Assessment Report Western Australian Abalone Managed Fishery*. Department of Fisheries, Western Australia, 288pp.

Sandoval-Castillo J, Robinson NA, Hart AM, Strain LWS, and Beheregaray LB. 2018. Seascape genomics reveals adaptive divergence in a connected and commercially important mollusc, the greenlip abalone (Haliotis laevigata), along a longitudinal environmental gradient. Molecular Ecology 27 (7): 1603-1620.

Strain LWS, Hesp SA, Fabris F, and Hart AM. 2017. Demographic performance of Brownlip abalone: exploration of wild and cultured harvest potential. FRDC Project No. 2012/016. Fisheries Research Report No. 280. Department of Fisheries, Western Australia. 104p.

Strain L, Hart A and Jones R. 2021. Western Australian Abalone Managed Fishery. Western Australian Marine Stewardship Council Report Series No. 8. Addendum 4. Department of Primary Industries and Regional Development, Western Australia. 28p.

SOUTH COAST ESTUARINE AND NEARSHORE SCALEFISH AND INVERTEBRATE RESOURCE STATUS REPORT 2021

R. Duffy, D. Harris and N. Blay

OVERVIEW

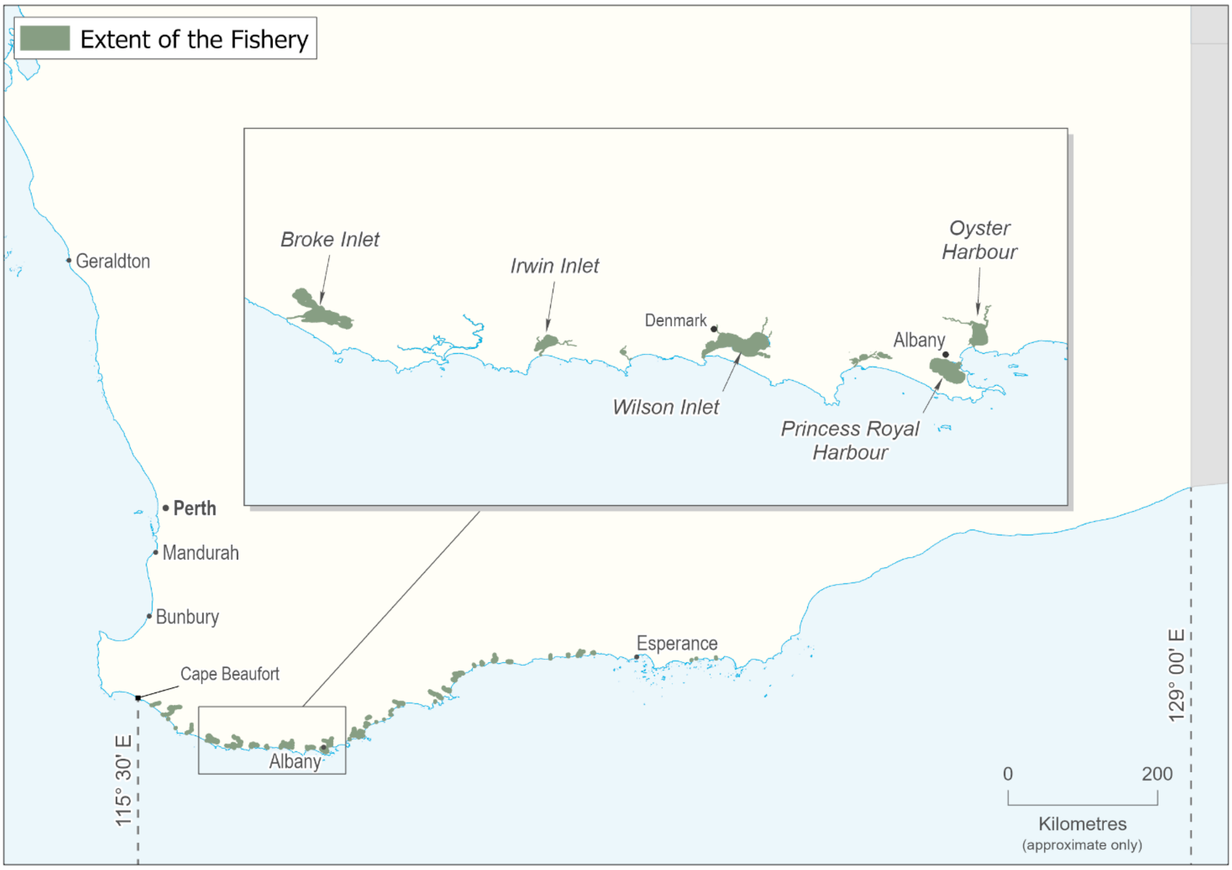
The South Coast Estuarine and Nearshore Scalefish and Invertebrates Resource (SCENSIR) covers three commercial fisheries (South Coast Estuarine Managed Fishery (SCEMF) [South Coast Nearshore and Estuarine Figure 1], South Coast Salmon Managed Fishery (SCSMF), and the Open Access South Coast Fishery), and two non-commercial fisheries (recreational fishing and customary fishing) operating in estuaries, and nearshore waters (defined as oceanic waters of less than 20 m depth). The Open Access South Coast Fishery is due to be succeeded by two managed fisheries (South Coast Nearshore Net Managed Fishery and the South Coast Line and Fish Trap Managed Fishery) in 2021.

The majority of the commercial catch in this resource is taken by gill net, purpose-designed crab traps, haul net and beach seine; 'G traps' caught large quantities of herring until the fishery was closed in 2015. Fish capture in non-commercial fisheries occurs mainly by line (finfish), drop and scoop nets (target blue swimmer crabs), and there is also a small catch via recreational netting. Catch from commercial fisheries is monitored through compulsory monthly catch returns. Recreational catch is monitored through surveys of fishers, customary catch has not been assessed and is considered minimal.

For more detailed descriptions of blue swimmer crab biology and South Coast crab fisheries see the Resource Assessment Report (Johnston *et al.*, 2020).

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2020: 334 t	Recovering (Wilson Inlet Cobbler)
Recreational fishery	Total Catch 2017/18: 17–35 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Western Australian salmon	Above target	Adequate
Australian Herring	Above threshold	Recovering
Cobbler (Wilson Inlet)	Below limit	Recovering
Black bream	Above target	Adequate
Blue swimmer crab	Not assessed	Adequate
Ecological		
Bycatch	Low risk	Adequate
Protected Species	Negligible risk	Adequate
Habitat	Negligible risk	Adequate
Ecosystem	Low risk	Adequate
Social (high amenity)	Moderate risk	Acceptable
Economic (GVP < $1m)	Moderate risk	Acceptable
Governance	Moderate risk	Acceptable
External Drivers	High risk	Acceptable



SOUTH COAST NEARSHORE AND ESTUARINE FIGURE 1.
Map showing the boundaries, and primary finfish and crab fishing areas, of the South Coast Estuarine Managed Fishery.

CATCH AND LANDINGS

In 2020, the total commercial catch of this resource was 334 t, the majority of which (<200 t) was from the estuarine fisheries. The top 10 species (or species groupings), by weight, caught in this resource are shown in South Coast Estuarine and Nearshore Scalefish and Invertebrate Resource Table 1.

Since 1990 there has been a major decline in total catch in each of the main commercial finfish fisheries, resulting in a steady decline in commercial production in the SCB. This has been due to a complex suite of drivers, including effort reductions, changing environmental conditions, changing market demands, and declining abundance of some species.

The estimated boat-based recreational harvest ranges for the top 10 nearshore and estuarine scalefish species in the South Coast were steady at 26 t (95% CI 17–35 t) in 2017/18 compared with 17 t (95% CI 13–21) in 2015/16, 25 t (95% CI 20–30) in 2013/14, but lower than 44 t (95% CI 37–52) in 2011/12 (Ryan *et al*. 2019). The boat-based recreational harvest range for blue swimmer crab in the SCB in 2017/18 was estimated to be between 0-0.14 t (95% CI), representing <1% of state wide catch (Ryan *et al*., 2019). No recent estimates of shore-based recreational catches are available.

SOUTH COAST ESTUARINE AND NEARSHORE SCALEFISH AND INVERTEBRATE RESOURCE TABLE 1.

Catch (tonnes) of top 10 species (ordered by weight in 2020) from commercial fisheries in the South Coast Estuarine and Nearshore Scalefish and Invertebrates Resource in the previous five years.

Species	Scientific name	2016	2017	2018	2019	2020
Western Australian Salmon	*Arripis truttaceus*	5.0	50.4	51.5	59.6	78.1
Black Bream	*Acanthopagrus butcheri*	71.9	76.8	50.9	63.8	70.0
Estuary Cobbler	*Cnidoglanis macrocephalus*	70.2	60.6	37.2	35.0	41.2
Australian Herring	*Arripis georgianus*	20.9	38.9	19.9	16.6	34.2
Sea Mullet	*Mugil cephalus*	27.8	28.0	18.0	18.0	19.8
King George Whiting	*Sillaginodes punctatus*	17.2	8.7	11.9	17.1	13.7
Triggerfishes & Leatherjackets		10.2	10.4	11.0	8.9	12.9
Pink Snapper	*Chrysophrys auratus*	10.4	3.0	2.4	11.2	11.8
Blue Swimmer Crab	*Portunus armatus*	23.1	10.5	7.3	19.0	10.7
Tarwhine	*Rhabdosargus sarba*	12.1	8.2	8.0	9.8	9.7
Other species		37.1	33.4	31.8	30.2	32.0
Total		305.9	328.9	249.9	289.2	334.1

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

The status of each stock listed below is assessed using a weight-of-evidence approach that considers all available information about the stock. The species reported below, Western Australian Salmon, Australian Herring, Estuarine Cobbler and Black Bream are those species currently identified as indicator species (Department of Fisheries 2011). Use of the indicator species approach for the SCENSIR is currently under review. Blue Swimmer Crab catch has been included in this year’s report as increasing warmer temperatures (such as the 2011 extreme marine heatwave), which are influenced by the strength of the Leeuwin Current, have resulted in substantial increases in crab catches on the south coast.

Western Australian Salmon (Sustainable-Adequate)

Commercial catches have been at historically low levels since 2011 as a result of weak market demand and low wholesale prices (historical landings in WA were primarily sold as bait) (South Coast Nearshore and Estuarine Figure 2). In 2020 the catch of salmon within the Southern Bioregion was 78.1 t.The majority of the catch, approximately 76 t, was taken within the South Coast Salmon Managed Fishery.

The estimated boat-based recreational harvest range for Western Australian Salmon in the South Coast was lower in 2017/18 (<1 t) compared with 2015/16 (95% CI 1–5 t), 2013/14 (2–5 t) and 2011/12 (4–11 t) (Ryan *et al*. 2019). Shore-based recreational catches are not estimated but believed to be substantial for this species.

The breeding component of this stock resides in WA, with only immature/nonbreeding fish occurring in South Australia and Victoria. The assessment is based on catch data from each jurisdiction and 2012-2015 age composition data from WA. Analyses based on catch curves, a per recruit model, an equilibrium age structured model (Wise and Molony 2018), and a stock reduction model (catch MSY) indicate that the current rate of fishing mortality is relatively low (less than natural mortality) and biomass is likely to be well above the target level of 40%. On the basis of this evidence, the western Australian salmon breeding stock is classified as **sustainable – adequate.**

Australian Herring (Sustainable-Recovering)

Commercial catches are at historically low levels as a result of the closure of the 'G Trap' fishery (South Coast Nearshore and Estuarine Figure 3). In 2020 the catch of herring within the resource was 34.2 t, well down on historic highs. This small catch is shared between the South Coast Nearshore Net Managed Fishery and the South Coast Line and Fish Trap Managed Fishery (previously open access fisheries) and the South Coast Estuarine Managed Fishery.

The estimated boat-based recreational harvest range for Australian Herring in the SCB was 1.9-2.6 t (95% CI), in 2017/18 **(Ryan *et al*. 2017),** similar to 2015/16, but showing an ongoing declining trend from 2011/12 (Ryan *et al*. 2017). Shore-based recreational catches are not estimated but believed to be substantial for this species.

The breeding component of this stock resides in WA, with only immature/non-breeding fish occurring in other States. There is currently a **Medium Risk** to the stock, determined by a weight-of-evidence assessment workshop held in 2017 (Wise and Molony 2018). The workshop was attended by DPIRD staff, South Australian scientists and managers, independent scientists, and commercial and recreational fishing industry representatives. Stock biomass is projected to continue to increase under current management arrangements. On this basis, the Australian herring stock is classified as **sustainable – recovering.**

Estuarine Cobbler (Sustainable-Recovering - Wilson Inlet)

In WA, cobbler occurs in marine and estuarine waters but is primarily caught by commercial fishers in estuaries. Landings by recreational fishers are negligible (Smallwood and Sumner 2007, Ryan *et al*. 2017). Each estuary hosts a discrete stock of cobbler, which is genetically distinct to other estuarine populations and also distinct from populations in adjacent ocean waters (Ayvazian *et al*. 1994).

In 2020 a total of 41.2 t was caught, the majority of the catch (over 40 t) was taken by the South Coast Estuarine Managed Fishery (South Coast Nearshore and Estuarine Figure 4). The largest portion of the catch comes from a single estuary (~73% from Wilson Inlet).

A Level 4 assessment completed in 2020 found a High Risk to the sustainability of the Wilson Inlet stock based on catches of over 50 t, that occured prior to 2018. Catches since 2018 have been approximately 40 t or less, and at this level the risk has been reduced to moderate.

The stock status of estuarine cobbler in Wilson Inlet is used as a proxy for the status of estuarine cobbler in all south coast estuaries, therefore estuarine cobbler in the resource is considerd as **sustainable - recovering.**

Black bream (Sustainable-Adequate)

Black bream is an estuary-dependent species, with little movement between estuaries. Each estuarine population of black bream represents a genetically discrete stock (Chaplin et al. 1997).

In 2020 the catch of bream within the Southern Bioregion was 70 t, all of which was taken by the South Coast Estuarine Managed Fishery (South Coast Estuarine and Nearshore Scalefish and Invertebrate Resource Figure 5). Most of the catch was taken from Stokes Inlet (35 t), Wilson Inlet (16 t) and Jerdacuttup (10.5 t). Catch from Beaufort inlet in 2020 declined to zero, from over 17 t in 2019. This was due to fish kills related to reduced freshwater flows, algal blooms and very high salinity.

Total commercial catches in south coast estuaries have followed an increasing trend since the 1970s, suggesting an increasing availability of this species across the Bioregion. However, this trend is puncutated by large inter-annual fluctuations within each south coast estuary, most likely a response to environmental factors, particularly river flow.

Catch-MSY analysis, which treated the stock at the level of bioregion, estimates the current biomass to be greater than 50% of the unfished biomass. At this level the stock is considered adequate.

The estimated boat-based recreational harvest of black bream in the SCB in 2017/18 (1.6 – 3 t) (95% CI), was similar to previous years (2015/16: 1-6 t, 2013/14: 1-3 t, 2011/12: 3-11 t estimates) (95% confidence intervals; Ryan et al. 2017). The current shore-based recreational catch is unknown, but is believed to comprise a significant share of the catch of this species.

On the basis of the above evidence, South Coast Bioregion black bream stocks are classified as **Sustainable - adequate**.

Blue swimmer crab (Sustainable-Adequate)

The SCEMF reported a total annual blue swimmer crab catch of 10.5 t for 2020, almost half the 19 t landed in 2019 (South Coast Nearshore and Estuarine Figure 6). Most crabs were caught in Princess Royal Harbour (dedicated traps - 4.3 t; gill nets – 2.0 t) and Oyster Harbour (dedicated traps – 2.0 t; gill nets – 1.7 t), with a further 0.3 t retained as by-product from gill net fishing in the Wilson Inlet. Stock abundance of blue swimmer crabs in the SCB appears to be heavily influenced by the strength of the warm, southward flowing Leeuwin Current. Crabs recruit to these waters during strong Current years which result in warmer water temperatures, with subsequent catch and effort highly variable in response to these pulses of abundance. The two peaks in abundance in the last 20 years have been as a result of the 1999 and 2011-2013 marine heatwaves.

While the size of stock and relative exploitation level along the south coast is not fully understood, the relatively low level of commercial and recreational catch and effort suggests that blue swimmer crab stocks in the SCB are **sustainable-adequate.**

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

The small-scale commercial fisheries in nearshore and estuarine waters mainly use gill, seine and haul nets that are deployed in a targeted manner. Few non-target species are taken. Mesh size regulations ensure that target species caught by

these methods are within appropriate size ranges. Minimal discarding occurs because virtually all fish taken can be retained and marketed. Recreational fishers mainly use line-based methods in nearshore and estuarine waters. This method can result in the capture and release of non-target species and undersized fish. The risks associated with post-release mortality vary considerably among species. In general, fish in nearshore and estuarine waters are captured from shallow depths and have lower risks of barotrauma-related injuries than deep water oceanic species and so bycatch species are at **low risk**.

Blue swimmer crab traps are purpose-designed to minimise the capture of non-target species and undersized crabs. The majority of fish and other bycatch species escape through the trap entrance gaps when the trap is soaking or hauled. The small quantity of bycatch that is caught and returned by commercial crab fishers is considered to pose a **negligible risk** to these stocks.

Protected Species

It is compulsory for commercial fishers to report all interactions with protected listed marine species. New Zealand fur seals and Australian sea lions are occasionally surrounded by beach seine nets used in the South Coast nearshore and estuarine fisheries, but are released immediately by the fishers. This is possible because seine netting is a labour-intensive operation and the fishing team will immediately notice a sea lion or seal in the net. Fishers are then able to release it from their seine net without injury to the animal. There have been no reports of incidental mortalities in these fisheries and it is believed that the present level of interaction (direct and indirect) is not a significant threat to the populations of fur seals and sea lions. An assessment of the impact of interactions is performed on an annual basis and, if required, appropriate management arrangements will be devised to mitigate these interactions. The current risk is considered to be **negligible**.

Birds such as pelicans, cormorants and shearwaters sometimes interact with commercial fishing nets in estuaries and with recreational line-fishing gear but the risks to bird populations are considered to be **negligible**.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

The operation of gill nets, haul nets and crab traps over predominantly sand and mud bottoms is unlikely to have any impact on these habitats in estuaries and nearshore waters. Similarly, the risks from line fishing, and drop and scoop netting methods used by recreational fishers, to bottom substrates are **negligible**. Anchoring by recreational fishing vessels may have localised impacts on habitats such as seagrass.

Haul nets may be deployed over low or medium density seagrass. This type of net tends to 'roll' over the surface of seagrass beds without removing attached leaves or uprooting plants. At times, haul nets may collect floating vegetation including seagrass leaves or algae. Hence the risk to benthic habitats are considered **negligible** .

Ecosystem

Excessive removal by commercial and recreational fisheries of certain species, such as Australian herring or Western Australian salmon, could potentially impact on prey and predator species including larger fish, cetaceans and seabirds. However, commercial fishing effort directed towards these species in recent years has been declining and is very low compared to historic levels. Recreational fishing effort directed towards Australian herring is relatively high. Total removals by fishing currently pose a **low risk**.

SOCIAL AND ECONOMIC OUTCOMES

Social

The nearshore and estuarine recreational fisheries of the SCB provide a high social amenity for the WA community. There is currently a **moderate risk** to these values.

In 2020, catch was recorded against 25 licences in the South Coast Estuarine Manged Fishery, and six in the South Coast Salmon Fishery. An additional commercial fisher is currently operating in the SCB targeting sand crabs by Exemption. Additional employment is created by these fisheries in processing and distribution networks and retail fish sales sectors. Western Australian salmon fisheries supply WA bait and human consumption markets. The South Coast Estuarine Managed Fishery is an important source of fresh local fish and crabs to regional centres. The use of beach seine nets by commercial salmon fishers may temporarily impact on beach access by members of the public.

Economic

Estimated annual value (Gross Value of Production) to commercial fishers for 2020

Level 1: <$1 million

This reflects commercial beach price of landed product only and does not include economic flow-on values such as employment within the fishery, additional employment/value in distribution networks, retail fish sales sectors and spending on fuel and equipment.

Recreational fishing in nearshore and estuarine waters generates economic activity in many

regional towns in the SCB. Recreational fishing in the Great Southern area is estimated to be worth approximately $45.8 million, and $146.6 million in the Goldfields-Esperance area (McLeod and Lindner 2018).

Due to low catches in commercial salmon and estuarine fisheries as well as the long term decline in commercial production the economic risk is considered **Moderate.**

GOVERNANCE SYSTEM

Harvest Strategy

This resource is harvested using a constant exploitation approach, where the annual catch taken varies in proportion to variations in the stock abundance. Indicator species are used to determine the status of the resource. Indicator species are assessed annually based on catch and/or catch rate trends, where data are available (noting that recreational fishery data is limited for these stocks). Additionally, higher level assessments are periodically undertaken for some stocks. There is currently no formal harvest strategy developed for the commercial Western Australian salmon fisheries or the South Coast Estuarine Managed Fishery.

Annual Catch Tolerance Levels

Catch tolerance levels require a review. Previous measures were set for finfish, however, blue swimmer crabs now compose a substaintial amount of the catch. In addition, salmon and herring fishing has undergone a substaintial reduction in effort due to both market demand and management restrictions.

Compliance

The Department undertakes regular compliance inspections to ensure fishing is being undertaken in accordance with the governing legislation.

Consultation

The Department undertakes consultation directly with the Southern Seafood Producers Association, and licensees on operational issues. Industry Management Meetings are convened by the Department through the West Australian Fishing Industry Council (WAFIC), who are also responsible for undertaking statutory management plan consultation on behalf of the Department under a Service Level Agreement. Consultation with the recreational sector is undertaken via the peak representative body, Recfishwest and/or the Department's website when documents are released for public comment.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

In 2013, an independently reviewed stock assessment of Australian herring concluded the stock was at an unacceptable level and subsequently management changes were introduced to help the stock recover. A herring stock assessment workshop was held in September 2017 which showed that Australian herring was recovering but had not yet recovered. As a result of the review current management arrangements are being maintained to support stock recovery. The next stock assessment is scheduled for completion during 2021.

A trial of extended penning time for Western Australian salmon is being undertaken in the SCSMF. The trial continued during 2020.

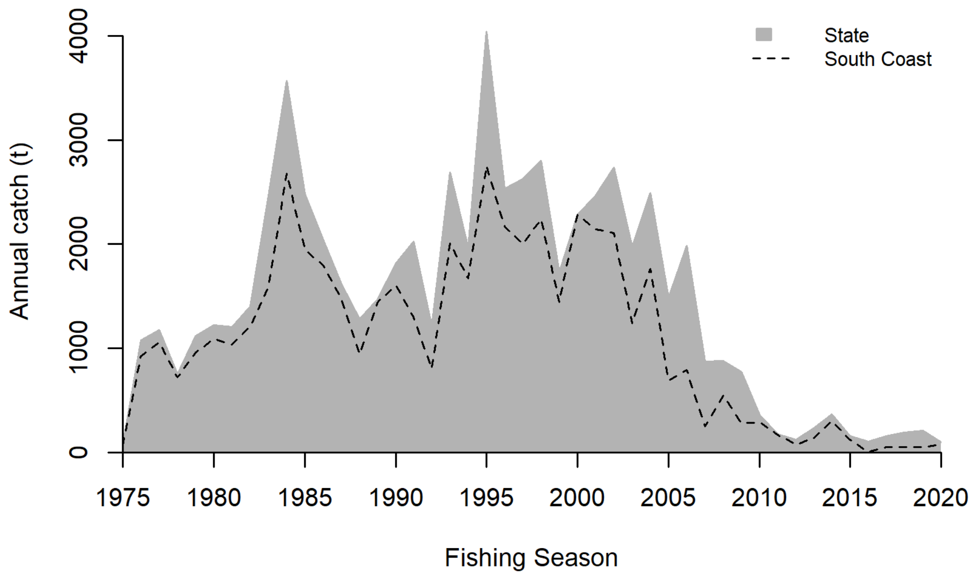
The Minister for Fisheries finalised the review of South Coast commercial line, fish trap and net fisheries in January 2019. The Department drafted two new management plans to give effect to the outcomes of the review, namely the South Coast Nearshore Net Managed Fishery Management Plan and the South Coast Line and Fish Trap Managed Fishery Management Plan. These new Management Plans will regulate previous open-access nearshore netting activities on the South Coast. The two new management plans commenced on 1 July 2021.

A five-year Instrument of Exemption was issued endorsing one commercial fisher to target the sand crab (*Ovalipes australiensis*) using purpose-designed hourglass traps in waters between Augusta and Hopetoun.

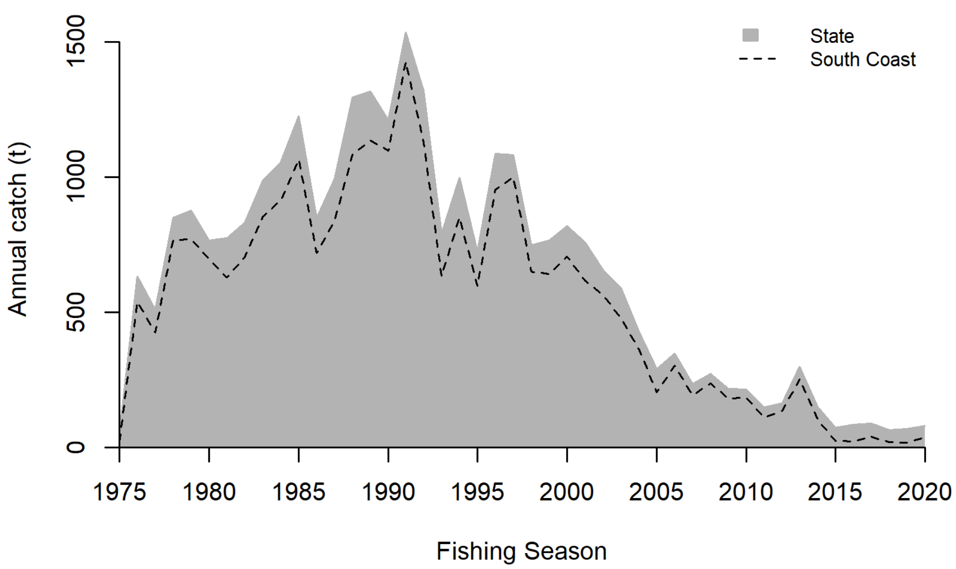
EXTERNAL DRIVERS

The abundance of fish species in SCB estuaries are strongly influenced by climatic and other environmental factors, independent of fishing. Catchment processes (e.g. runoff) can have major effects on estuary condition and fishery production. Annual variations in coastal currents (particularly the Leeuwin and Capes Currents) influence spawning, recruitment, distribution and catchability of species such as Australian herring, Western Australian salmon, and blue swimmer crab. Cool inshore temperatures due to a strong Capes Current provided a favourable 'corridor' for salmon to migrate northwards in 2016, with exceptionally high numbers of fish observed along the west coast during the autumn spawning period, and some travelling as far north as Exmouth.

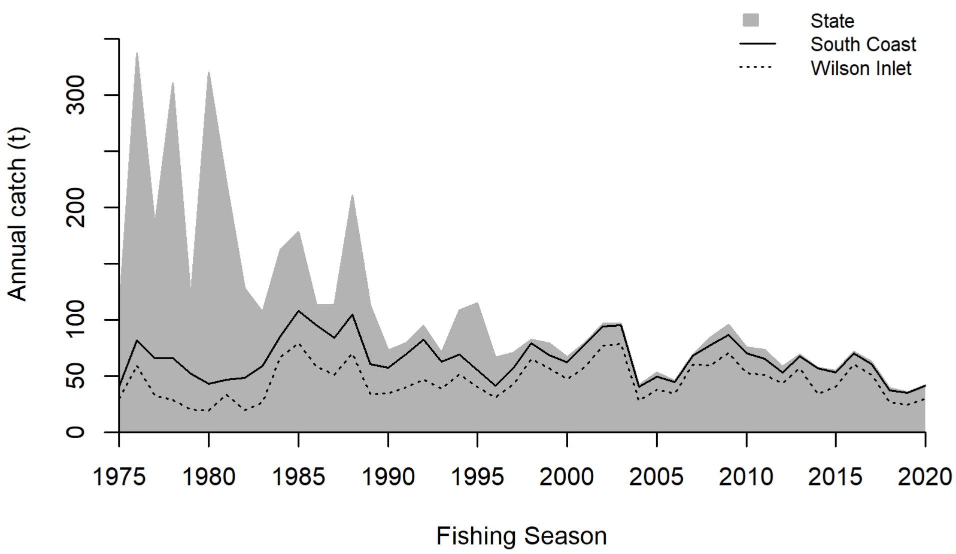
Fluctuating market demand is a significant factor affecting the annual commercial catch level of many species. On the basis of market demand and price commercial fishers sometimes elect not to capture a school of fish, or release part of their catch, when a market is not available. This is particularly relevant to western Australian salmon. **High** risk.



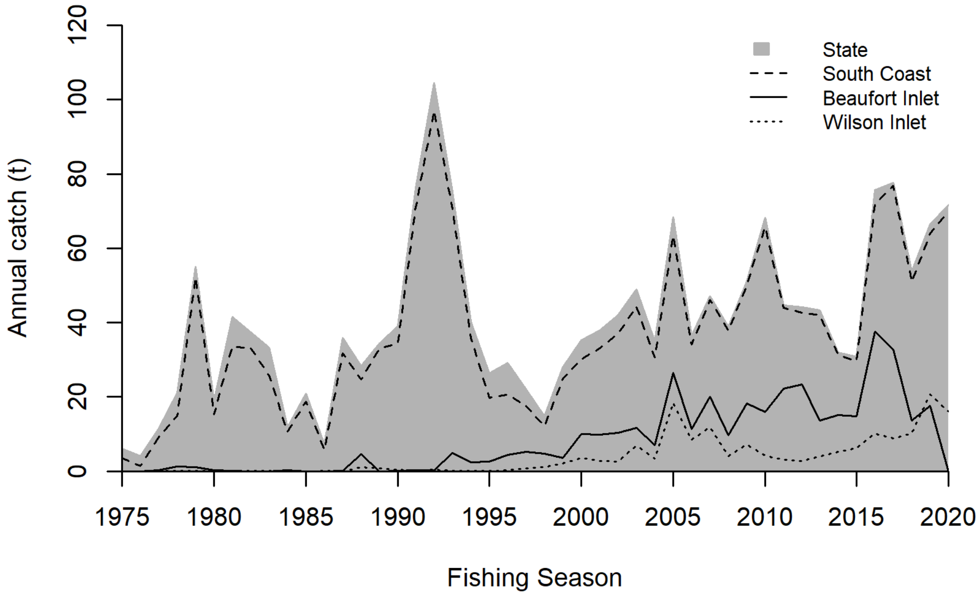
SOUTH COAST NEARSHORE AND ESTUARINE FIGURE 2.
Annual commercial catches of Western Australian salmon in the State and the South Coast Bioregion 1975 to 2020.



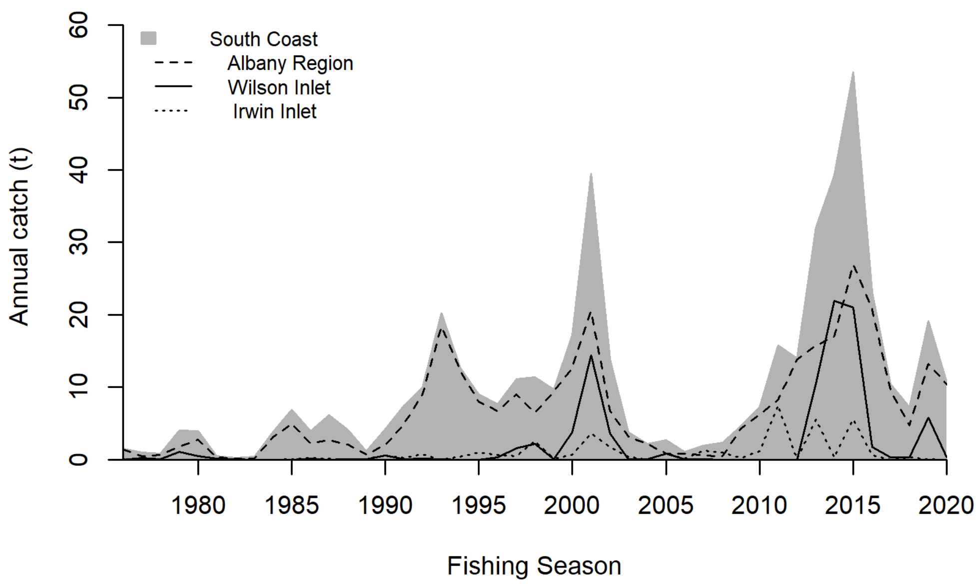
SOUTH COAST NEARSHORE AND ESTUARINE FIGURE 3.
Annual commercial catches of Australian herring in the State and the South Coast Bioregion 1975 to 2020.



SOUTH COAST NEARSHORE AND ESTUARINE FIGURE 4.
Annual commercial catches of estuary cobbler in the State, South Coast Bioregion and Wilson Inlet, 1975 to 2020.



SOUTH COAST NEARSHORE AND ESTUARINE FIGURE 5.
Annual commercial catches of black bream in the State, South Coast Bioregion, and two major estuaries, Wilson Inlet and Beaufort Inlet, 1975 to 2020.



SOUTH COAST NEARSHORE AND ESTUARINE FIGURE 6.
Annual commercial blue swimmer crab catch for the resource. The Albany region incorporates primarily the Princess Royal and Oyster Harbours, and King George Sound.

REFERENCES

Ayvazian SG, Johnson MS and McGlashan DJ. 1994. High levels of genetic subdivision of marine and estuarine populations of the estuarine catfish *Cnidoglanis macrocephalus* (Plotosidae) in southwestern Australia. 118:25–31.

Chaplin JA, Baudains GA, Gill HS, McCullock R and Potter IC. 1997. Are assemblages of black bream (*Acanthopagrus butcheri*) in different estuaries genetically distinct? International Journal of Salt Lake Research 6:303-321.

Johnston, D., Harris, D. and Yeoh, D. 2020. Blue Swimmer Crab (*Portunus armatus*) and Sand Crab (*Ovalipes australiensis*) Resource in the South Coast Bioregion of Western Australia. Fisheries Research Report No. 310. Department of Primary Industries and Regional Development, Western Australia. 63pp.

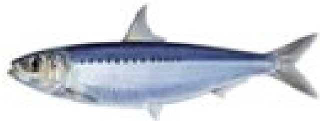
McLeod P and Lindner R. 2018. Economic dimension of recreational fishing in Western Australia. Research report for the Recreational Fishing Initiatives Fund. Final report. Economic Research Associates, Perth. https://recfishwest.org.au/wp-content/uploads/2019/03/Economic-Dimensions-of-Recreational-Fishing-in-Western-Australia-Report-2.pdf

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia.

Smallwood CB, and Sumner NR. 2007. A 12-month survey of recreational estuarine fishing in the South Coast Bioregion of Western Australia during 2002/03. Fisheries Research Report, No. 159. Department of Fisheries, Western Australia. 56pp.

Wise BS and Molony BW. (Editors). 2018. Australian Herring and West Australian Salmon Scientific Workshop Report, October 2017. Fisheries Research Report, No. 289. Department of Primary Industries and Regional Development, Western Australia. 158pp.

SOUTH COAST SMALL PELAGIC SCALEFISH RESOURCE STATUS REPORT 2021



J. Norriss and S. Blazeski

OVERVIEW

The five species comprising the south coast small pelagic scalefish resource are Australian sardine (pilchards, *Sardinops sagax*), yellowtail scad (*Trachurus novaezelandiae*), Australian anchovy (*Engraulis australis*), scaly mackerel (*Sardinella lemuru*) and maray (*Etrumeus jacksoniensis*). Australian sardine is the indicator species and dominates the catch, taken predominantly by the quota managed, limited entry South Coast Purse Seine Managed Fishery (SCPSMF). These fishers use purse seine gear in waters between Cape Leeuwin and the South Australian border. The SCPSMF is also entitled to take sandy sprat (*Hyperlophus vittatus*) and blue sprat (*Spratelloides robustus*), which form part of the South Coast Nearshore and Estuarine Finfish Resource, however this catch is very small and infrequent. The SCPSMF has five management zones (South Coast Small Pelagic Figure 1), centred on King George Sound (Zone 1), Albany (Zone 2), Bremer Bay (Zone 3), Esperance (Zone 4) and a developmental zone near Augusta (Zone 5) where the recorded catch has been negligible in recent years. The SCPSMF was the largest tonnage fishery in WA during the late 1980s and early 1990s, until a virus devastated Australian sardine stocks in 1995 and 1998/99. While surveys demonstrated a strong recovery by the mid-2000s, low fishing effort has resulted in ensuing catches remaining well below the total allowable commercial catch (TACC), which was conservatively set at 5,683 t.

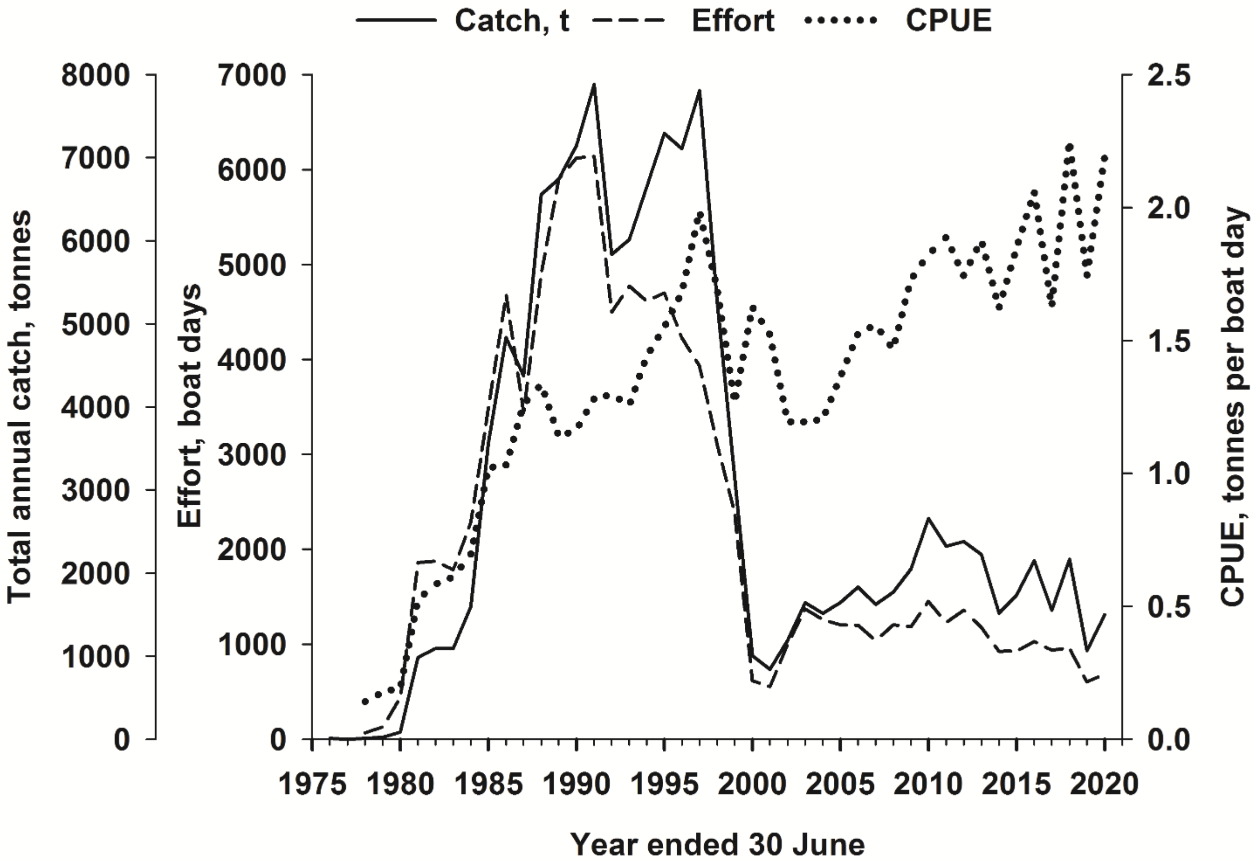
SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (5,683 t)	Total Catch 2019/20: 1,498 t	Acceptable
Recreational fishery (not applicable)	Total Catch 2017/18: <1 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Australian sardine	Above target	Adequate
Ecological		
Bycatch	Negligible risk	Adequate
Listed Species	Medium risk	Monitoring, voluntary mitigation and industry consultation
Habitat	Negligible risk	Adequate
Ecosystem	Low risk	Adequate
Economic (GVP $1-5 m)	Moderate risk	Acceptable
Social (low amenity)	Low risk	Acceptable
Governance	Stable	Acceptable
External Drivers	Moderate risk	Acceptable

SOUTH COAST SMALL PELAGIC FIGURE 1.
Map showing the boundaries and management zones of the South Coast Purse Seine Managed Fishery. Fishing operation occur over a small area, almost exclusively in coastal embayments near Albany, Bremer Bay and Esperance.

CATCH AND LANDINGS

The SCPSMF total catch of 1,498 t in the 2019/20 quota year, was comprised entirely of Australian sardine, and represents an increase of 29% from the previous year (South Coast Small Pelagic Figure 2). The total catch was comprised of 816 t from King George Sound (Zone 1), 1 t from the greater Albany region (Zone 2) and 680 t from Bremer and Esperance (Zones 3 and 4) combined (South Coast Small Pelagic Table 1). Fishing effort in the 2019/20 quota year was 684 boat days, a 12% increase from the previous year, and was landed by 11 vessels.



SOUTH COAST SMALL PELAGIC FIGURE 2.
Total annual catch, effort and nominal catch per unit effort (CPUE) for Australian sardine in the SCPSMF from 1975/76 to 2019/20.

INDICATOR SPECIES ASSESSMENT AND STOCK STATUS

Australian sardine (Sustainable-Adequate)

The Australian sardine is a small, low trophic level pelagic species that feeds by filtering plankton. Longevity is reported up to 9 years of age, sexual maturity is achieved in the second year, with a maximum size of 200-250 mm SL.

Population modelling, based on spawning biomass estimates (using the daily egg production method), catch-at-age and catch data, show that by the mid-2000s the stock had recovered from a mass mortality event in 1998/99 caused by a herpesvirus (Gaughan *et al*. 2008). The annual exploitation rate in mid-2000s was around 3 per cent (less than 3,000 t from an estimated spawning biomass of approximately 97,000 t), and the total annual catch has not exceeded 3,000 t to date. Since 2008/09 the nominal catch rate has remained relatively high (South Coast Small Pelagic Figure 2). The stock is therefore not considered to be recruitment overfished. Under the current level of fishing pressure, the biological stocks of Australian sardine are considered **sustainable-adequate**.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

The SCPSMF is a species-restricted fishery prohibiting the landing of any species not listed in the management plan (listed above). Small quantities of fish bycatch species are sometimes captured incidentally, but this occurs infrequently

and the majority are released from the net unharmed resulting in a **negligible** risk.

Protected species

SCPSMF operators must record all interactions with endangered, threatened and protected species on Catch and Disposal Records for each fishing trip and on statutory monthly Catch and Effort Statistics returns.

For 2019-20, fishers reported catching and releasing 1 dolphin alive and unharmed as well as 6 Flesh-footed shearwaters (FFS) killed and 69 released alive and unharmed. FFS opportunistically feed on fish trapped inside the purse seine net and may drown if caught in net folds.

Interactions with protected species are mitigated and managed through the implementation of a voluntary SCPSMF Code of Practice (Code) which is reviewed annually. A Special Management Period (SMP, March & April) has been designated under this Code, when the risk of FFS interactions is highest. During the SMP fishers avoid fishing at dawn when interaction risk is believed to be elevated. Analyses of fishery dependent and independent observer data confirm that the timing of the SMP is acceptable as this is when FFS interactions are highest (Norriss *et al*. 2020). Moreover, Norriss *et al*. (2020) generated estimates of total FFS annual mortalities (±95% confidence limits) of 123 (52-251) and 172 (91-302) in the 2016/17 and 2017/18 quota years, respectively. Although these mortality estimates are below the sustainable limits estimated for WA's FFS population, the extent of other anthropogenic mortalities is unknown. **Medium risk**.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

Purse seine nets are pelagic in nature, with no impact on benthic habitats during normal operations. On rare occasions nets may be deployed in shallow waters and come into contact with habitats such as seagrass beds. The light structure of the net is expected to cause minimal damage to benthic habits when this occurs, and any impact is restricted to a small, localised area. Moreover, the likely net damage motivates fishers to avoid contact with reef or coral. The SCPSMF is therefore considered a **negligible** risk to these habitats.

Ecosystem

Australian sardine are a relatively short lived, low trophic level species important for ecosystem structure and function. Their abundance is subject to large natural variation in response to environmental conditions. Catch quotas are likely to be <10% of the spawning biomass, and trophic modelling by the much larger South Australian Australian sardine fishery (Goldsworthy *et al*. 2013) indicates minor impacts on top order predators. The ecosystem impact from fishing in the SCPSMF is considered **low** risk.

SOCIAL AND ECONOMIC OUTCOMES

Social

Small pelagic fish are not a major target for recreational fishers and catches are low: the only species detected in the catch of boat-based recreational fishers during 2017/18 was <1 t of yellowtail scad (Ryan *et al*. 2019). Australian sardine are an important bait for recreational fishers. **Low** risk.

Economic

Eleven active vessels as well as local fish processing facilities in Albany, Bremer Bay and Esperance provided local employment during 2019/20. A small proportion of the catch is sold for human consumption but the large majority is used for bait, aquaculture feed or pet food. The estimated gross value of product (GVP) for the SCPSMF in 2019/20 was level 2 ($1-5 million). There is a **moderate** risk to this level of return, considering possible management responses to seabird interactions.

GOVERNANCE SYSTEM

Harvest Strategy

The SCPSMF is managed under a constant catch harvest strategy approach, with catches limited to quotas (TACC) set for each management zone. Any proposed changes to the TACC are made with regard to total catches and nominal catch rates, in consultation with stakeholders.

Allowable Catch Tolerance Levels

The SCPSMF total annual catch for all species combined in the 2019/20 quota year was only 26% of the total allowable commercial catch (TACC, South Coast Small Pelagic Table 1). Catches are therefore at **acceptable** levels.

Compliance

SCPSMF licensees are allocated individual transferable quotas and catches are assessed against quotas through the lodgement of trip Catch and Disposal Records by fishers to the Department. Compliance is monitored via aerial patrols and both at-sea and land based inspections.

Consultation

The Department undertakes consultation directly with the Southern Seafood Producers Association, and SCPSMF licensees on operational issues on an as needs basis, and more formally via industry Management Meetings convened by the Western Australian Fishing Industry Council (WAFIC) pursuant to a Service Level Agreement with the Department. Consultation with the recreational sector is undertaken via the peak representative body, Recfishwest and/or the Department's website when documents are released for public comment.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives/Outlook Status

The South Coast Small Pelagic Scalefish Resource will continue to be monitored using catch and nominal catch rates.

In late 2021, the SCPSMF intends to apply to the Commonwealth Department of Agriculture, Water and the Environment to be assessed against the Commonwealth Guidelines for the Ecologically Sustainable Management of Fisheries, for the purpose of becoming an approved wildlife trade operation and gaining export approval. As a key part of this process, the Department convened an Ecological Risk Asessment (ERA) in 2021, the outcomes of which will be reported on in the next Status of the Fisheries report. The ERA focussed on evaluating the impact of SCPSF activities on all relevant retained and bycatch species, endangered, threatened and protected species, habitats and the broader environment. The ERA involved a broad range of stakeholders including representatives of the commercial fishing sector, State and Australian Government agencies, Birdlife Australia, Conservation Council WA, the University of Western Australia, Murdoch University and the Marine Stewardship Council.

A formal harvest strategy for the Statewide Small Pelagic Scalefish Resource is yet to be developed, however, it is noted as a future management initiative.

EXTERNAL DRIVERS

Licensed operators in the Commonwealth Small Pelagic Fishery are permitted to take Australian sardine in waters adjacent to the West Australian coastline south of 31° 00' S (near Lancelin) but no fishing in these waters was identified in 2019/20 (Marton and Steven 2020). Climate change is likely to be causing a gradual southward contraction in the natural distribution of Australian sardine. These external drivers represent a **moderate** risk.

SOUTH COAST SMALL PELAGIC TABLE 1.
2019/20 catches and total allowable commercial catches (TACC) for the major Management Zones of the South Coast Purse Seine Managed Fishery.

Management Zone	TACC (t)	2019/20 catch (t)	Active vessels	2019/20 catch as % of TACC
Albany (Zones 1 and 2)	2,683	818	5	30%
Bremer Bay and Esperance (Zones 2 and 3)#	3,000	680	3	23%
Total for Fishery	5,683	1,498	11	26%

Zones cannot be reported individually because insufficient vessels operated in 2017/18

REFERENCES

Gaughan D, Carine M, Stephenson P, Leary T, and Lewis P. 2008. Regrowth of pilchard (*Sardinops sagax*) stocks off southern WA following the mass mortality event of 1998/99. Final FRDC Report – Project 2000/135. Fisheries Research Report No. 176. Department of Fisheries, Western Australia. 82p.

Goldsworthy SD, Page B, Rogers PJ, Bulman C, Wiebkin A, McLeay LJ, Einoder L, Baylis AMM, Braley M, Caines R, Daly K, Huveneers C, Peters K, Lowther AD, and Ward, TM. 2013. Trophodynamics of the eastern Great Australia Bight ecosystem: ecological change associated with the growth of Australia's largest fishery. Ecological Monitoring 255: 38–57.

Marton N. and Steven A.H. 2020. Small Pelagic Fishery. In: Patterson, H, Larcombe J, Woodhams, J, and Curtotti, R, *Fishery Status Reports 2020*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 4.0. https://doi.org/10.25814/5f447487e6749.

Norriss, J.V., Fisher, E.M. and Denham, A. (2020). Seabird bycatch in a sardine purse seine fishery. ICES Journal of Marine Science 77: 2971–2983.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS 2019. State-wide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia.

TEMPERATE DEMERSAL GILLNET AND DEMERSAL LONGLINE FISHERIES RESOURCE STATUS REPORT 2021

M. Braccini & M. Watt

OVERVIEW

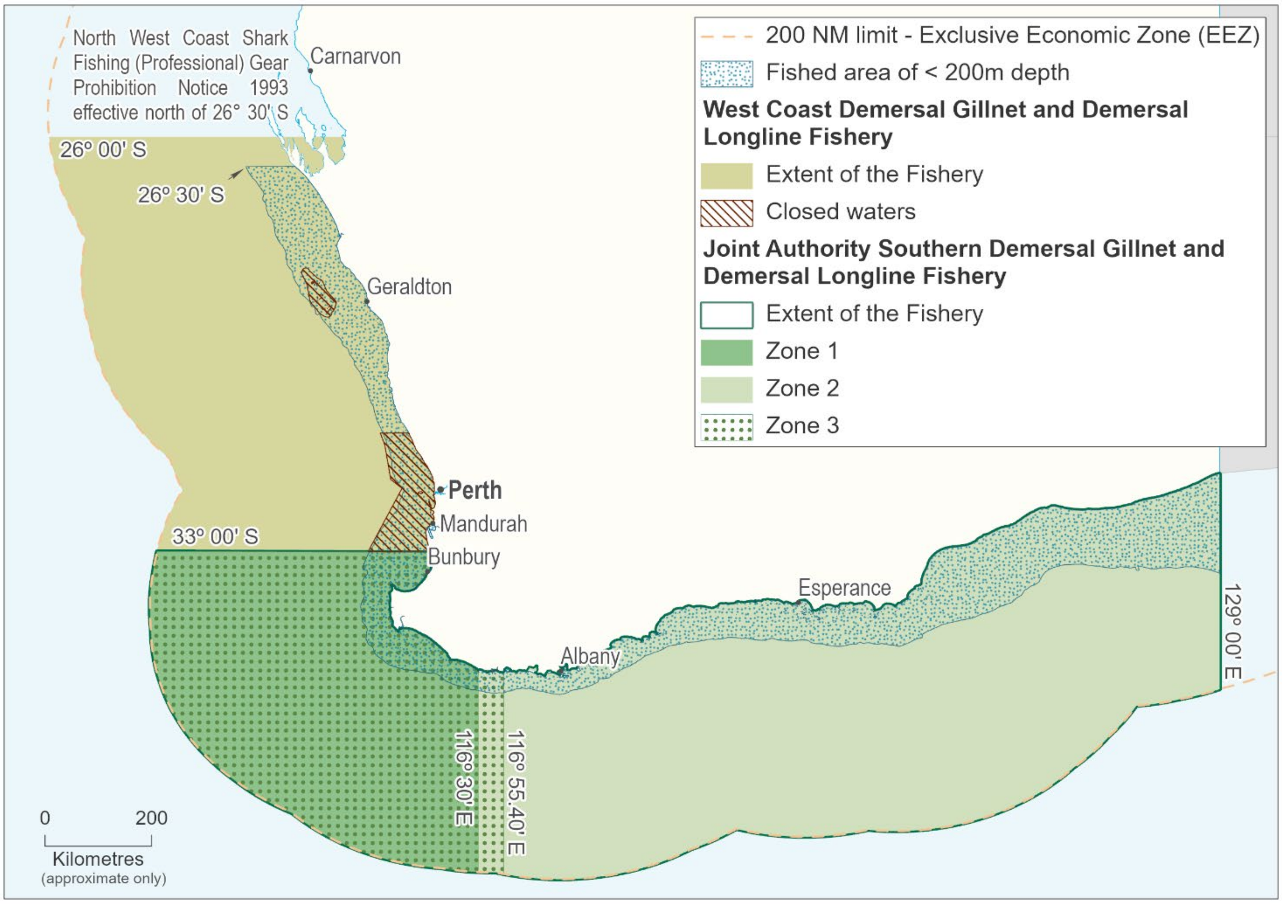
The Temperate Demersal Gillnet and Demersal Longline Fisheries (TDGDLF) comprises the West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (WCDGDLF), which operates between 26° and 33 S, and the Southern Demersal Gillnet and Demersal Longline Managed Fishery (SDGDLF)[1], which operates from 33 S to the Western Australian (WA)/South Australian border. Most fishers employ demersal gillnets to target mainly sharks with scalefish being a byproduct. Demersal longline is also permitted but is not widely used. Gummy (*Mustelus antarcticus*), dusky (*Carcharhinus obscurus*), whiskery (*Furgaleus macki*), and sandbar (*C. plumbeus*) sharks are the main shark species targeted (~80% of the fisheries' shark catch) and they have been identified as indicators for the status of the temperate shark 'suite' as they represent the range of life history strategies of other shark species caught by these fisheries. For further details, see Braccini *et al*. (2018) and SAFS (2018).

1 Previously the Joint Authority Southern Demersal Gillnet and Demersal Longline Fishery (JASDGDLF). The JASDGDLF transitioned from joint Commonwealth/State management to State only management in December 2018

SUMMARY FEATURES

Asset (Allowable catch for indicator species)	Outcome	Status
Commercial fishery (725−1,095 t)	Total Catch 2019-20 Sharks and rays*: 774 t Scalefish*: 117 t	Acceptable
Recreational fishery (not defined)	Total Catch 2017/18: < 10% of commercial catch	Acceptable
EBFM		
Indicator species		
Gummy shark	Above threshold	Adequate
Dusky shark	Above threshold	Recovering
Whiskery shark	Above threshold	Adequate
Sandbar shark	Above threshold	Recovering
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Negligible Risk	Adequate
Ecosystem	Low Risk	Adequate
Economic (GVP $1-5 m)	Low Risk	Acceptable
Social (Moderate amenity)	Significant Risk	Unacceptable
Governance	Stable	Acceptable
External Drivers	Moderate Risk	Acceptable

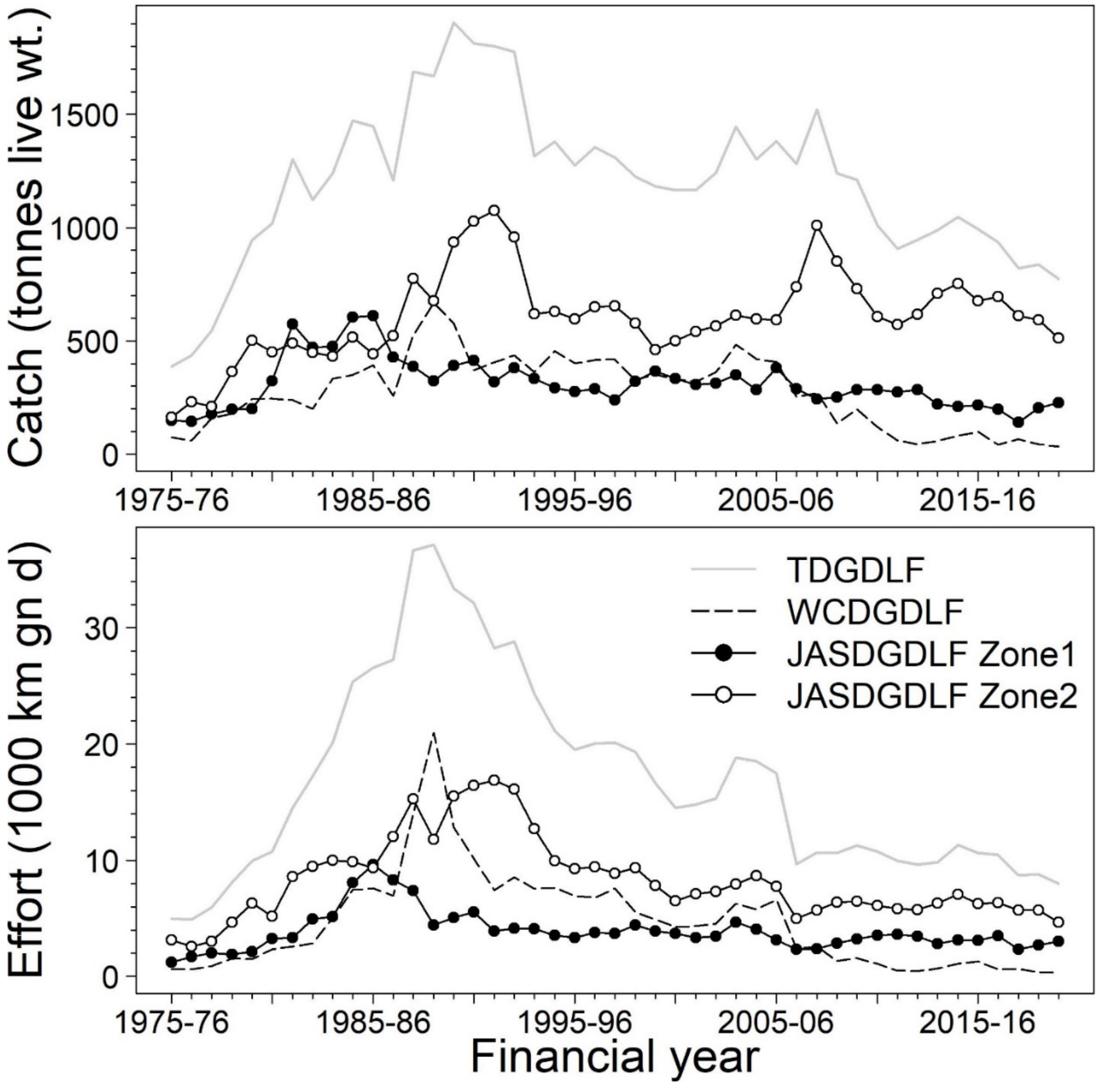
*All reported weights are live weight



TEMPERATE DEMERSAL FIGURE 1.
Map showing the boundaries of the Temperate Demersal Gillnet and Demersal Longline Fisheries.

CATCH AND LANDINGS

For the TDGDLF, the reported catches of elasmobranchs and fishing effort peaked during the late 1980s and early 1990s and have stabilised at lower levels in recent years (Temperate Demersal Figure 2). The catch of sharks in other WA commercial fisheries is **negligible** (~ 10 t). Additionally, boat-based recreational fishers retain very small numbers of sharks in WA (Ryan *et al*. 2019). Scalefish catches are reported in the West Coast and South Coast Demersal Scalefish Resource Status Report chapters, respectively. For a detailed historic account of shark catch and effort in WA refer to Braccini *et al*. (2018).



TEMPERATE DEMERSAL FIGURE 2.
Total elasmobranch catches, and demersal gillnet and longline effort (in km gillnet days, km gn d^{-1}). Black circles = JASDGDLF Zone 1; white circles = JASDGDLF Zone 2; dashed black line = WCDGDLF; plain grey line = total from the three management zones.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Gummy shark (Sustainable - Adequate)

Previous calculations of catch rates defined fishing effort as the product of the net length used per day and the number of days fished per month. This resulted in an historic peak in catch rates in the mid/late 2000s, which coincides with the historic peak in catches. Unfortunately, this catch rate series could not be used to fit population dynamics models. The peak in catch rates was partly due to a systematic increase in the number of hours fished per day in Zone 2 during that period of time. Hence, a new standardisation process was implemented where hours fished per day was included in the definition of fishing effort. Based on this, standardised catch rates have been stable since 2010 (Temperate Demersal Figure 2). The most recent weight of evidence assessment estimated a low current risk level for the gummy shark stock, with 87%, 100% and 100% of the simulated current (2015-16) relative total biomass trajectories being above the target, threshold and limit biomass reference points, respectively (Braccini *et al*. 2018). On the basis of the above, the current status of gummy sharks is **sustainable-adequate.**

Dusky shark (Sustainable - Recovering)

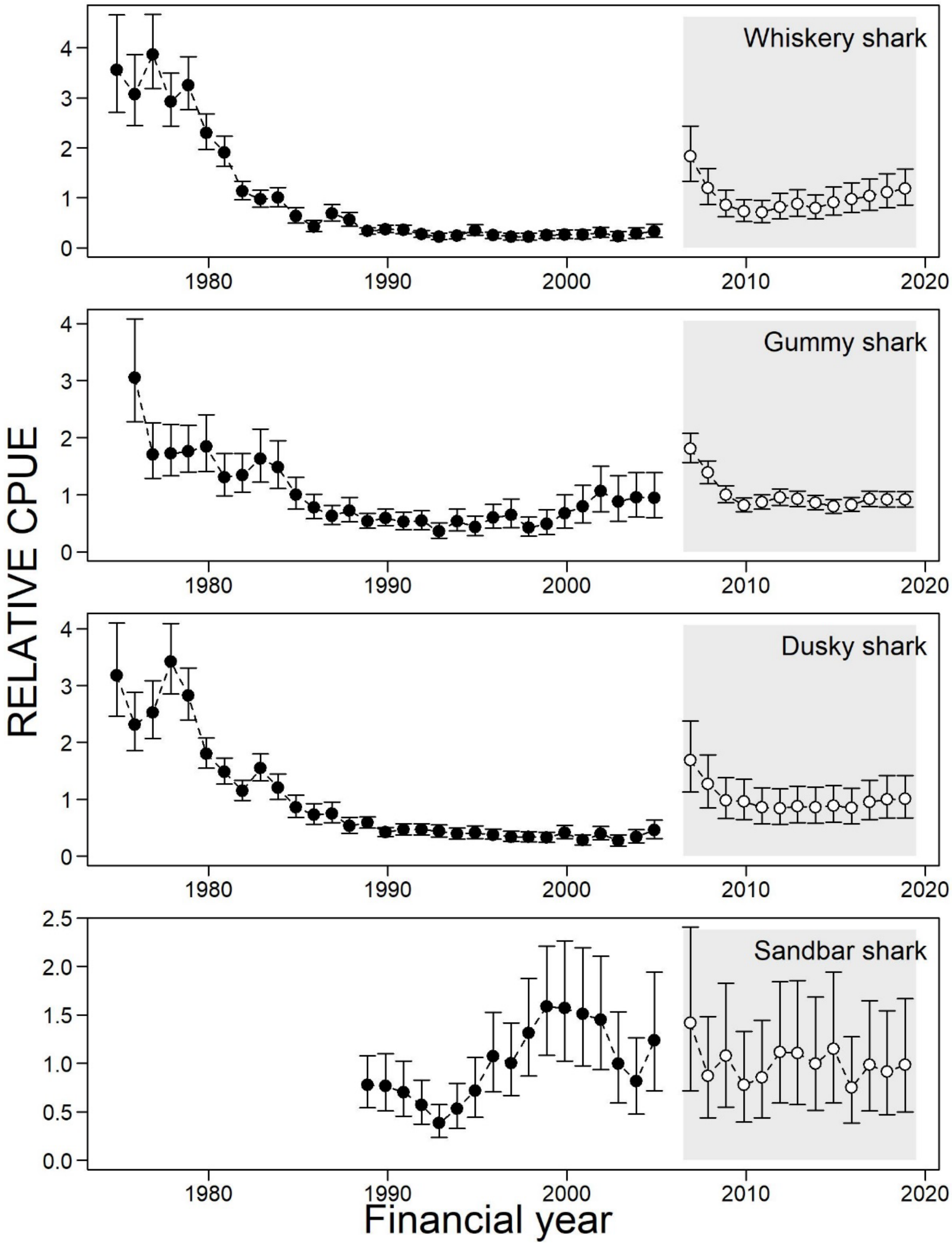
Standardised catch rates have been stable since 2009 (Temperate Demersal Figure 2). The most recent weight of evidence assessment estimated a Medium current risk level for the dusky shark stock, with 46%, 73% and 100% of the simulated current (2015-16) relative total biomass trajectories being above the target, threshold and limit biomass reference points, respectively (Braccini *et al*. 2018). Hence, current management arrangements are considered suitable to allow the gradual recovery of the breeding stock. On the basis of the above, the current status of dusky sharks is **sustainable-recovering.**

Whiskery shark (Sustainable - Adequate)

Significant declines in standardised catch rates in the early 1980s (Temperate Demersal Figure 2) was likely a result of changes in targeting practices (Simpfendorfer *et al*. 2000). Since 2010, standardised catch rates have steadily increased. The most recent weight of evidence assessment estimated a Medium current risk level for the whiskery shark stock, with 82%, 92% and 100% of the simulated current (2015-16) relative total biomass trajectories being above the target, threshold and limit biomass reference points, respectively (Braccini *et al.* 2018). On the basis of the above, the current status of whiskery sharks is **sustainable-adequate.**

Sandbar shark (Sustainable - Recovering)

Standardised catch rates have fluctuated since 2007 (Temperate Demersal Figure 2). The most recent weight of evidence assessment estimated a Medium current risk level for the sandbar shark stock, with 62%, 83% and 99% of the simulated current (2015-16) relative total biomass trajectories being above the target, threshold and limit biomass reference points, respectively (Braccini *et al*. 2018). In addition, recent annual catches have been well below allowable catch tolerance levels. On the basis of the above, the current status of sandbar sharks is **sustainable-recovering.**



TEMPERATE DEMERSAL FIGURE 2.
Relative annual standardised catch rates by species (mean and 95% confidence intervals). Each series has been normalised to a mean score of 1. The shaded area highlights the daily logbook time period.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

The TDGDLF have low levels of discarded bycatch of unsaleable species of sharks, rays and scalefish (McAuley & Simpfendorfer 2003). As maximum potential fishing effort is now explicitly capped at less than 70% of the mid to late 1990s levels, bycatch in all management zones has reduced. Reconstructions of annual bycatch, found dusky morwong, buffalo bream and Port Jackson shark to be the most commonly discarded species (Braccini and Murua in review). The impact of TDGDLF activities on stocks of bycatch species is considered **low** risk.

Protected Species

The TDGDLF has low reported interactions with listed species (McAuley & Simpfendorfer 2003).

For 2019-20, fishers reported catching and releasing 0 Australian sea lions (ASL), 6 dead and 13 alive grey nurse sharks, 3 dead and 10 alive white sharks, 1 alive turtle, and 1 alive giant manta ray (Appendix 2). The impact of TDGDLF activities on protected species is considered to be **low** risk. For a detailed description of species interactions refer to Braccini *et al*. (2018).

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

The level of effort in the TDGDLF is such that the gear is deployed infrequently over approximately 40% of the fisheries' areas and under normal circumstances the physical impact of the gear on the benthic habitat is minimal. Moreover, the very small footprint of each net would combine to make a very small percentage (< 5%) of the area that would be contacted by these gears annually and therefore represents a **negligible** risk to benthic habitats.

Ecosystem

There is no evidence of any systematic change in species diversity, richness or trophic index (Hall & Wise 2011), indicating that the TDGDLF is not having a material impact on food chain or ecosystem structure therefore representing a **low** risk to the ecosystem. For a detailed description of habitat and ecosystem effects refer to Braccini *et al*. (2018).

SOCIAL AND ECONOMIC OUTCOMES

Social

Fishing returns reported that between 32 and 46 skippers and crew were employed in the SDGDLF and between 4 and 6 skippers and crew were employed in the WCDGDLF during 2019-20.

As sharks are generally not targeted by recreational fishers in Western Australia, their direct social importance to this group is **negligible**. However, at the community level sharks generate a high level of community interest and debate, creating **moderate** social amenity and **significant** social risk.

Economic

Shark meat is mostly sold in the WA fish and chip shop market (WCDGDLF and Zone 1 of the SDGDLF) or sold to wholesalers in Adelaide and Melbourne (Zone 2 of the SDGDLF). However, anecdotal evidence suggests that recent tourism expansion in the southwest of the State may have resulted in a higher proportion of shark meat being sold to restaurants and fish retailers around landing ports.

The estimated annual value (to fisheries) for 2019-20 is $2.7 million and $0.11 million for SDGDLF and WCDGDLF, respectively (GVP level 2).

There is currently a **low** risk to this return.

GOVERNANCE SYSTEM

Harvest Strategy

The TDGDLF is managed under a constant catch harvest strategy. Although the harvest strategy has not been formally developed, the operational management objective of the TDGDLF has been 'to maintain the biomass of the fisheries' for the three traditional target stocks (gummy, whiskery and dusky sharks) at or above 40% of their unfished levels'. Management is via input controls in the form of transferable time/gear effort units and restrictions on mesh and hook sizes, net height ('drop') and maximum net length. Maximum acceptable effort levels for each management zone have been based on their respective 2001/02 (daily) levels (Zones 1 & 3 of the SDGDLF: 84,075 km gn.hr^{-1} or 3,503 km gn.d^{-1}; Zone 2 of the SDGDLF: 144,102 km gn.hr^{-1} or 7,205 km gn.d^{-1} ; WCDGDLF: 67,692 km gn.hr^{-1} or 2,832 km gn.d^{-1}).

The 2019-20 effort levels were maintained within these ranges (50,100 km gn.hr^{-1} or 3,014 km gn.d^{-1} for Zones 1 & 3 of the SDGDLF; 88,400 km gn.hr^{-1} or 4,664 km gn.d^{-1} for Zone 2 of the SDGDLF; 9,300 km gn.hr^{-1} or 312 km gn.d^{-1} for WCDGDLF).

Allowable Catch Tolerance Levels

The 2019-20 total catch of sharks and rays was 774 t (289 t for gummy, 191 t for dusky, 36 t for sandbar, and 135 t for whiskery sharks), similar to previous years and within the acceptable catch ranges (725-1,095 t for the four key species and 350-450 t for gummy, 200-300 t for dusky, < 120 t for sandbar and 175-225 t for whiskery sharks).

Whiskery catch was maintained below historical allowable levels due to reductions in targeted effort. Reported dusky shark catches are for *C. obscurus* only. In the past, dusky shark catches had been combined with copper shark (*C. brachyurus*) catches, which is a minor component, and recommended catch ranges were defined for the combined species. Therefore, the recommended catch ranges should be revisited as part of the development of a new harvest strategy.

The catch levels of both the commercial and recreational sectors indicate that the fishery performance for both sectors is considered **acceptable**.

Compliance

TDGDLF vessels are fitted with an Automatic Location Communicator (ALC) that enables the Department to monitor vessels using a Vessel Monitoring System (VMS) and manage compliance with temporal and spatial closures. The Department also undertakes regular vessel inspections to ensure fishing is being undertaken in accordance with the governing legislation.

Consultation

The Department undertakes consultation directly with licensees on operational issues. Industry Management Meetings are held annually between the Department and TDGDLF license holders, in conjunction with the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC).

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

In 2018, the TDGDLF was reaccredited under Parts 13 and 13A of the *Environment Protection and Biodiversity Conservation Act 1999*. The Wildlife Trade Operation export approval, includes conditions associated with monitoring and reviewing the gillnet exclusion zones implemented in mid-2018. The gillnet exclusion zones were negotiated between the State and Commonwealth and are located around identified ASL colonies in the WCDGDLF and the SDGDLF to address potential interactions between ASL and the TDGDLF.

The development of a formal harvest strategy for the Statewide Elasmobranch Resource is expected to be finalised in 2022.

EXTERNAL DRIVERS

The TDGDLF key target species span multiple regional boundaries and sandbar and dusky sharks were targeted in the Northern Shark Fisheries. The risks to these stocks are currently low due to no fishing being undertaken in the Northern Shark Fisheries since 2008/09 and low catches from fisheries other than the TDGDLF.

Environmental drivers pose a low risk to shark stocks. The main external risk to the viability of the TDGDLF is the introduction of Commonwealth Marine Parks (South-west Marine Parks Network introduced July 2018), State Marine Parks and ASL closures, which exclude the use of demersal gillnet and demersal longline in specific areas. The introduction of these spatial closures have resulted in the displacement of fishing effort which has implications for the interpretation of standardised catch rates. These external drivers represent a **moderate** risk.

REFERENCES

Braccini M, Blay N, Hesp A and Molony B. 2018. Resource Assessment Report Temperate Demersal Elasmobranch Resource of Western Australia. Fisheries Research Report No. 294. Department of Primary Industries and Regional Development, Western Australia. 149 p.

Braccini, M. and Murua, H. (in review). The catch of discarded sharks and rays in Western Australia's shark fisheries is negligible compared to the retained catch.

Hall NG, and Wise BS. 2011. Development of an ecosystem approach to the monitoring and management of Western Australian fisheries. FRDC Report – Project 2005/063. Fisheries Research Report No. 215. Department of Fisheries, Western Australia. 112p.

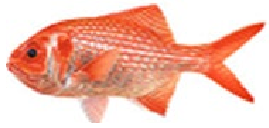
McAuley R, and Simpfendorfer C. 2003. Catch composition of the Western Australian temperate demersal gillnet and demersal longline fisheries, 1994 to 1999. Fisheries Research Report No. 146. Department of Fisheries, Western Australia. 78p.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297. Department of Primary Industries and Regional Development, Western Australia.

SAFS. 2018. Status of Australian Fish Stocks. Fisheries Research and Development Corporation. Canberra. http://fish.gov.au/Reports.

Simpfendorfer CA, Donohue KJ, and Hall NG. 2000. Stock assessment and risk analysis for the whiskery shark (*Furgaleus macki* (Whitey)) in south-western Australia. Fisheries Research 47: 1–18.

SOUTH COAST DEMERSAL SCALEFISH RESOURCE STATUS REPORT 2021



J. Norriss and M. Watt

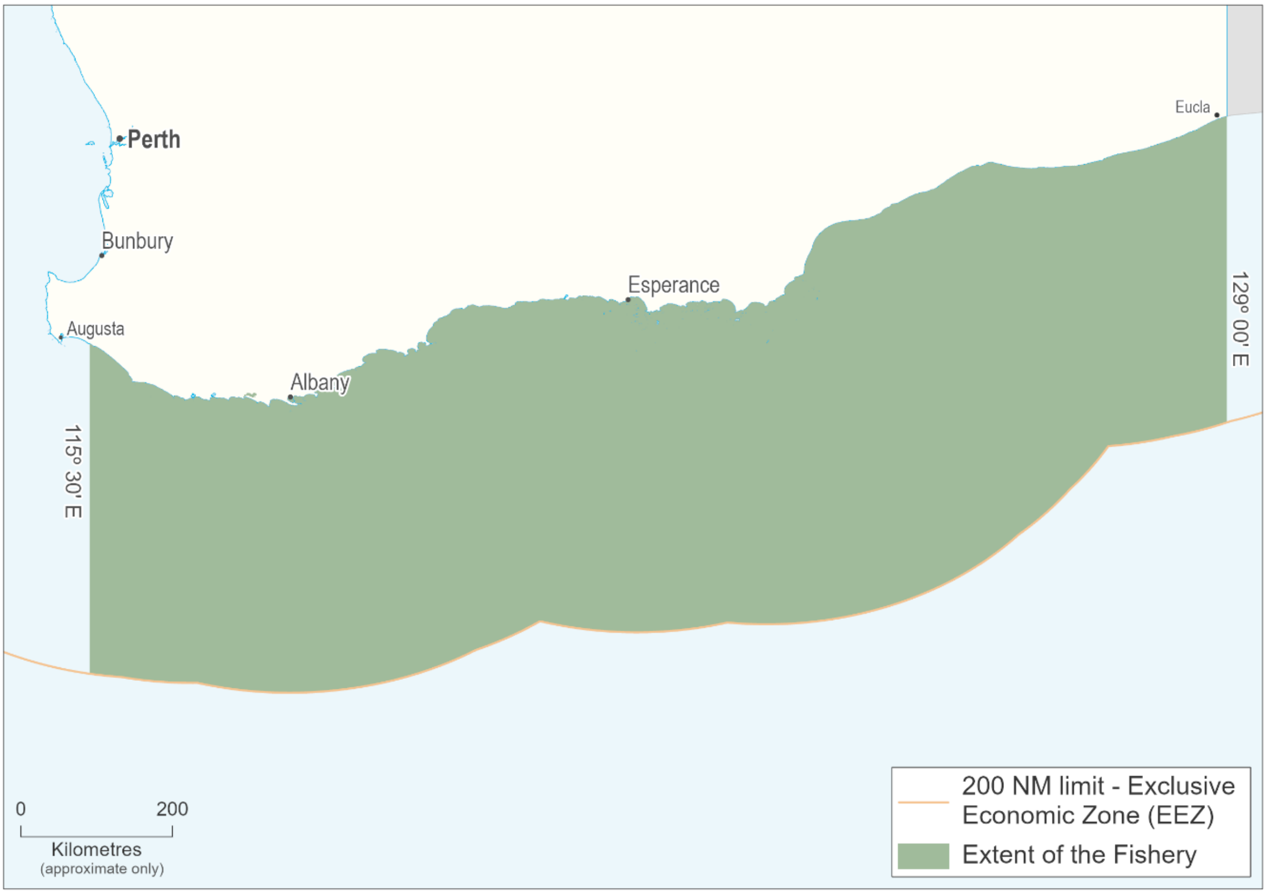
OVERVIEW

The south coast demersal scalefish resource (SCDSR) includes demersal species taken predominantly in marine waters deeper than 20 metres in the South Coast Bioregion (SCB). Indicator species are snapper (*Chrysophrys auratus*), Bight redfish (*Centroberyx gerrardi*), blue morwong (*Nemadactylus valenciennesi*), western blue groper (*Achoerodus gouldii*) and hapuku (*Polyprion oxygeneios*). Commercial fishers take these species predominantly by hook and line, however some species (e.g., blue morwong and western blue groper) are landed by demersal gillnet as part of the Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (JASDGDLMF; see the Temperate Demersal Gillnet and Demersal Longline Fisheries Resource Status Report). Snapper are also taken in estuaries by the South Coast Estuarine Managed Fishery using nets (see South Coast Nearshore and Estuarine Finfish Resource Status). Recreational and charter catches are almost exclusively boat-based using hook and line.

Details rearding the biology and assesment of the indicator species are reported in Norriss et al. (2016: www.fish.wa.gov.au/Documents/research_reports/frr276.pdf).

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (not defined)	Total Catch 2019/20: 201 t	Acceptable
Recreational fishery (not defined)	Total Catch 2017/18: 59–77 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Snapper	Above threshold	Adequate
Bight redfish	Above threshold	Adequate
Blue morwong	Above threshold	Adequate
Western blue groper	Above target	Adequate
Hapuku	Above threshold	Adequate
Ecological		
Bycatch	Low Risk	Acceptable
Listed Species	Negligible Risk	Acceptable
Habitat	Negligible Risk	Acceptable
Ecosystem	Low risk	Acceptable
Economic (GVP $1-5 m)	Moderate Risk	Acceptable
Social (moderate amenity)	Moderate Risk	Acceptable
Governance	Under Review	Under Review
External Drivers	Moderate Risk	Acceptable

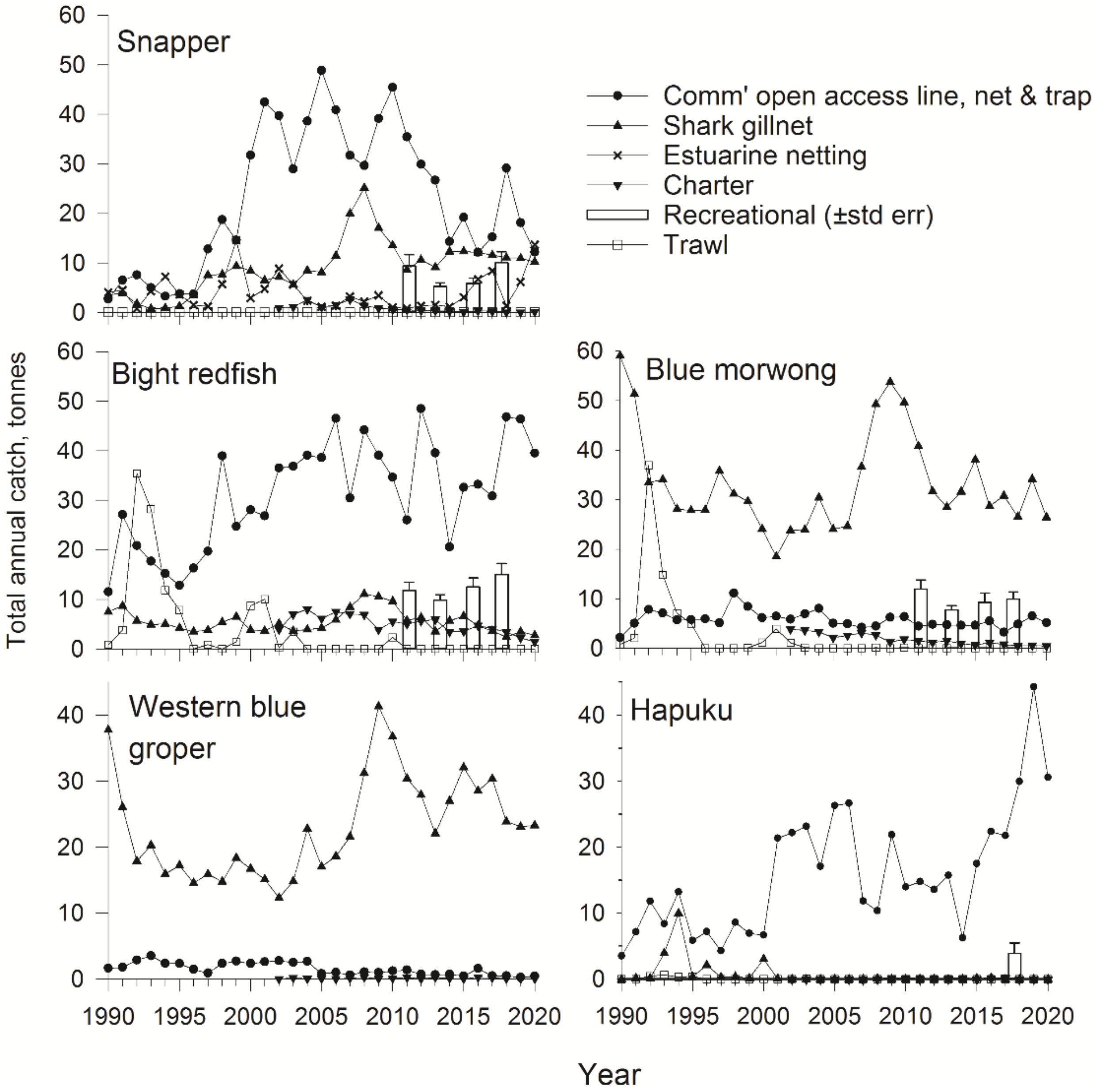


SOUTH COAST DEMERSAL FIGURE 1.
Map showing the boundaries of the south coast demersal scalefish resource.

CATCH AND LANDINGS

The SCDSR total commercial catch of 201 t in 2019/20 was an 11% increase from the 233 t landed in 2018/19. Catches for all indicator species remain within recent historical levels except for hapuku, which increased to the second highest landed catch (South Coast Demersal Figure 2).

The top 10 demersal species in the South Coast represented 99% of the boat-based recreational catch (kept by numbers) in 2017/18. The estimated recreational harvest range for the top 10 demersal species (or groupings) in the South Coast were higher at 68 t (95% CI 59–77) in 2017/18 compared with 45 t (95% CI 38–51) in 2015/16, 33 t (95% CI 30–37) in 2013/14 and 54 t (95% CI 46–63) in 2011/12 (Ryan *et al*. 2019).



SOUTH COAST DEMERSAL FIGURE 2*:*
Annual catches by sector for each demersal indicator species in the South Coast Bioregion from 1989/90 to 2019/20. Commercial and charter catches are now reported for financial year to synchronise with the 1 July 2021 introduction of the South Coast Line and Fish Trap Managed Fishery. Recreational harvest weights for western blue groper/hapuku were too small to be estimated for all/some years, respectively.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Demersal species on the south coast are typically long lived (≥24 years) and slow growing, making them inherently vulnerable to overfishing. Snapper in the SCB, and Bight redfish throughout their distribution in southern WA, comprise single genetic stocks. The stock structure of the other three indicator species is less well known.

Inshore Demersal (Sustainable-Adequate)

A weight-of-evidence assessment that incorporated catch-at-age sampling in 2013 and 2014 indicated risk profiles to be **moderate** for snapper, Bight redfish and blue morwong, and **low** for western blue groper. Fishing mortality and breeding stock levels for these species were therefore considered **sustainable-adequate** (Norriss et al. 2016).

Snapper and Bight redfish (Sustainable-Adequate)

Age-based estimates of fishing mortality (F) and spawning potential ratio (SPR) show these parameters were unlikely to have breached threshold reference levels (1.0 and 0.30, respectively), and had only a remote likelihood of breaching the limit reference levels (1.5 and 0.20, respectively). However, any significant increase in catches beyond the historical range would constitute an unacceptable risk.

Blue morwong (Sustainable-Adequate)

Age-based estimates of F and SPR for females show an almost zero likelihood of breaching threshold reference levels (1.0 and 0.30, respectively). Males were unlikely to have breached these thresholds and there was only a remote likelihood they breached the limit reference levels (1.5 and 0.20, respectively). There is only a very small capacity for increased catches beyond the historical range before risk levels become unacceptable.

Western blue groper (Sustainable-Adequate)

Age-based estimates of F (both sexes) and SPR for females shows an almost zero likelihood of breaching threshold reference levels (1.0 and 0.30, respectively). The male SPR estimate showed that a breach of the threshold was unlikely and a breach of the limit reference level only a remote possibility. There is a small capacity for increased catches beyond recent historical levels.

Hapuku (Sustainable-Adequate)

An age-based assessment from sampling of the 2005 and 2006 catches estimated F to be within target and threshold levels (Wakefield *et al*. 2010). A recent, updated analysis of that data, which assumed variable recruitment and age-based selectivity, generated two spawning potential ratio estimates (±95% c.i.) using the per recruit and dynamic pool methods: 0.48 (0.43 - 0.54) and 0.44 (0.38 – 0.50) respectively, indicating a high likelihood that spawning biomass was above the threshold reference level of 0.30. Simultaneously generated estimates of fishing (F) and natural mortality (M) year[1] were 0.045 (0.04-0.05) and 0.09, respectively, giving an F/M estimate of 0.50 (0.42 – 0.60), well below the threshold reference level of 0.67. The new analysis shows the breeding stock was adequate, and level of fishing mortality sustainable, at the time the sample was collected. However, catches have increased to record highs in recent years. Age samples have been collected recently and a new, updated assessment is in progress.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Line fishing for demersal species using baited hooks is highly selective for demersal scalefish, with only low levels of catches of species that are not retained (i.e. **low** risk). The risk to protected species from interactions with commercial line fishers is **negligible**.

HABITAT AND ECOSYSTEM INTERACTIONS

Line fishing using baited hooks has minimal physical impact on the benthic environment and therefore constitutes a **negligible** habitat risk. An analysis of a long time series of commercial fishery data showed no reduction in mean trophic level in the finfish catches within the SCB (Hall and Wise 2011), suggesting a **low** ecosystem risk.

SOCIAL AND ECONOMIC OUTCOMES

Social

The SCDSR provides **moderate** level of social amenity to recreational fishing and diving and to consumers via commercial fish supply to markets and restaurants. There is currently a medium level of risk to these values.

The annual estimated boat-based recreational fishing effort in the South Coast Bioregion was steady in 2017/18 (21,460 boat days, SE=1,680) compared with 2015/16 (24,444 boat days, SE=2,042), and lower than 2013/14 (28,277, SE=2,323), and 2011/12 (40,073, SE=3,354) (Ryan *et al*. 2019).

Economic

In 2019/20, a total of 75 commercial line/trap or estuarine net vessels reported taking demersal scalefish and it is estimated that ~210 fishers were directly employed (i.e., ~3 crew per vessel). Employment is also generated by seafood processors in the SCB. The estimated gross value of product (GVP) for the SCDSR in 2020 was $1-5 million, which is subject to a **moderate** level of risk.

Recreational fishers make a significant contribution to Western Australia's economy, and support economic activity in many regional towns on the coast and near inland fishing spots. These resources contribute in part to the $2.4 billion attributed to the value of recreational fishing to the WA economy each year (McLeod and Lindner 2018).

GOVERNANCE SYSTEM

The South Coast commercial line fishery operated under open-access arrangements (as opposed to a Management Plan) until the commencement of the *South Coast Line and Fish Trap Managed Fishery Management Plan 2020* from 1 July 2021 (see below). The recreational sector is managed through a range of input and output controls such as a Recreational Fishing from Boat Licence, bag and size limits authorised under the *Fish*

Resources Management Act 1994 and *Fish Resources Management Regulations 1995*.

Harvest Strategy

A formal harvest strategy has not been developed for this resource.

Allowable Catch Tolerance Levels (Acceptable)

Not developed, but a recent stock assessment recommending that catches remain within the historical range (Norriss et al. 2016).

Compliance

Fisheries and Marine Officers conduct both at-sea and on-land inspections.

Consultation

A broad consultation process continues as part of the implementation of the *South Coast Line and Fish Trap Managed Fishery Management Plan 2020*, which commenced 1 July 2021. This includes consulation with commercial fishers regarding transitioning to new management arrangements and the use of a new formal daily/trip fishing log book (see Management Initiatives/Outlook Status below). Consultation also occurs with the West Australian Fishing Industry Council (WAFIC) on management issues and initiatives. For the recreational sector, consultation processes are facilitated by Recfishwest under a Service Level Agreement, although the Department undertakes direct consultation with the community on specific issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

The *South Coast Line and Fish Trap Managed Fishery Management Plan 2020* formally commences from 1 July 2021 following extensive consultation and a review of the previous open-access arrangements. The Plan introduces different classes of fishing license with varying entitlements with regard to fishing gear and access to spatial zones.

EXTERNAL DRIVERS

Bight redfish are an important component of the catch of the Great Australia Bight Trawl Sector, a Commonwealth managed fishery permitted to operate across southern Australia as far west as Cape Leeuwin. Bight redfish landings by that fishery in 2019/20 were 170 t, or 28% of the Commonwealth TAC, predominantly from continental shelf waters (depths usually 120-200 m) off South Australia and the western Great Australian Bight (GAB) east of 125º E (Moore *et al.* 2020). Limited analysis indicates genetic homogeneity between Western Australia and the Great Australian Bight but there is some separation based on otolith chemistry between southwest WA and the GAB (Norriss *et al.* 2016).

REFERENCES

Department of Fisheries. 2015. The south coast commercial fish trap, g-net and open-access line and net scalefish fisheries and squid jig fishery review. Discussion paper. Fisheries Management Paper No. 270. Department of Fisheries WA, Perth.

Hall NG, and Wise BS. 2011. Development of an ecosystem approach to the monitoring and management of Western Australian fisheries. Final FRDC Report – Project 2005/063. Fisheries Research Report, No. 215. Department of Fisheries, Western Australia.

McLeod P, and Lindner R. 2018 Economic dimensions of recreational fishing in Western Australia. Research report for the Recreational Fishing Initiatives Fund, October 2018, 83p.

Moore A, Maloney L, and Mobsby D. 2020. Great Australia Bight Trawl Sector. In: Patterson, H, Larcombe J, Woodhams, J, and Curtotti, R, *Fishery status reports 2020*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 4.0. https://doi.org/10.25814/5f447487e6749.

Norriss JV, Fisher EA, Hesp SA, Jackson G, Coulson PG, Leary T, and Thomson AW. 2016. Status of inshore demersal scalefish stocks on the south coast of Western Australia. NRM Project 12034 Final Report. Fisheries Research Report, No. 276. Department of Fisheries, Western Australia, 116 pp.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia

Wakefield CB, Newman SJ, Molony BW. 2010. Age-based demography and reproduction of hapuku, *Polyprion oxygeneios*, from the south coast of Western Australia: implications for management. ICES Journal of Marine Science 67(6), 1164-11

NORTHERN INLAND BIOREGION

ABOUT THE BIOREGION

The Northern Inland Bioregion, which encompasses the northern half of Western Australia, is predominantly a desert area, with few permanent water bodies. As a result of occasional summer cyclones, the various river systems flow at flood levels for short periods before drying-out to residual waterholes. The only exceptions to this are man-made dams which trap rainfall for water supply purposes and irrigation.

The only significant fishable water body in the region is Lake Argyle, created by the damming of the Ord River. The continuous release of water from the dam has resulted in the Ord River maintaining its freshwater fish populations year-round, as does the lake, where some freshwater native fish populations have expanded (e.g. silver cobbler).

Populations of reptiles, such as the protected freshwater crocodile, are also supported by the expanded food chain of native fish, and are thought to have increased significantly from their original billabong-based populations.

SUMMARY OF ACTIVITIES POTENTIALLY IMPACTING THE BIOREGION

Climate Change

Some of the key environmental trends that may be affecting ecosystems in WA (state-wide) include:

- Increasing frequency of *El Niño*/Southern Oscillation (ENSO) events;
- More years with a weaker Leeuwin Current;
- Increases in water temperature off the lower west coast of WA;
- Increases in salinity, which includes large annual fluctuations;
- Change in the frequency and location of storms (and rainfall) affecting the lower west coast; and
- Change in the frequency of cyclones (and summer rainfall) affecting the north-west coast.

The Northern Inland Bioregion is predicted to have relatively minor impacts from climate change, especially in the coming decade, compared to more southerly locations. The variables expected to drive climate change impacts include changes in rainfall and extreme weather conditions (e.g. cyclones and tropical storms).

Commercial Fishing

The main water body in the Northern Inland Bioregion, Lake Argyle, is a man-make lake in the East Kimberley that was formed in 1973 following the completion of the Ord River Dam. The lake supports the State's only commercial freshwater fishery, the Lake Argyle Silver Cobbler Fishery (LASCF). In Lake Argyle, the population of silver cobbler (*Neoarius midgleyi*) increased after the Ord River Dam was first filled to capacity in the 1974 wet season. The LASCF uses gillnets to specifically target this species.

Recreational Fishing

Relative to the commercial catch, the total recreational catch of silver cobbler is likely to be small but is currently unable to be estimated. A small recreational and charter boat fishery for this species exists in Lake Argyle with fishing activities peaking during the dry season (winter months). The 2017/18 iSurvey of boat-based recreational fishing in WA[1] indicated that silver cobbler are targeted mainly by hook and line fishing, with the majority of fish being released after capture. A single charter vessel has operated in Lake Argyle since 2001, with very few silver cobbler being retained.

Lake Argyle and its associated river system also support recreational fishing for cherabin (freshwater prawns). Limited surveys of recreational fishing in this region have been completed and shore-based and riverine recreational catches are unavailable at this time.

Aquaculture

Aquaculture development operations in the region have previously included the production of barramundi from cage operations in Lake Argyle, and a small but growing pond production of redclaw crayfish in the Ord River irrigation system around Kununurra.

1 Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate, A.,Taylor SM, Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia. 195pp.

Tourism

A small scale tourism industry operates on Lake Argyle, with boat operators, helicopter and plane flights, fishing, canoeing and bird watching. There is recreational boating usage on the Lake including water skiing and swimming. Since 2012 the State Government has funded a stock enhancement project at Lake Kununurra to create an impoundment based recreational barramundi fishery in the region.

Other Factors

While the Lake was created to supply water for irrigation and hydroelectric power generation in the Ord River Irrigation Area, it is also a source of water for supplying mining operations, town water supplies and a large number of industrial operations.

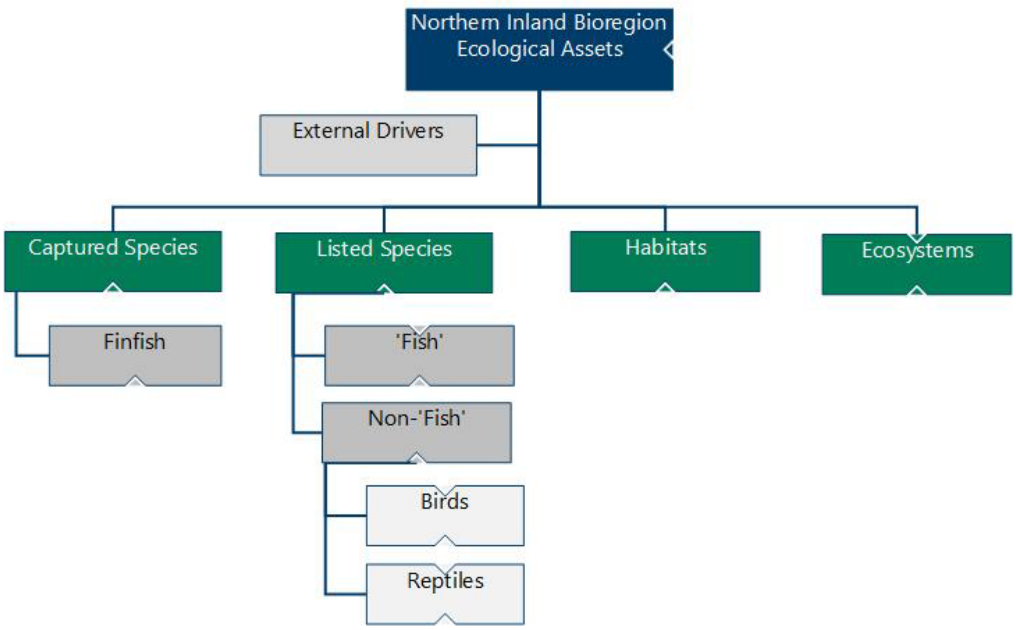
BIOREGIONAL SPECIFIC ECOSYSTEM MANAGEMENT

Within each Bioregion there are a range of management measures that have been implemented to manage the potential impact of activities (See the Ecosystem Management Section for an overview).

As one of the key ecosystem risks is the introduction of non-endemic species, the Department has an approval process in place for assessing proposals to translocate live non-endemic fish species into and within Western Australia, so as to minimise the environmental risks to freshwater ecosystems in the Northern Inland Bioregion associated with this activity. The introduced cane toad (*Rhinella marina*) has also been reported from around Kununurra and will likely reach Lake Argyle within a few years, posing a major threat to the system.

ECOSYSTEM MONITORING AND STATUS

In order to assess the adequacy of management arrangements aimed at ensuring sustainability of the ecological assets within the Northern Inland Bioregion, the Department must identify and monitor trends in the condition of these resources. This is achieved through application of an Ecosystem Based Fisheries Management (EBFM) framework (see How to use this Volume for more information) to identify, in a hierarchical manner, the key ecological resources that require ongoing monitoring and assessment. (*See How to Use section for more details*). The key ecological assets identified for the Northern Inland Bioregion are identified in Northern Inland Overview Figure 1 and their current risk status reported on in the following sections.



NORTHERN INLAND ECOSYSTEM MANAGEMENT FIGURE 1
Component tree showing the ecological assets identified and separately assessed for the Northern Inland Bioregion.

External Drivers

External factors include factors impacting at the bioregional-level that are likely to affect the ecosystem as whole and may not fall within the direct control of Fishery legislation (e.g. climate change). An understanding of these factors, which are typically environmental (e.g. cyclones, floods and droughts) is necessary to fully assess the performance of the ecological resource. The main external drivers identified with potential to affect the Northern Inland Bioregion include climate change and introduced pests and diseases[1].

Climate

External Drivers	Current Risk Status
Climate	MEDIUM

The Northern Inland Bioregion is predicted to have relatively minor impacts from climate change in the coming decade, compared to more southerly Bioregions.

Captured Species

FINFISH

Captured Species	Aquatic zone	Ecological Risk
Native Finfish	Freshwater	LOW

The LASCF operates throughout Lake Argyle using gillnets to target silver cobbler (*N. midgleyi*). As silver cobbler is essentially the only retained species, the main impacts of the fishery on the ecosystem are likely to be due to the removal of individuals of this species. The Fishery removes only a small portion of the overall biomass of this species within the lake.

Listed Species

Fish

Listed Species	Aquatic zone	Ecological Risk
Fish	Freshwater	NEGLIGABLE

The stocks of native freshwater fishes are not under threat.

Non-Fish

Listed Species	Aquatic zone	Ecological Risk
Birds and Reptiles	Freshwater	LOW

There is an incidental capture of freshwater or Johnston's crocodiles (*Crocodylus johnstoni*) and some tortoises by the LASCF. Where practicable freshwater crocodiles are released alive, however, there is an incidental mortality of some individuals that do not impact the ongoing sustainability of the species. It should be noted that Lake Argyle is an impoundment and despite incidental capture, the population of crocodiles in that water body is considerably larger than it was in its pre-impoundment state.

Habitats and Ecosystems

Category	Aquatic zone	Current Risk Status
Habitats	Freshwater	LOW
Ecosystems	Freshwater	LOW

The Northern Inland Bioregion occurs north of Shark Bay (27˚S), from the coastline to the Northern Territory borders. Within the Bioregion are a series of freshwater rivers and wetlands which have native fringing vegetation and aquatic plants and provide habitat for birds, frogs, reptiles, native fish and macroinvertebrates.

Lake Argyle, with its large capacity, deep water and rapidly fluctuating water levels, provides a range of habitats not available at the adjacent Lake Kununurra or downstream Ord River. Most of the eastern and southern shoreline of Lake Argyle is bare sediment, with highly variable water levels preventing the establishment of plants. There are areas of emergent sedges (*Eleocharis brassii*), as well as submerged aquatic plants such as *Myriophyllum spp.*, *Najas tenuifolia* and *Potamogeton sp*. However, distribution is limited to localised patches where large weed mats can form. The western and northern shorelines are generally steeper and consist of rock exposed by wave action.

Gillnets have relatively low habitat impacts and fishers actively avoid fishing in areas where the nets may become entangled on submerged vegetation in Lake Argyle.

1 Biosecurity issues are now reported by the Biosecurity pillar of the Department of Primary Industries and Regional Development.

FISHERIES

NORTHERN INLAND LAKE ARGYLE FINFISH RESOURCE STATUS REPORT 2020

S. Newman, C. Skepper, G. Mitsopoulos and L. Wiberg

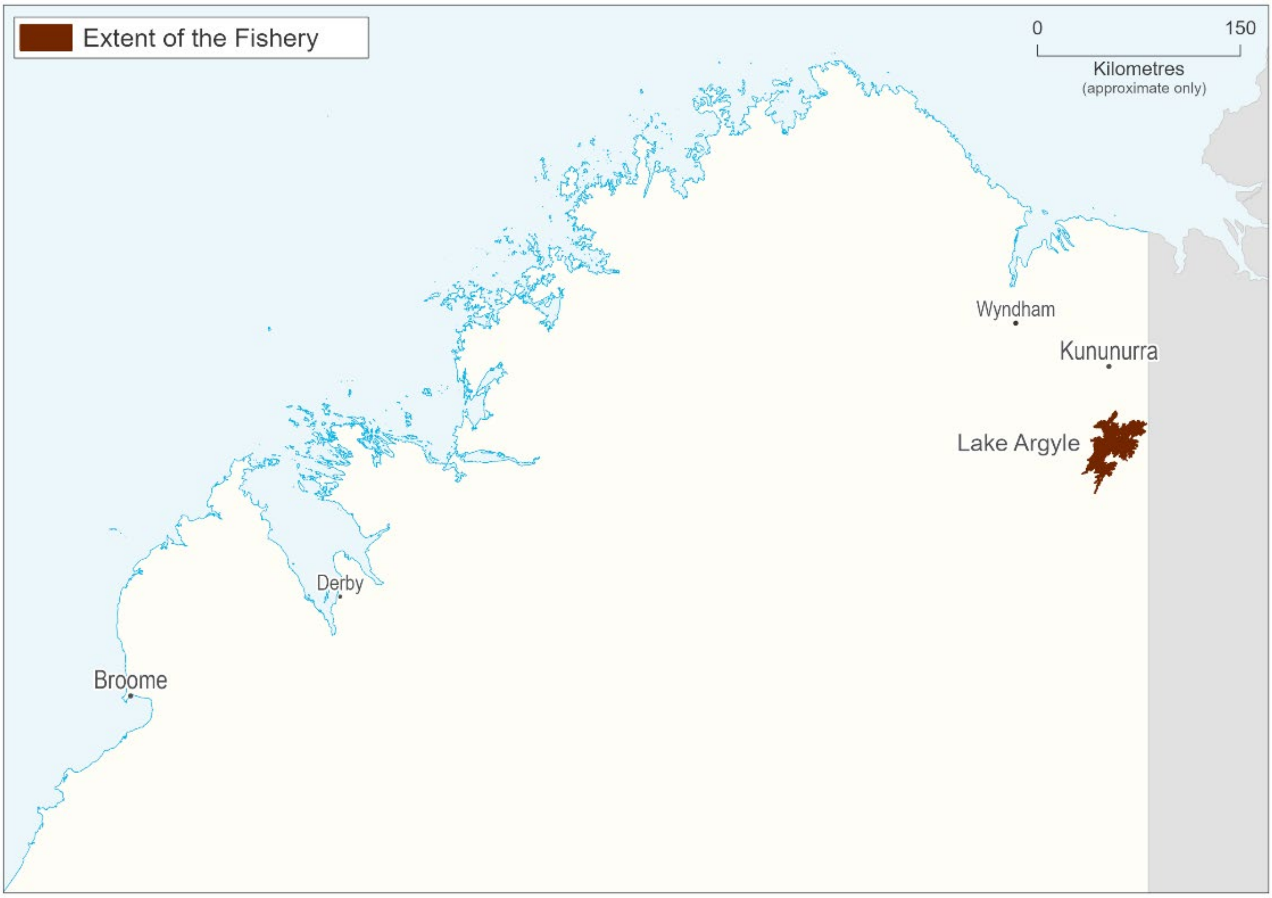
OVERVIEW

The Lake Argyle Silver Cobbler Fishery (LASCF) is the only commercial freshwater fishery in Western Australia. This gillnet fishery is located in the artificially created Lake Argyle in the north-eastern Kimberley (Lake Argyle Silver Cobbler Figure 1) and specifically targets silver cobbler (*Neoarius midgleyi*), with catches of barramundi (*Lates calcarifer*) not permitted. A small recreational and charter boat fishery also operates in Lake Argyle and surrounding waters for silver cobbler and barramundi, with fishing activities peaking during the dry season (winter months).

In addition to the waters of Lake Argyle, recreational anglers can fish in all creeks and tributaries that feed into the Ord River and Lake Argyle.

SUMMARY FEATURES

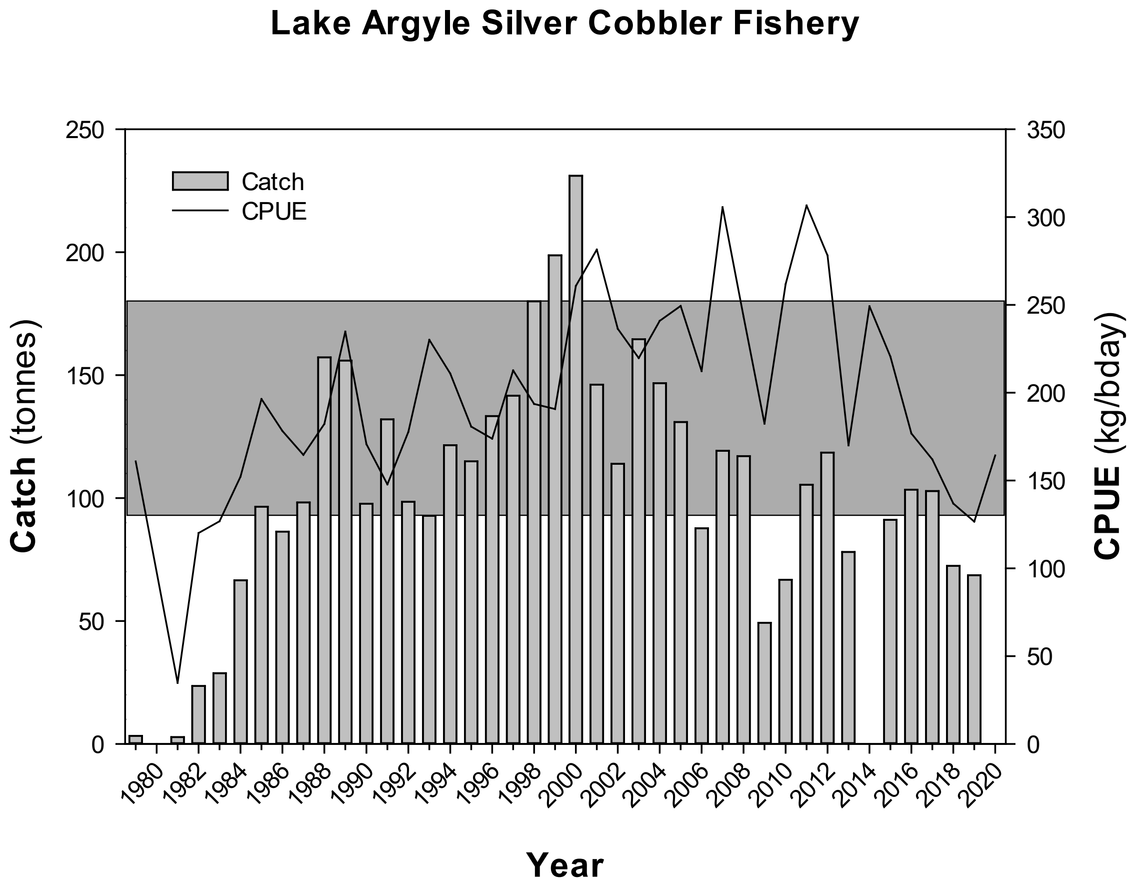
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (93-180t)	Total Catch 2020: Not reportable.	Acceptable
Recreational fishery (NA)	Total Catch 2020: NA	Acceptable
EBFM		
Indicator species		
Silver Cobbler	Below target commercial catch range	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Negligible Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (GVP $ <1 m)	Low Risk	Acceptable
Social (low amenity)	Low Risk	Acceptable
Governance	Stable	Acceptable
External Drivers	Low Risk	Acceptable



LAKE ARGYLE SILVER COBBLER FIGURE 1.
Location of the Lake Argyle Silver Cobbler Fishery in northwestern Australia illustrating the remoteness and extent of the fishery.

CATCH AND LANDINGS

Following the damming of the Ord River in 1971 and the creation of Lake Argyle, the commercial fishery first developed in 1979 with annual catches of silver cobbler landed up to 1984 being less than 41 t (Lake Argyle Silver Cobbler Figure 2). From 1984 catches increased to reach a historical peak of 231 t in 2000 and then, following reductions in effort, catches steadily declined to a low of <50 t in 2009 (Lake Argyle Silver Cobbler Figure 2). Catches from 2009 to 2020 have fluctuated between 49 t and 119 t.



LAKE ARGYLE SILVER COBBLER FIGURE 2.
The annual catch and catch per unit effort (CPUE, kg block day-1) for silver cobbler in the Lake Argyle Silver Cobbler Fishery over the period from 1979 to 2020. The upper and lower bounds of the target commercial catch range are shown by the shaded catch area between 93 and 180 tonnes. Catch is not reportable in those years where less than three vessles fish.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Northern Inland (Sustainable-Adequate)

Data for assessing the status of the silver cobbler stock in Lake Argyle are derived from the catch and effort returns provided by industry. These data are compiled annually and used as the basis for this assessment. Biological data on the species' specialised reproductive behaviour and low fecundity are used to interpret these assessments. There remains uncertainty around the biological parameters (e.g. longevity, growth rate) for silver cobbler.

The level of catch in the fishery in 2020 is below the acceptable catch range. This level of catch is considered acceptable as the effort in the fishery is relatively low and catch rate is within the historical range. The lower level of catch in the fishery in recent years is likely to have allowed the spawning stock biomass to increase. The above evidence indicates the biomass of this stock is unlikely to be depleted and recruitment is unlikely to be impaired and that current levels of fishing mortality (catch) are unlikely to cause the stock to become recruitment impaired.

On the basis of the evidence provided above, the silver cobbler stock is classified as **sustainable-adequate**.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

As a result of the large mesh size used relative to the species present in the lake, there is minimal fish by-catch in this fishery. **Negligible** risk.

Protected species

Although Lake Argyle is an artificially-created aquatic environment it is now designated as a wetland of international importance under the Ramsar Convention. There is an incidental capture of freshwater or Johnston's crocodiles (*Crocodylus johnstoni*) and some turtles by the silver cobbler fishery in Lake Argyle. Where practicable, freshwater crocodiles and turtles are released alive, and based on the reports by fishers, only low levels of crocodile and turtle capture occur and this is considered to be of **low** risk to the stock.

HABITAT AND ECOSYSTEM INTERACTIONS

The gillnets used in this fishery have minimal impact on the habitat. This results in a **negligible** risk to the overall ecosystem from the fishery.

SOCIAL AND ECONOMIC OUTCOMES

Social

During 2020, two vessels fished in the LASCF, with an average crew of 2 people per vessel, indicating that four people were directly employed in the fishery, which operates from 1 January to 31 October each year. Additional employment occurs throughout the fish processing and distribution networks. **Low** risk.

Economic

The fishery's score value in 2019 was estimated to be Level 1 (i.e. Risk level – **Low**; Economic value – < $1 million). There is limited social amenity value for the silver cobbler fishery. There is currently a **low** level of risk to these values.

Recreational fishers make a significant contribution to Western Australia's economy, and support economic activity in many regional towns on the coast and near inland fishing spots. These resources contribute in part to the $2.4 billion attributed to the value of recreational fishing to the State's economy each year.

GOVERNANCE SYSTEM

Harvest Strategy

The harvest strategy for silver cobbler in the Lake Argyle Silver Cobbler Fishery in the Northern Inland Bioregion of Western Australia is based on a constant exploitation approach where the annual commercial catches of silver cobbler are allowed to vary proportional to stock abundance within the target catch range.

Annual Catch Tolerance Levels (Acceptable)

The target commercial catch range is calculated based on catch information from 1990 – 1998, a period during which the fishery was stable and levels of exploitation were considered to have been sustainable. The catch range is specified as the values within the minimum and maximum catches observed during the reference period. The target catch range is 93 – 180 t. The level of catch in the fishery in 2020 is below the target acceptable catch range. The catch rate is within the historical range, and the lower level of catch in the fishery in recent years is likely to have allowed the stock to increase and it is thus considered **adequate**.

Compliance

A licence condition restricts the net type permitted, with fishers permitted to use no more than 1,500 m of set nets at any one time. These nets must have a minimum mesh size of 159 mm and maximum net drop of 30 meshes.

The management arrangements for the fishery are contained in the *Prohibition on Commercial Fishing (Lake Argyle) Order 2012*. The six Fishing Boat Licences listed are prohibited from taking any fish by means of nets during the period from 1 November to 31 December in any year. This seasonal closure is aimed at protecting silver cobbler during the spawning season. Additionally, at this time of the year water temperatures in the lake are high and would cause spoilage of fish in the nets. Commercial operators in the LASCF are not permitted to take barramundi at any time and all nets used by LASCF fishers must be suitably marked with licence identification.

Consultation

The Aquatic Resource Management Division of the Department of Primary Industries and Regional Development undertakes consultation directly with licensees on operational issues. Industry Management Meetings are convened by the West Australian Fishing Industry Council (WAFIC), who are also responsible for statutory management plan consultation under a Service Level Agreement with the Department. Consultation processes for the recreational fishing sector are facilitated by Recfishwest under a Service Level Agreement with the Department, although the Department undertakes direct consultation with the community on specific issues.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives (Stable)

The next management review for the Fishery is scheduled for 2022/23. The Lake Argyle Silver Cobbler Fishery Ecological Code of Practice is being reviewed and updated by industry.

EXTERNAL DRIVERS

A number of external factors may impact on the silver cobbler biomass. These include the introduced cane toad (*Rhinella marina*) which has been observed in Lake Argyle and may affect prey and predators of silver cobbler.

The population of the freshwater crocodile (*Crocodylus johnstoni*) has increased and is likely to impact silver cobbler biomass in the form of predation and competition for food. The external drivers currently pose a **low** risk to the stock

SOUTHERN INLAND BIOREGION

ABOUT THE BIOREGION

This region contains WA's only natural permanent freshwater rivers, which are fed by rainfall through winter and spring. These permanent rivers are restricted to the high-rainfall south-west corner of the State and flow through native forest areas. Some of the rivers are more saline in their upper reaches owing to the effects of agricultural clearing of native vegetation.

Across the remainder of the Southern Inland Bioregion, rivers flow primarily during the winter, with occasional summer flows from inland, rain-bearing depressions, resulting from decaying cyclones. Most large fresh water bodies are man-made drinking water dams, irrigation water supply dams or stock-feeding dams.

There is a diverse variety of natural water bodies in this region ranging from numerous small springs and billabongs, up to Lake Jasper, the largest permanent freshwater lake in the South West region, with 440 ha of open water up to 10 m deep. In combination, these diverse natural and man-made permanent waterbodies provide valuable habitat for fish and freshwater crustaceans during the summer months. Some natural salt lakes also occur but these generally dry out over summer each year.

The few natural freshwater rivers and man-made lakes support native fish and crustaceans and create an environment, particularly in forest areas, which is highly valued by the community for a variety of recreational pursuits.

SUMMARY OF ACTIVITIES POTENTIALLY IMPACTING THE BIOREGION

Climate Change

The Southern Inland Bioregion is expected to be affected similarly to the West and South Coast Bioregions, mainly a result of predicted further reductions in rainfall and increases in temperature.

Commercial Fishing

There are currently no commercial fisheries in the Southern Inland Bioregion.

Recreational Fishing

The Southern Inland Bioregion provides significant recreational fishing opportunities. The major species fished recreationally are native marron, trout (both rainbow and brown trout) produced and stocked by the Department into public dams and rivers, and feral redfin perch, an introduced, self-perpetuating species. The native freshwater cobbler is also taken in small numbers.

Aquaculture

Aquaculture development in the Southern Inland Bioregion is dominated by the farm-dam production of yabbies, which can reach about 200 t annually depending on rainfall and market demand. Semi-intensive culture of marron in purpose-built pond systems provides around 60 t per year and has some potential to expand.

Rainbow trout have historically been the mainstay of finfish aquaculture production in this region, originating from the heat-tolerant stock maintained at the Department's Pemberton Freshwater Research Centre. Silver perch are also grown in purpose-built ponds to supply local markets.

Tourism

The bioregion is a popular tourist destination which is known for its national parks and wineries. Recreational fishing in the region's lakes and rivers is also important for both residents and tourists.

BIOREGIONAL SPECIFIC ECOSYSTEM MANAGEMENT

Within each Bioregion there are a range of management measures that have been implemented to manage the potential impact of activities (See the Ecosystem Management Section for an overview). Management measures specific to the South Inland Bioregion are detailed below.

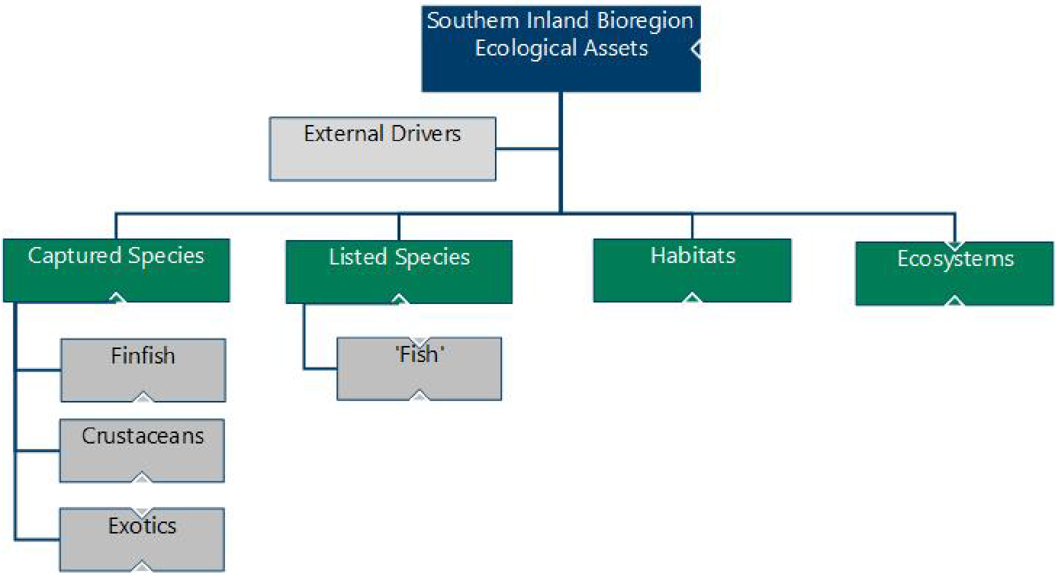
The conservation of the 11 species of freshwater native fishes in freshwater ecosystems in the South-West of WA is an issue for the Department. Most of these species are only found in WA, all have had major contractions in their distribution as a result of habitat loss. Many species now only consist of small, fragmented populations, and half are now listed as threatened. They are under pressure from feral fish populations, migration barriers (bridges and dams) and urban land-use development, particularly in the form of unfiltered storm water discharge from roads into natural waterbodies.

The Department undertakes a risk-based approach to managing the spread of feral fish in the bioregion. To support this, it has developed a community based reporting tool and education program to support its own routine surveillance activity. Information on aquatic pest distribution is used to prioritise management actions aimed at limiting the impact and preventing the spread of high risk pest fish within the State's freshwater ecosystems.

A key element of reducing the risk of feral fish is the approval process that the Department has in place for assessing proposals to translocate live non-endemic fish species into and within Western Australia, so as to minimise the environmental risks to freshwater ecosystems associated with this activity.

ECOSYSTEM MONITORING AND STATUS

In order to assess the adequacy of management arrangements aimed at ensuring sustainability of the ecological assets within the Southern Inland Bioregion, the Department must identify and monitor trends in the condition of these resources. This is achieved through application of an Ecosystem Based Fisheries Management (EBFM) framework (see How to use this Volume for more information) to identify, in a hierarchical manner, the key ecological resources that require ongoing monitoring and assessment. (See How to Use section for more details). These key ecological assets identified for the Southern Inland Bioregion are identified in Southern Inland Ecosystem Management Figure 1 and their current risk status reported on in the following sections.



SOUTHERN INLAND ECOSYSTEM MANAGEMENT FIGURE 1
Component tree showing the ecological assets identified and separately assessed for the Southern Inland Bioregion.

External Drivers

External drivers include factors impacting at the bioregional-level that are likely to affect the ecosystem as a whole and may not fall within the direct control of Fishery legislation (e.g. climate change). An understanding of these factors, which are typically environmental (e.g. floods and droughts) is necessary to fully assess the performance of the ecological resource. The main external drivers identified with potential to affect the Southern Inland Bioregion include climate (i.e. a drying climate), habitat loss and introduced pests and diseases.

Climate

External Drivers	Current Risk Status
Climate	MEDIUM

The south west of Western Australia is predicted to be heavily influenced by the impacts of climate change (e.g. increasing sea temperatures, declines in rainfall). Further reductions in rainfall are expected for the Southern Inland Bioregion.

Captured Species

Native Finfish

Captured Species	Aquatic zone	Ecological Risk
Native Finfish	Freshwater	HIGH (non-fishing)

The abundance and distribution of most native fish, include the native cobbler (*Tandanus boostockii*), have been severely impacted due to land and water management practices. This has

led to widespread fragmentation of native fish populations (i.e. local extinctions). Competition with feral fishes has also decreased abundance of native fishes in freshwater systems in the Southern Inland region.

Native Crustaceans

Captured Species	Aquatic zone	Ecological Risk
Native Crustaceans	Freshwater	HIGH (non-fishing)

The recreational marron fishery has its own licence. The abundance of smooth marron (*Cherax cainii*) has been monitored at regular intervals for a number of decades. The fishery arrangements have been through a number of significant updates to ensure that the catch is sustainable. The biggest threat to these stocks is from non-fishing causes, especially due to reduced rainfall and habitat loss.

Exotics

Captured Species	Aquatic zone	Ecological Risk
Exotics (stocked)	Freshwater	LOW

Anglers require a south-west freshwater angling licence to capture trout, native cobbler and other freshwater angling species. Trout have been stocked into a limited number of streams in WA for decades. The trout are produced from the Pemberton Freshwater Research Centre and are tolerant of warmer water temperatures. Research activities are aimed at improving growth rate by increasing the number of sterile fish produced at the Centre. Trout are unlikely to breed naturally in local conditions. Combined with a decreased number of locations stocked with trout has reduced this ecological risk score.

Listed Species

Fish

Listed species	Ecological Risks
Fish*	SEVERE (non-fishing)

*Crustaceans are classified as fish under the FRMA 1994

Listed freshwater species in the Southern Inland region are subject to the same non-fishing ecological pressures as noted under Native Finfish.

Hairy marron (*Cherax tenuimanus*) are only found in the upper reaches of Margaret River and are a totally protected species. They are threatened due to being outcompeted by smooth marron (*C. cainii*). Some fishing is still reported despite hairy marron being totally protected. This species is expected to number less than 100 in the wild.

Habitats and Ecosystems

Habitat / Ecosystem	Aquatic zone	Current Risk Status
Habitat	Freshwater	SEVERE (non-fishing)
Ecosystems	Freshwater	HIGH (non-fishing)

The community structure of most river and lake systems in this bioregion are substantially altered from historical levels. A survey of the main areas found that 24% no longer have any fish and less than 5% have native fish populations, the rest contain feral species.

In addition, there is concern that climate change may lead to a drying climate that could potentially alter the habitats and ecosystems in the bioregion. Given that these lakes are predominantly groundwater fed, a significant contributing factor is the over-extraction of water to supply Perth's increasing human population. This is causing the ground water levels to drop and is recognised as being unsustainable for either fish or people.

FISHERIES

SOUTH-WEST RECREATIONAL FRESHWATER RESOURCE STATUS REPORT 2021

R. Duffy, F. Trinnie, K. Ryan and L. Wright

OVERVIEW

The South-West Recreational Freshwater Resource (SWRFR) incorporates the Recreational Marron Fishery and the South West Recreational Freshwater Angling (SWRFA) fishery. Both fisheries have separate recreational licenses and are managed with rules around gear, bag limits, size limits and, spatial and temporal closures.

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2020: NA	NA
Recreational marron fishery (50,000- 100,000 marron)	Total Catch 2020: 55,668 (± 3696 s.e.) marron	Acceptable
Recreational angling (50,000 – 120,000 fish – review required)	Total Catch 2019/20: 104,319 fish (±10,125 se)	Acceptable
EBFM		
Indicator species		
Marron	Above threshold of 50,000 marron	Adequate
Trout (Rainbow & Brown)	NA – stocked fishery	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Significant Risk	Management Action
Habitat	Medium Risk	Adequate
Ecosystem	Low Risk	Adequate
Economic (GVP)	NA	NA
Social (High amenity)	Moderate Risk	Acceptable
Governance	Negligible Risk	Acceptable
External Drivers	Significant Risk	Acceptable

CATCH AND LANDINGS

Marron (*Cherax cainii*): The estimated total recreational catch for marron (by number) of 55,668 (± 3,696 s.e.) in 2020 was lower than the estimated catch in 2019 of 66,619 (± 4,972 s.e.), and within the catch range of the last 10 years (Recreational Fishery Figure 1). The average number of marron caught per fisher of 8.42 (± 0.56 s.e.) in 2020, was similar to the 2019 estimate of 9.7 (± 0.72 s.e.). Catch of marron from dams and rivers has remained stable over the last 10 years (approximately 30% from dams and 70% from rivers), as too has the distribution of effort (also approximately 30% dams, 70% rivers).

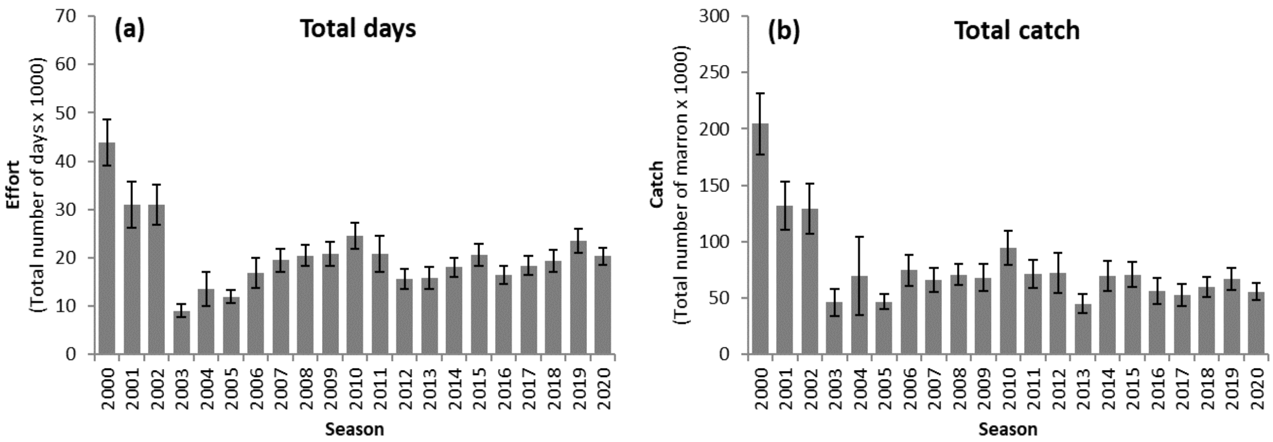
The total number of licensed fishers was 12,487 in 2020, which was lower than the 13,355 in 2019. Estimated total effort in 2020 was 20,368 days (±900 se), lower than the 2019 effort of 23,465 days (± 1,296 s.e.), but higher than that reported in 2018 (19,348 days (± 1,168 s.e), Recreational Fishery Figure 1). The average number of days fished per fisher of 3.08 days (± 0.14 s.e.) is within the range surveyed over the last 10 years.

More licensed marron fishers resided in the country (8,160) than the metro area (4,327), similar to 2019. Participation rates of licence holders in 2020 was 53%, higher than 2019 and 2018 (49% and 46% respectivley), which equates to an estimated total number of 6,610 active fishers in 2020. Participation rate was similar between country and metro licence holders, 54%, and 51% respectivley, and was similar between years for country licence holders, alhthough city participation went up 7% from 44% in 2019.

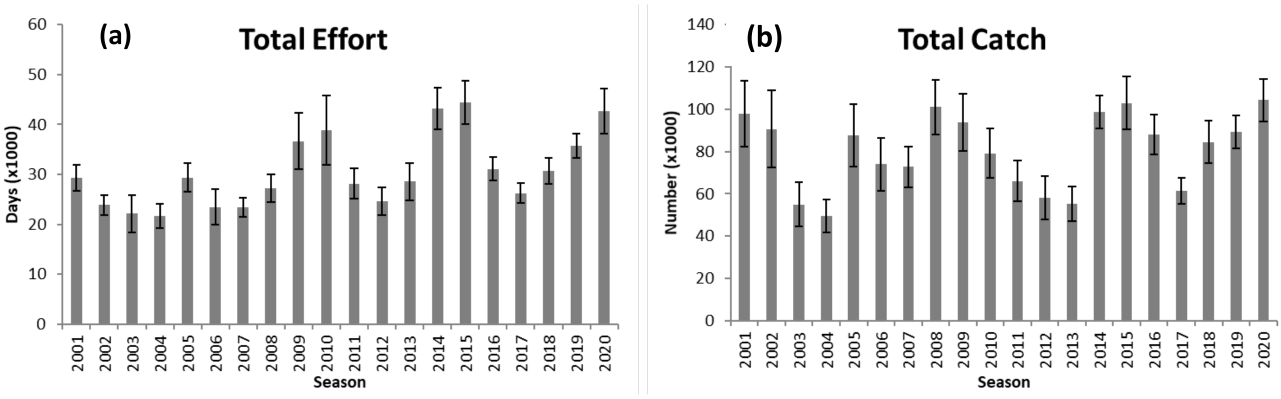
SWRFA: Since March 2016, children under the age of 16 are no longer required to hold a Freshwater Angling licence. Survey design does not permit apportioning of the contribution of this age group to historical surveys. Therefore, data from the 2017 survey and onwards, are not directly comparable to previous surveys.

The estimated total recreational catch from SWRFA across all species for 2020 (2019/20) was 104,319 fish (±10,125 se) of which 63,776 fish (±8,752 se) were kept and 40,543 fish (±4756 se) were released. The catch is 17% higher than the previous season (Recreational Fishery Figure 2).

The total number of licensed fishers was 7,791 in 2020 (2019/20), 4% lower than last year and continuing a downward trend since 2017, and participation rate was similar (46% of licence holders). However, the total estimated fishing effort of 42,267 days (with standard error ±4,487) was 18% higher than last year and is the highest since 2015, prior to changes to licencing arrangments; and similar to the highest levels since 2001 (Recreational Fishery Figure 2).



RECREATIONAL FISHERY FIGURE 1.
Estimated (a) total days people went marroning and (b) total number of marron caught, for marron licence holders in the Recreational marron fishery since 2000. Note, changes to season length and bag limits have occurred since 2000, so annual differences are not directly comparable. Refer to Southern Inland Freshwater Fishery Resource Assessment Report (*in prep.*) for further information.



RECREATIONAL FISHERY FIGURE 2.
Estimated (a) total days fished (with standard error) and (b) total number of finfish caught (with standard error), from 2001 to 2020 for licence holders in the SWRFA fishery. Note the freshwater angling survey collects data for an entire 12-month period (1 July–30 June). For ease of presentation, season 2020 will refer to the year of the most recent survey (i.e. season 2019/20 and throughout).

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Marron (Sustainable-Adequate)

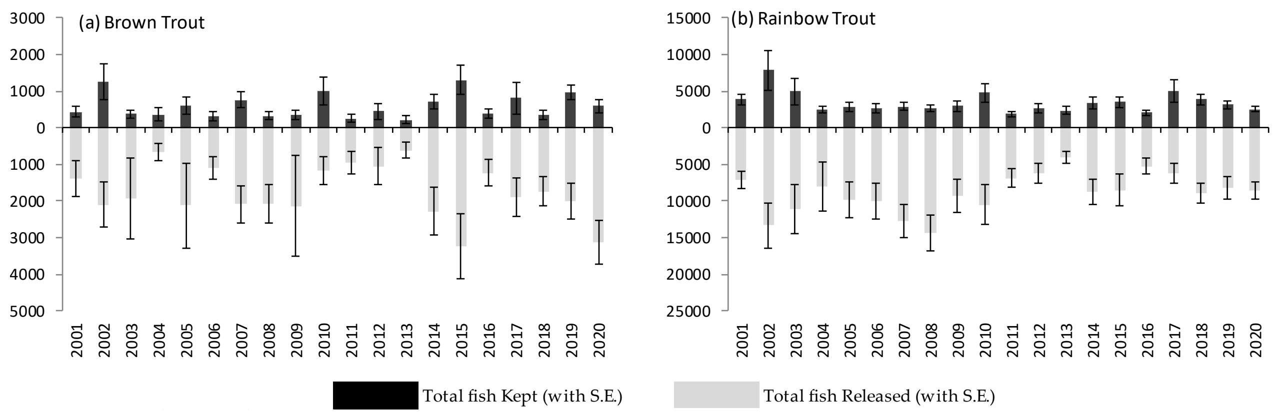
Smooth marron (*Cherax cainii*), are the third largest crayfish in the world and are endemic to Western Australia (Beatty *et al*. 2016). The Marron fishery is composed of many discrete populations that exhibit biological and life history traits that differ among systems, including fecundity (Beatty *et al.* 2016) and growth (Lawrence 2007). Refer to the Southern Inland Freshwater Fishery Resource Assessment Report (RAR) (*in prep.*) for further information.

Overall marron stocks are considered **sustainable-adequate** due to stable recreational catches above 50,000 marron. Fishery-independent survey data collected up until 2016, however, indicated that marron stocks are under pressure from environmental conditions (reduced rainfall and river flow), illegal fishing and potentially unsustainable levels of fishing at some easily accessed and popular sites. For more information, refer to the RAR (*in prep.*).

Trout (Annually Stocked)

Rainbow trout (*Oncorhynchus mykiss*) and Brown trout (*Salmo trutta*) are produced at the Pemberton Freshwater Research Centre and released into the rivers and dams of south-west WA. Wild self-sustaining populations are thought to be limited; therefore, stock levels are largely dependent on release rates and are supplemented annually.

The total estimated recreational catches of brown and rainbow trout in 2019/20 (3,723 ±724 se & 11,131 ±1,426 se respectively) were similar to brown and rainbow trout catches since 2016/17 (Recreational Fishery Figure 3). For information on other freshwater fish species, refer to the RAR (*in prep.*).



RECREATIONAL FISHERY FIGURE 3.
Total kept and released by species (a) Brown trout (b) Rainbow trout since 2001.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

The Marron Fishery also reports captures of small quantities of non-target species, principally gilgies (*Cherax quinquecarinatus*, *C. crassimanus*) and koonacs (*C. plebejus, C. glaber*). The impact of the Marron Fishery on these species is thought to be low as gilgies and koonacs are smaller than marron and are not targeted by recreational marron fishers. The introduced yabby also comprises a small part of the fishery. There is negligible bycatch in the SWRFA Fishery due to the small size of non-target native species. Therefore, the impact of the fishery on bycatch is a **negligible** risk.

Protected Species

Trout stocking occurs only in waterways where protected species are absent, therefore the fishery has no impact on protected species. Anecdotal evidence suggests that Redfin Perch, are still illegally stocked and translocated by fishers. Therefore, they have the potential to negatively impact protected species through direct predation.

A second species of marron, the critically endangered hairy marron, *Cherax tenuimanus*, occurs only in Margaret River. The largest negative impact on the hairy marron has resulted through the illegal introduction of the recreationally fished smooth marron. In late 2002, recreational marron fishing within Margaret River, upstream of Ten Mile Brook Junction was prohibited to remove the impacts of fishing on the remaining hairy marron stocks. Illegal fishing is still reported in this reach of the Margaret River, and combined with the small population size (and degrading habitats (e.g. reduced rainfall) is considered a **significant** risk.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

The major habitat impacts of the Marron Fishery and the SWRFA Fishery are litter in surrounding areas, and fishers trampling riparian vegetation and subsequent bank erosion. Whilst fishers can provide an environmental benefit through the removal of large numbers of feral redfin perch (*Perca fluviatilis*) some fishers also deliberately spread redfin perch into new water bodies. Therefore, impact on habitat is considered a **moderate** risk.

Ecosystem

The removal of legal-sized marron from freshwater rivers is unlikely to have a significant effect on ecosystem function as the bulk of the marron biomass is below legal size, and marron of all sizes have similar food and habitat requirements. Marron taken from man-made dams are already living in highly modified habitats, as such their removal does not significantly impact on ecosystem function.

To minimise adverse impacts of trout on native species, they were generally stocked only in rivers where non-native fish species are also present, and protected species are absent.

SWRFA is largely a lure and fly fishery, however there is a small risk to the ecosystem through bait collection, its use, the release of unwanted live bait (mainly for redfin perch), and potential to spread disease and parasites, e.g. *Thelohania*. Therefore, the resource is considered to have a **moderate** risk to the ecosystem.

SOCIAL AND ECONOMIC OUTCOMES

Social

The Marron Fishery in particular is iconic and provides a high social amenity.The SWRFA has an enthusiastic base of fishers and a dedicated angling group (Western Australian Trout and Freshwater Angling Association (WATFAA)) and has a medium social amenity. Both fisheries attract tourists to regional areas.

The effect of reduced rainfall on the availability of marron habitat is expected to increase awareness of changes in climate patterns in the South-West. Social aspects are identified as having **high** amenity and a **moderate** risk.

Economic

Both the Marron Fishery and SWRFA may support tourism to regional towns in the South-West. A risk score that captures non-GVP related risk has not been developed.

GOVERNANCE SYSTEM

Harvest Strategy

The marron fishery is managed under a constant catch harvest strategy, although the harvest strategy has not been formalised. Review of this approach is required.

The SWRFA fishery is based on stocking (inputs). A stocking committee provides advice to the Department on numbers and locations to be stocked. As it is a stocked fishery, a harvest strategy focused on susatainability is not required.

Allowable Catch Tolerance Levels (Acceptable)

Marron: In 2006, the Recreational Freshwater Fisheries Stakeholder Subcommittee (RFFSS) proposed that, based on the available science the fishery be managed to a catch range of 96,000-136,000 marron. This level of catch has rarely been achieved with the exception of 2010, a year of extremely low rainfall. Recreational catch has largely fluctuated between 50,000 and 100,000 animals since 2001. The catch in 2020 was within the historic range (55,668 ± 3696 s.e.), and therefore status is considered **acceptable.**

Compliance

Southern Region Fisheries and Marine Officers apply compliance through the delivery of an Operational Plan. Areas of high interest have been identified and patrols are designed to frequent those, and other areas. Patrol and compliance planning focuses on out-of-season illegal fishing, illegal use of fishing gear, and a high profile presence through the marron season. Compliance activities are supported by educational activities.

Consultation

Meetings between the Department, Recfishwest, Freshwater Fisheries Reference Group and freshwater fishers are held regularly.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department's Stakeholder Engagement Guidelines.

Management Initiatives

The South West freshwater angling season is now open all year round.

The Western Australian Inland Freshwater Research Advisory Committee was established in mid-2019 to enhance freshwater recreational fishing experiences in the South-West. The Committee is run by the Department and includes members from Recfishwest and WATFAA and is initially focusing on reviewing existing trout stocking strategies.

The Department continues to support a licence-free weekend for the SWRFA. The licence-free weekend occurred in early October 2020 to

coincide with the beginning of the peak recreational freshwater fishing season and the annual TroutFest family fishing day run by Recfishwest.

The licence-free weekend applied to all inland waters south of Greenough (29°S) and above the tidal influence, including all lakes, dams, rivers and their tributaries. All other freshwater recreational fishing rules still applied.

EXTERNAL DRIVERS

Rainfall in the south-west of Western Australia has declined by approximatley 20%, and is predicted to decrease by a further 5-6% by 2030 (Sudmeyer et al. 2016). The decline has been most noticeable in autumn and early winter rains. The impact of reduced rainfall has included a greater than 80% reduction of runoff into dams. This has had negative implications for rivers and lakes in the south-west and the associated fish and crustacean assemblages. The major impact of these changes will be through a reduction in habitat availability, with negative implications for fish and crustacean abundance. Reduced river flows inhibit movement, and combined with increasing salinity, could negatively impact populations of all freshwater species. In addition, the drying climate may lead to more frequent and higher intensity bushfires that can impact the fisheries through restricting fisher access, and associated impacts of fire, and fire management methods on stream fauna. **Significant** risk.

REFERENCES

Beatty, S., de Graaf, M., Molony, B., Nguyen, V. and Pollock, K. 2011. Plasticity in population biology of *Cherax cainii* (Decapoda: Parastacidae) inhabiting lentic and lotic environments in south-western Australia: Implications for the sustainable management of the recreational fishery. Fisheries Research 110: 312-324.

Beatty, S., de Graaf, M., Duffy, R., Nguyen, V. and Molony, B. 2016. Plasticity in the reproductive biology of the smooth marron *Cherax cainii* (Decapoda: Parastacidae): A large freshwater crayfish of south-western Australia. Fisheries Research 177: 128-136.

de Graaf, M., Beatty, S.J. and Molony, B.M. 2010. Evaluation of the recreational marron fishery against environmental change and human interaction. Final report to Fisheries Research and Development Corporation on Project No. 2003/027. Fishereis Reseach Report No. 211. Department of Fisheries, Western Australia.

Lawrence, C. 2007. Improved performance of marron using genetic and pond management strategies. Final FRDC Report – Project No. 2000/215.

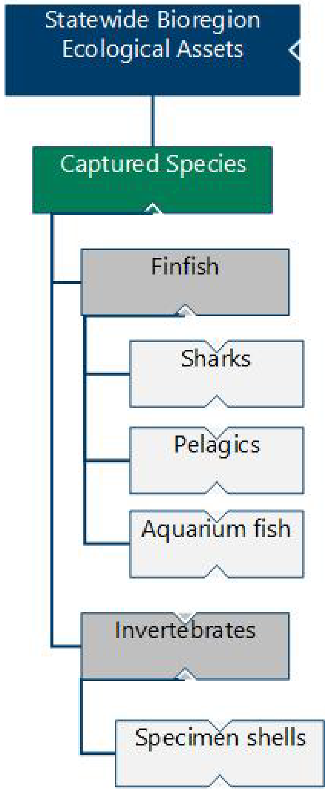
Sudmeyer, R., Edward, A., Fazakerley, V., Simpkin, L. and Foster, I. 2016. Climate change: impacts and adaptation for agriculture in Western Australia. Bulletin 4870, Department of Agriculture and Food, Western Australia, Perth.

STATEWIDE BIOREGION

ECOSYSTEM BASED FISHERIES MANAGEMENT

Identification of Statewide Ecological Assets using the EBFM framework

While the bioregional scale of management has been adopted by the Department through the implementation of an Ecosystem Based Fisheries Management (EBFM) framework (see How to Use section for more details), due to their life histories or broader impacts, a small number of ecological assets cannot realistically be managed at a single bioregional level but need to be considered at either a Statewide or at a multiple bioregional level.



STATEWIDE ECOSYSTEM MANAGEMENT FIGURE 1

Component tree showing the Statewide ecological assets and external drivers identified and separately assessed.

Risk Assessment of Statewide Ecological Assets and External Drivers

The EBFM process identifies the ecological assets in a hierarchical manner such that the assets outlined in Statewide Ecosystem Management Figure 1 are often made up of individual components at species or stock levels. The risks to each of the individual stocks or lower level components are mostly detailed in the individual fishery reports presented in this document. The following Ecosystem sections provide an overview and cumulative assessment of the current risks to those ecological assets that function at a Statewide level. These risk levels are used by the Department as a key input into the Department's Risk Register which, combined with an assessment of the economic and social values and risks associated with these assets, is integral for use in the annual planning cycle for assigning priorities for activities across all Divisions for Statewide issues.

Captured Species

FINFISH

Sharks (and other Elasmobranchs)

Captured Species	Aquatic zone	Ecological Risk
Sharks	South and lower west	MEDIUM
	Mid West – North	MEDIUM

The stock levels of most sharks in the south and lower west regions (some of which migrate seasonally into the north) are now either at acceptable levels or are deemed to be recovering at acceptable rates following management intervention.

The stocks levels of sharks in the mid west and north regions are considered to be recovering with some more productive species having recovered.

Pelagic

Captured Species	Aquatic zone	Ecological Risk
Finfish	Pelagic	MEDIUM

Large pelagic species of finfishes are targeted throughout the State. In the North Coast and Gascoyne Coast Bioregions, Spanish mackerel, grey mackerel, billfishes and other species are regularly captured by commercial fisheries and recreational fishers. Samsonfish, Spanish mackerel and a range of other large pelagic species are landed by commercial and recreational fishers in temperate bioregions.

Spanish Mackerel are the only large pelagic species heavily targeted, mainly by the Mackerel Managed Fishery (MMF) and recreational fishers. The MMF operates in the North Coast, Gascoyne Coast and West Coast Bioregions. The current risk level for Spanish mackerel is moderate based on trends in catch, effort, catch rates, and a vulnerability assessment (see Statewide Large Pelagic Finfish Chapter). Few other pelagic species are exploited at any significant levels and these stocks are lightly impacted by fishing.

Aquarium Fish

Captured Species	Aquatic zone	Ecological Risk
Aquarium Fish	Marine	MEDIUM

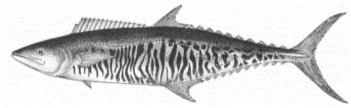
The level of capture is low and the management arrangements ensure that species are not at risk. Management arrangements are being reviewed to address levels of uncertainty in stock status.

INVERTEBRATES

Captured Species	Aquatic zone	Ecological Risk
Specimen Shells	Marine	MEDIUM

The level of capture is low and the management arrangements are such that these species are not considered at risk.

STATEWIDE LARGE PELAGIC FINFISH RESOURCE STATUS REPORT 2021



P. Lewis and M. Watt

OVERVIEW

The statewide large pelagic finfish resource is distributed throughout Western Australia (WA) and includes a range of tropical and temperate pelagic species. The three indicator species for the resource are Spanish mackerel (*Scomberomorus commerson*) and grey mackerel (*S. semifasciatus*) representing the tropical suite, and Samson fish (*Seriola hippos*) for the temperate suite (DOF 2011).

Commercially the resource is predominantly accessed by the Mackerel Managed Fishery (MMF) in the North Coast (NCB) and Gascoyne Coast Bioregions (GCB) targeting primarily Spanish mackerel. In the West Coast (WCB) and South Coast Bioregions (SCB) the major retained temperate species is Samson fish, mostly as bycatch in a number of line and net fisheries (see relevant chapters for more details). The recreational fishery for large pelagic fish is dominated by Spanish mackerel, which by weight is the 5th highest retained finfish species (Appendix 2) and the 4th highest retained by charter/fishing tour operator in 2019/20 catch. For most other large pelagic species, the majority of the recreational catch is released (Ryan *et al*. 2019). For further details in regard to the Statewide Large Pelagic Scalefish Resource Assessment Report see Lewis (2020) https://www.fish.wa.gov.au/Documents/resource_assessment/resource_assessment_report_019.pdf .

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (Spanish mackerel 430 t, Grey mackerel 180 t)	Total catch 2020: 288 t (Spanish mackerel), 11 t (Grey mackerel)	Acceptable
Recreational fishery	Total catch 2017/18: 87–121 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Spanish mackerel	Medium Risk, no formal HS, catches within tolerance ranges but declining nominal catch rates	Breeding stock status - Adequate
Grey mackerel	Low Risk, catch only	Breeding stock status - Adequate
Samson fish	Low Risk, catch only	Breeding stock status - Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Negligible Risk	Adequate
Habitat	Low Risk	Adequate
Ecosystem	Low Risk	Adequate
Economic (GVP Level 2)	Low Risk	Acceptable
Social (Moderate/high amenity)	Low Risk	Acceptable
Governance	Stable	Acceptable
External Drivers	Moderate Risk	Acceptable

LARGE PELAGIC FINFISH FIGURE 1.
Map showing the boundaries of the Mackerel Managed Fishery.

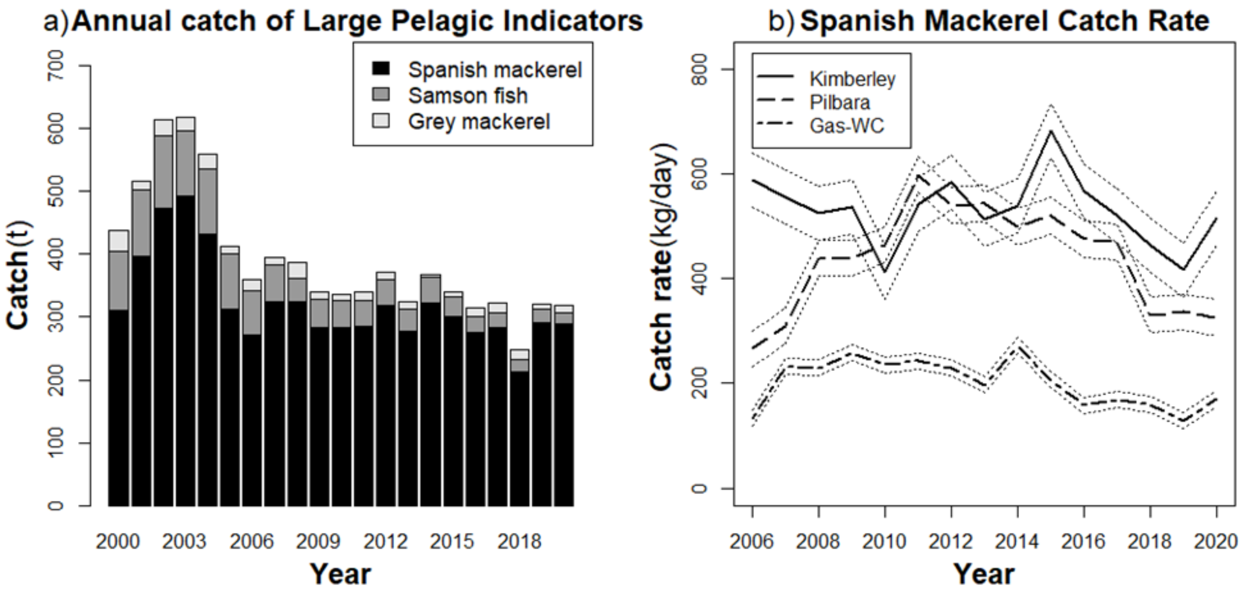
CATCH AND LANDINGS

The combined commercial landings of all large pelagic species in WA have ranged from 294-433 t over the past 10 years and were at 404 t in 2020, after a reduced catch in 2018. The main commercial catch is of Spanish mackerel by the MMF, which has ranged from 270-330 t since quotas were introduced in 2006, and in 2020 the landed catch was 288 t (Large Pelagic Finfish Figure 2a). The commercial catch of grey mackerel in 2020 was 11 t and has been consistently below 20 t since 2006. The commercial landings of other tropical large pelagic species in the NCB and GCB such as Amberjack (*Seriola dumerili*), Cobia (*Rachycentron canadum*) and Golden Trevally (*Gnathanodon speciosus*) were 11.7 t, 18.3 t, and 22.3 t, respectively, with remaining species <10 t in 2020. For the temperate large pelagic species only the combined WCB and SCB catch of 20.4 t for Samson fish in 2020 was >10 t.

The fishing tour operator annual catches of the three large pelagic indicator species was only 9 t in 2020, likely due to COVID-19 restrictions, but have previously ranged from 27-54 t (since 2010), with grey mackerel contributing <1 t annually.

The statewide estimated recreational harvest range (95% CI) for the top 10 pelagic species was steady at 87-121 t in 2017/18 compared with 93-118 t in 2015/16, but lower than 124-163 t in 2013/14 and 154-193 t in 2011/12 (Ryan *et al.* 2019). The top 10 pelagic scalefish species (or species groupings) in 2017/18 represented 85% of the total retained large pelagic finfish resource catch (kept by numbers). In each survey a similar or higher amount of large pelagic species were released.

The changes to recreational trip possession limits, introduced in July 2021, will likely lead to higher fishing effort and retained catches from the statewide large pelagic finfish resource.



LARGE PELAGIC FINFISH FIGURE 2.
a) Annual statewide commercial catch (t) for the three large pelagic indicator species and b) Annual nominal catch rate (kg/day) of Spanish mackerel in the MMF by management area, with dotted line around each representing +/- standard errors.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Spanish mackerel (Sustainable-Adequate)

Spanish mackerel are fast growing, moderately long lived (to 26 years), grow to a large size (to 40 kg), have high fecundity and have a young age at sexual maturity (less than 2 years) (Mackie *et al*. 2003) indicating a moderate resilience to fishing pressure. Spanish mackerel in WA form a complex of meta populations (Buckworth *et al* 2007) and are likely a shared biological stock with the Northern Territory.

The 2020 Spanish mackerel commercial catch of 288 t (Large Pelagic Finfish Figure 2a) is a return to the previously relatively stable level of catch throughout the MMF of 270-320 t since 2006, after the low level of catch reported in 2018. The low catch can be partially attributed to a significant change in operators in the MMF but may also be due to widespread environmental changes in Northern Australia, with catches declining in other states. The nominal catch rates in the Kimberley and Pilbara management areas are generally decreasing (Large Pelagic Finfish Figure 2b), which is partially due to changes in operators, but may also indicate a decline in the spawning stock after the influence of the 2015/16 extreme marine warming (Benthuysen *et al.* 2018) during the spawning period. The catch rate in the southern GCB-WCB area has declined after a peak in 2014 when catches were high, possibly due to the effects of the 2010/11 west coast marine heatwave (Pearce 2011).

In 2020 the annual charter boat operators' catch of Spanish mackerel in WA was only 7.3 t, due the influence of COVID-19. Prior to 2020, this catch had been stable ranging from 17-37 t since 2003 with 34-61% released/discarded. In 2019, the statewide charter catch was 21 t with 75% taken in the NCB, with 32% released.

The estimated recreational harvest range of Spanish mackerel was steady in 2017/18 (37-58 t) compared with 2015/16 (35-54 t), and lower than 2013/14 (69-103 t) and 2011/12 (78-108 t) (Ryan *et al*. 2019). In each survey a further 42-48% of the Spanish mackerel catch was released. The decline in catch can be partly attributed to the 20-35% decline in recreational effort in the NCB and GCB between surveys, particularly during the months from April-August, when higher catches of these species occur.

The estimated retained catch (by number) of Spanish mackerel in the WCB was steady in 2017/18 (775, SE=233) and 2015/16 (704, SE=243), but lower than 2013/14 (2,376, SE=425) and 2011/12 (2,927, SE=443) (Ryan *et al*. 2019). This is likely due to lower water temperatures reducing the abundance of the tropical species in the southern extent of their range.

On the basis of the available evidence, including trends in catch, effort, catch rates, and a vulnerability assessment the current risk level for Spanish mackerel is **medium**. Thus, the breeding stock of Spanish mackerel in WA is considered to be **sustainable-adequate**.

Grey mackerel (Sustainable-Adequate)

Grey mackerel in WA likely constitute a single biological stock (Newman *et al*. 2010). Grey mackerel are fast growing, relatively short lived (to 12 years) and have a young age at sexual

maturity (less than 2 years) (Cameron and Begg 2002) indicating resilience to fishing pressure.

Grey mackerel catches in the MMF since 2000 have been relatively low ranging from 3.5 to 24 t (Large Pelagic Finfish Figure 1a). In 2020 the WA catch of 11.2 t, was predominantly taken by two vessels (94%), split between both the Pilbara and GCB-WCB areas. This level of catch is well below the TACC (60 t for each of the three management areas) for grey mackerel and negligible when compared to the 1200 t landed annually in Australia (Roelofs *et al.* 2021). The low levels of catch are likely to reflect the gear limitations (line only) and limited targeting of the species in the MMF by only two vessels.

The annual charter boat operators' catch of grey mackerel in WA has been 1 t or less since 2003. The estimated recreational retained catch of grey mackerel was 1-5 t in 2017/18 but has been <1 t in 2011/12, 2013/14 and 2015/16, although the uncertainty is high for this species (Ryan *et al.* 2019).

On the basis of the evidence provided above, the current risk level for grey mackerel is **low** and the breeding stock is classified as **sustainable-adequate**.

Samson fish (Sustainable-Adequate)

Samson fish in WA is likely to constitute a shared biological stock with South Australia. The species are moderately long lived (to 29 years), can grow to a large size (40 kg+), mature at four years of age, can undertake large scale movements and are able to withstand capture from deep water (Rowland 2002), indicating resilience to effects of barotrauma.

The statewide commercial catch of Samson fish in 2020 was 20.4 t, which is the lowest on record compared to the historical high catch of 115 t in 2002. The catch was split between the WCB and SCB. Since 2008 catches have been at low levels, <45 t (Large Pelagic Finfish Figure 1a), due primarily to reductions in the WCB since management changes in the West Coast Demersal Scalefish Interim Managed Fishery (WCDSIMF) and Temperate Demersal Gillnet and Demersal Longline Fishery (TDGDLF), see related chapters for details. Over the past 5 years the catches of Samson fish have been variable at 7-16 t in the South Coast open access line fishery, variable from 3-7 t in the TDGDLF, and stable at 6-8 t in the WCDSIMF.

The annual charter boat operators' total estimated catch of Samson fish in WA for 2020 was the lowest on record at <2 t with 95% taken in the WCB and 60-70% released. Previously the total catch has been up to 48 t (in 2003), but has been <20 t since 2010 with 68-76% released/discarded.

The species is also targeted recreationally with the majority (>70%) released/discarded. The estimated recreational harvest range of Samson fish was steady in 2017/18 (10-17 t) compared with 2015/16 (11-19 t), 2013/14 (16-28 t) and 2011/12 (14-22 t), with similar high release rates of 74-86% (Ryan *et al*. 2019).

On the basis of the evidence provided above, the current risk level for Samson fish is **low** and the breeding stock is classified as **sustainable-adequate**.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

The non-mackerel bycatch taken by the MMF are predominantly other large pelagic species which annually contribute <1 t (2020). Thus, there is **negligible** risk to the breeding stocks of other finfish species, by fishers targeting the statewide large pelagic finfish resource.

Protected species

Due to the selectivity of the fishing methods used by commercial and recreational fishers targeting large pelagic species, and the low level of interactions with protected species by the MMF there is considered to be a **negligible** risk to listed species.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat

The surface and midwater troll fishing methods used by the MMF, fishing tour operators and recreational fishers when targeting large pelagic species do not impact with the benthic marine environment (DEWHA 2009). On longer fishing trips the vessels may anchor but the impacts from anchoring are considered to be minimal, as anchors are set in naturally dynamic environments.

Ecosystem

The amount of Spanish mackerel removed from the ecosystem is unlikely to impact trophic interactions, as mackerel are generalist carnivores and consume a wide range of fish and invertebrate species from both pelagic and demersal habitats (Mackie *et al*. 2003).

Therefore, the fishery is considered to be a **low** risk to both habitat structure and ecosystem interactions.

SOCIAL AND ECONOMIC OUTCOMES

Social

Sixteen boats fished in the MMF during the 2020 season, primarily from May-November, with approximately 35-40 people directly employed in the MMF. The estimated participation rate for recreational fishing in the population of WA is 31.1% in 2015/16 (DoF 2016a). Recreational boat based surveys indicate that Spanish mackerel is the 5th highest retained finfish species by weight (Appendix 2), with retained catches highest in the NCB and GCB (Ryan *et al*. 2019). Meanwhile other iconic large pelagic species are targeted but released/discarded in high numbers, such as Samson fish with 79% released and Billfish species with 86% or more released.

The statewide large pelagic finfish resource provides a **moderate/high** social amenity value to recreational fishing, diving and consumers via commercial fish supply to markets and restaurants. There is currently a **low** level of risk to these values through external drivers.

Economic

In 2020, the estimated value (to fishers) of the Spanish mackerel annual catch was Level 2, approximately $2.5-3 million. The value of the annual catch of grey mackerel, Samson fish and other large pelagic species is estimated at less than $500,000.

Recreational fishers make a significant contribution to WA's economy, and support economic activity in many regional towns on the coast and near inland fishing spots. These resources contribute in part to the $2.4 billion attributed to the value of recreational fishing to the WA economy each year (McLeod and Lindner 2018). As detailed in this report the sportfishing value of large pelagic fish to the recreational spend is much higher than for other species.

There is currently a **low** level of risk to this return.

GOVERNANCE SYSTEM

Harvest Strategy

For Spanish mackerel the current method of assessment focuses on analysis of catch and catch rates (Levels 1 and 2), with previous analyses having been used to determine the Tolerance Levels and TACC.

A preliminary harvest strategy has been developed for the MMF using reference levels for the catch rates of Spanish mackerel, which were derived from data collected over a reference period (2006 to 2011) when fishing was considered sustainable. Daily logbook catch rates are being examined and biological data is currently being collected to inform an age based (Level 3) stock assessment, to be conducted in 2022. These will inform the development of the harvest strategy for the resource.

Annual Catch Tolerance Levels (Acceptable)

The 2020 catch is within the target commercial catch range for Spanish mackerel in the MMF of 246-430 t. In the Kimberley area the 2020 Spanish mackerel catch of 199 t is within the range (110-225 t) while the catches of 71 t in the Pilbara and 17.4 t in the GCB/WCB are below the respective tolerance ranges of 80-126 t and 56-79 t. The Pilbara catch is often below the tolerance range, and the GCB/WCB catch has been below the tolerance range for almost all years since 2006. In 2018 there was a significant change in operators within the MMF contributing to the lower catches. Environmental conditions across northern Australia, particularly the 2015/16 extreme marine warming (Benthuysen *et al.* 2018), may have also contributed to low catches.

Due to the likely short-term influence of major changes in operators in the MMF and possible environmental factors the catch levels are considered **acceptable**.

Compliance

All boats in the MMF are fitted with an Automatic Location Communicator (ALC), which enables the Department to monitor the fleet using a Vessel Monitoring System (VMS). Masters of an authorised boat within the MMF are also required to submit daily logbook records along with catch and disposal records (CDRs). The Department also undertakes vessel inspections at sea to ensure fishing is being undertaken in accordance with the governing legislation (e.g. gear requirements, catch reporting).

Consultation

The Department undertakes consultation directly with licensees on operational issues. Industry Management Meetings are held annually between the Department and MMF licensees, in conjunction with the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC), with the latest meeting held in April 2021.

Consultation on recreational fishing regulations or relevant commercial management changes is undertaken through the peak body, Recfishwest.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department’s Stakeholder Engagement Guidelines.

Management Initiatives (Stable)

In August 2015, the MMF received an exemption from the export controls of the EPBC Act for a period of ten years. The 2018 Instrument of Exemption issued to all licence holders which

provides for operational and economic efficiencies relating to nomination requirements was extended in 2021. An industry working group was established in 2021 to assist with development of a harvey strategy for the MMF.

EXTERNAL DRIVERS

Many large pelagic species experience annual variations in recruitment strength and adult movement due to environmental fluctuations. The changing marine environment off the WA coast can temporarily benefit some tropical species in the southern parts of their range, as seen during the 2010/11 marine heatwave off WA when the Spanish mackerel distribution shifted southwards (Pearce *et al*. 2011). However, such events can be detrimental to recruitment in northern parts if it coincides with the spawning season (Welch *et al.* 2014) as occurred in the 2015/16 extreme marine warming. Other external factors on the fishery include the petroleum industry restricting access to fishing grounds and the likely detrimental influence of marine seismic surveys, particularly in some parts of the Pilbara area.

The high proportion of released/discarded charter and recreationally caught large pelagic fish with an unknown but likely high level of mortality (DoF 2016b) along with the increasing mortality of hooked and discarded large pelagic species by depredation, particularly in areas with higher effort (Carmody *et al. In Prep*), are factors affecting the statewide large pelagic finfish resource.

Finally, the past four Indian Ocean Tuna Commission (IOTC) assessments of the Spanish mackerel catch have determined a 73% likelihood the species is overfished and subject to overfishing with catches since 2009 well above the current MSY estimate of 131,000 t (IOTC 2020). However, this outcome does not apply to the WA component of the northern Australian stock, which is distinct from that of other parts of the Indian Ocean.

However, these external factors constitute an overall **medium** risk to WA's statewide large pelagic finfish resource, with possible impacts varying among individual species.

REFERENCES

Benthuysen JA, Oliver ECJ, Feng M, and Marshall AG. 2018. Extreme marine warming across tropical Australia during Austral summer 2015-2016, Journal of Geophysical Research: Oceans, 123, 1301-1326.

Buckworth R, Newman S, Ovenden J, Lester R, and McPherson G. 2007. *The stock structure of northern and western Australian Spanish Mackerel.* Fishery report 88, final report. Fisheries Research and Development Corporation Project 1998/159. Fisheries Group, Northern Territory Department of Business, Industry and Resource Development, Darwin.

Cameron D, and Begg G. 2002. *Fisheries biology and interaction in the northern Australian small mackerel fishery*. Final report to Fisheries Research and Development Corporation. Projects 92/144 & 92/144.02, Department of Primary Industries, Queensland.

Carmody H, Langlois T, Mitchell J, Navarro M, Lewis P, Jackson G, and McLean D. *In Prep*, Shark depredation in a commercial trolling fishery in sub-tropical Australia.

Department of Fisheries (DoF) 2011, Resource Assessment Framework (RAF) for finfish in Western Australia, Fisheries Occasional Publication 85, 24p

Department of Fisheries (DoF), 2016a. Annual Report to Parliament 2015/16. Department of Fisheries, Western Australia. 225 pp.

Department of Fisheries (DoF). 2016b. A review of size limits for finfish in Western Australia – Discussion paper. Fisheries Management Paper 280, 61p.

Department of the Environment, Water, Heritage and the Arts (DEWHA). 2009. *Assessment of the Western Australia Mackerel Fishery.* DEWHA, Canberra.

Indian Ocean Tuna Commission (IOTC). 2020. Appendix 22 Executive Summary: Narrow barred Spanish mackerel (2020). IOTC-2020-SC23-ES11, In Report of the 23rd session of the IOTC Scientific Committee, Dec 2020. IOTC-2020-SC23-R[E]_Rev1, 221pp.

Lewis PD. 2020. Statewide Large Pelagic Resource in Western Australia. Resource Assessment Report No.19.https://www.fish.wa.gov.au/Documents/resource_assessment/resource_assessment_report_019.pdf, Department of Primary Industries, Perth.

Mackie M, Gaughan D, and Buckworth RC. 2003. *Stock assessment of narrow-barred Spanish Mackerel (Scomberomorus commerson) in Western Australia.* Final report, Fisheries Research and Development Corporation project 1999/151. Western Australian Department of Fisheries, Perth.

Mcleod P. and Lindner R. 2018 Economic dimensions of recreational fishing in Western Australia. Research report for the Recreational Fishing Initiatives Fund, October 2018, 83pp.

Newman S, Wright I, Rome B, Mackie M, Lewis P, Buckworth R, Ballagh A, Garrett R, Stapley J, Broderick D, Ovenden J, and Welch D. 2010. Stock structure of grey mackerel, *Scomberomorus semifasciatus (Pisces: Scombridae*) across northern Australia, based on otolith isotope chemistry. Environmental Biology of Fishes, 89: 357–367.

Pearce A, Lenanton R, Jackson G, Moore J, Feng M, and Gaughan D. 2011. The 'marine heat wave' off Western Australia during the summer of 2010/11. Fisheries Research Report, 222. Western Australian Department of Fisheries, Perth.

Roelofs A, Lewis P, and Usher M. Grey Mackerel, *Scomberomorus semifasciatus*, in Toby Piddocke, Crispian Ashby, Klaas Hartmann, Alex Hesp, Patrick Hone, Joanne Klemke, Stephen Mayfield, Anthony Roelofs, Thor Saunders, John Stewart, Brent Wise and James Woodhams (eds) 2021, *Status of Australian fish stocks reports 2020*, Fisheries Research and Development Corporation, Canberra.

Rowland AJ. 2002. The biology of Samson Fish *Seriola hippos* with emphasis on the sportfishery in Western Australia. PhD Thesis, Murdoch University. 209 pp.

Ryan KL, Hall NG, Lai EK, Smallwood CB, Tate A, Taylor SM, and Wise BS 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297, Department of Primary Industries and Regional Development, Western Australia.

Welch D, Saunders T, Robins J, Harry A, Johnson J, Maynard J, Saunders R, Pecl G, Sawynok B and Tobin A. 2014. Implications of climate change on fisheries resources of northern Australia, Part 1, Vulnerability assessment and adaptation options, Fisheries Research and Development Corporation project 2010/565, James Cook University, Townsville.

STATEWIDE MARINE AQUARIUM FISH AND HERMIT CRAB RESOURCES STATUS REPORT 2021

S. Newman, C. Bruce and A. Bissell

OVERVIEW

The Marine Aquarium Fish Managed Fishery (MAFMF) operates in all State waters (between the Northern Territory border and South Australian border, Marine Aquarium Fish Figure 1). The fishery is typically more active in waters south of Broome with higher levels of effort around the Capes region, Perth, Geraldton, Exmouth, Dampier and Broome.

The MAFMF resource potentially includes more than 1,500 species of marine aquarium fishes, under the *Marine Aquarium Fish Managed Fishery Management Plan 2018.* Operators in the MAFMF are also permitted to take coral, live rock, algae, seagrass and invertebrates.

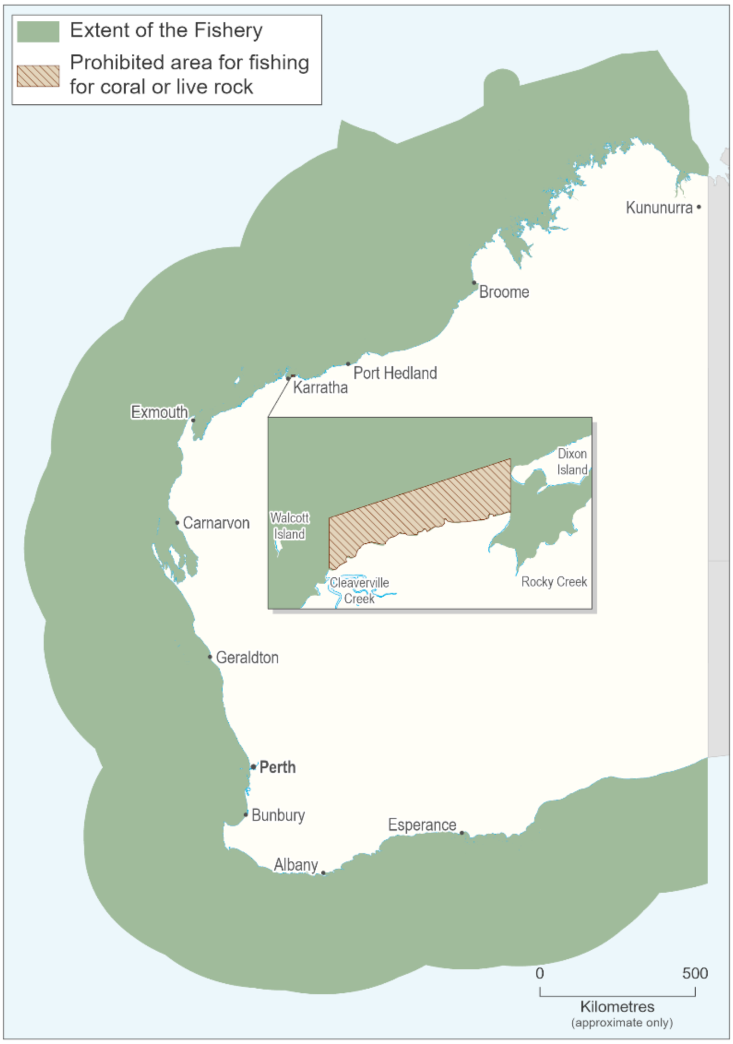
The Hermit Crab Fishery (HCF) specifically targets the Australian land hermit crab (*Coenobita variabilis*) for the domestic and international live pet trade. The fishery operates throughout the year and is one of two land-based commercial fisheries in Western Australia (WA). The HCF operates under Ministerial Exemptions and is currently permitted to fish Western Australian waters north of, and including, Exmouth Gulf (22°30'S, Marine Aquarium Fish Figure 2).

There are no documented recreational or customary fisheries.

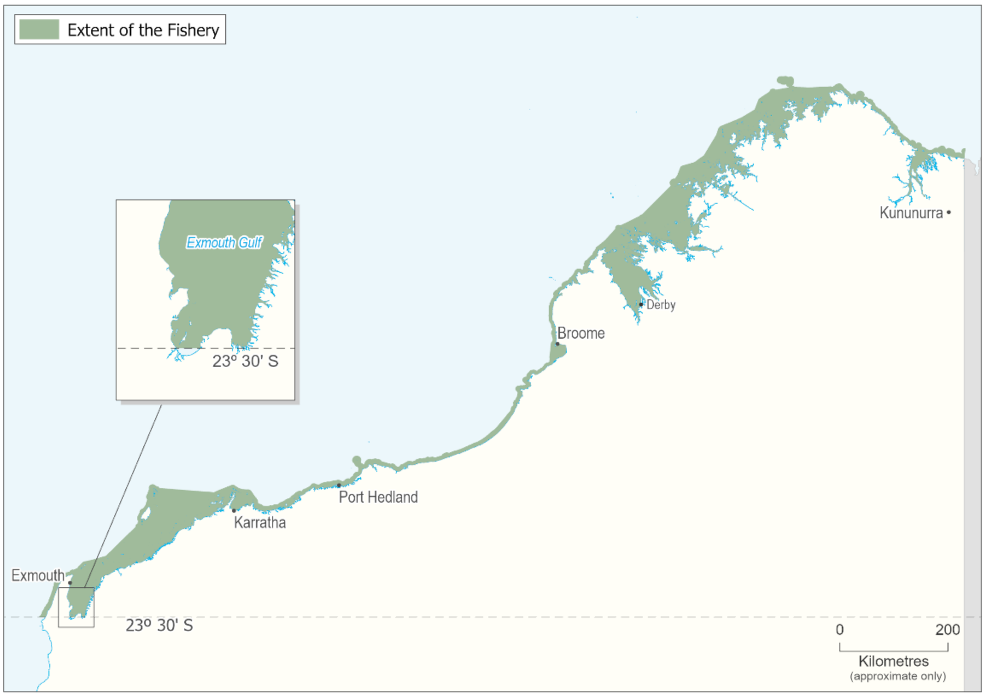
SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (NA)	Total Catch 2020: Fish (n) – 28,165	Acceptable
Recreational fishery (NA)	Total Catch 2020: NA	Acceptable
EBFM		
Indicator species		
Syngnathid (n) – 303; Invertebrates (n) -; 59,189; Hard coral (kg) – 11,907; Soft coral (kg) – 5,075.70; Living rock & Living sand (kg) – 15,133; Sponges (n) – 2,268; Algae/Seagrasses (l) – <20*	Small numbers of individual species taken annually.	Adequate
Hermit crabs (n) - > 75,000*	Catch is within the range of the last 10 years (2010 to 2019).	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Negligible Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (GVP $1-5 m)	Low Risk	Acceptable
Social (low amenity)	Low Risk	Acceptable
Governance	Low risk	Acceptable
External Drivers	Negligible Risk	Acceptable

* the specific data cannot be reported due to confidentiality provisions.



MARINE AQUARIUM FISH FIGURE 1
The extent of the Statewide Marine Aquarium Fish Managed Fishery of Western Australia. This map is indicative only regarding the extent of the fishery, and does not contain prohibited fishing areas, such as Marine Parks.



MARINE AQUARIUM FISH FIGURE 2.
The Hermit Crab Fishery of Western Australia operates in Western Australian waters north of, and including, Exmouth Gulf (22°30'S).

CATCH AND LANDINGS

There were eleven out of the twelve licences that were active in the MAFMF in 2020 and there were two active licences in the HCF (out of a total of five licences) during 2020. The total catch in the MAFMF in 2020 was 89,925 fishes, 32.12 t of coral, live rock & living sand and <20L of marine plants and live feed. MAFMF fish catches were dominated by Vachell's Glassfish (*Ambassis vachellii*) n =>13,000, Scribbled Angelfish (*Chaetodontoplus duboulayi*) n =1,961, Blue And Yellow Wrasse (*Anampses lennardi*) n = 1,167, Margined Coralfish (*Chelmon marginalis*) n = 1,116, Green Chromis (*Chromis cinerascens*) n = <1,000 and Allen's Glidergoby (*Valenciennea alleni*) n = >900 (Marine Aquarium Table 1), with nearly 250 other fish taxa also reported. In addition, more than 100 invertebrate taxa were also landed in the MAFMF dominated by gastropods, anemones and crabs. The main coral species landed in 2020 were the coral-like anemones of the Corallimorphidae family with 2,754 kg (Marine Aquarium Fish Table 2).

The total catch in the HCF in 2020 was more than 75,000 Australian land hermit crabs. The catch range of Australian land hermit crabs over the last 10 years (2010-2019) is ~58,000-106,000.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Statewide MAFMF & HCF (Sustainable-Adequate)

Due to the large number of species captured in the MAFMF, and the relatively low numbers per species, traditional stock assessments are not undertaken. Catches at the lowest taxonomic level are annually monitored based on fisher returns. A risk assessment was undertaken with industry and other marine management groups in 2014, which determined that the risk these fisheries are imposing on the stocks is **low**.

This low level of risk is a reflection of all specimens being collected for the live market. Therefore, fishers are restricted in the quantities that they can safely handle and transport (for example, by boat to shore, by vehicle to the holding facility and then on to the retailer) without impacting on the quality of the product. The size of the holding facility and access to regular freight and infrastructure services (such as airports, particularly in the remote northern locations of Western Australia), restricts the levels of effort, and therefore catches, that can be expended in the fishery at any given time.

The above evidence indicates that the biomass of individual species in the MAFMF is unlikely to be depleted and that recruitment is unlikely to be impaired and that current levels of fishing mortality (catch) is unlikely to cause any individual species to become recruitment impaired. Thus the breeding stocks of landed species in the MAFMF are classified as **sustainable-adequate**.

The level of harvest of the Australian land hermit crab in the HCF is low relative to the large area in which this species is distributed in WA. In addition, a Productivity Susceptibility Analysis (PSA) was conducted for the Australian land hermit crab. The derived PSA score was 2.18. This indicates a low risk score given the known life history attributes (fast growing, early maturation, long life). The above evidence indicates that the biomass of Australian land hermit crab in the HCF is unlikely to be depleted, recruitment is unlikely to be impaired and that current levels of fishing mortality (catch) is unlikely to cause the Australian land hermit crab to become recruitment impaired. Thus the breeding stocks of the Australian land hermit crab in the HCF are classified as **sustainable-adequate**.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

There is no bycatch in either fishery as both fisheries target specific taxon by hand (with the MAFMF also targeting specific taxon by fishing line), therefore chances of retaining non-targeted species are negligible. This results in a **negligible** risk for bycatch interactions.

Protected species

The potential for listed species interactions is limited due to low fishing effort and small areas accessed on each trip. The MAFMF has a small take of syngnathids under a Wildlife Trade Operation (WTO) approval from the Commonwealth. However, there is a prohibition on the take of leafy sea dragons (*Phycodurus eques*). This results in a **low** risk for protected species interactions.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat and ecosystem impacts are considered **negligible**. This is due to the small scale of the fisheries and the hand collection methods. While the fisheries can potentially operate over large areas, catches are relatively low due to the special handling requirements of live fish. Fishing operations are also heavily weather-dependent due to the small vessels used (MAFMF) and beach access (HCF). This results in a **negligible** risk to the overall ecosystem from the fishery.

SOCIAL AND ECONOMIC OUTCOMES

Social

In 2020, thirteen licences were active across the MAFMF and the HCF. Collections by the MAFMF are usually undertaken on SCUBA or surface supplied air (hookah) from small vessels, typically in small teams of two or three people. Operators in the HCF use four-wheel drive vehicles to access remote beaches where collection occurs on foot. There is currently a **low** level of risk to these values.

Economic

The value per individual marine aquarium fish and hermit crab licence is relatively high but difficult to estimate directly as operators can sell direct to the public, to wholesalers or they have vertically integrated businesses, including export. It is likely the combined value of both fisheries exceeds several million dollars (value is estimated to be $1-5 million). There is currently a **low** level of economic risk to these values.

GOVERNANCE SYSTEM

The current effort level in these fisheries is low and relatively consistent from year-to-year. The impact of these fisheries is very low relative to the widespread distribution of the numerous species targeted. No other fisheries exploit the majority of the species targeted and therefore there is extremely limited potential for any impact on breeding stocks. Therefore, the current level of fishing activity is considered **adequate**.

There are specific performance measures for CITES species taken by the MAFMF, as part of its WTO conditions. There are catch limits for hard corals along with individual species-specific limits (see DPIRD 2018a). Catches of CITES species in 2020 were below the WTO limits for hard corals.

A total limit of 15,000 kg applies for hard and soft coral combined – excluding Corallimorpharia and Zoanthidae spp.: Hard coral catch – 11,907 kg; the total hard and soft coral landed was 12,458.20 kg.

Corallimorpharia and Zoanthidae spp. – 4,524.50 kg.

A total limit of 2,400 Tridacnid clams applies across all species): Tridacnid clams – 654 individuals.

A total limit of 2000 individuals applies across all Syngnathiformes species: Seahorses (*Hippocampus* spp.) – 290 individuals; Syngnathids (total all species) – 303.

Harvest Strategy

The harvest strategy for the Marine Aquarium Fish Resource of Western Australia (2018 – 2022) was published in September 2018 (DPIRD 2018a). The Harvest Strategy defines Threshold Levels for a range of species. In 2020, the Threshold Limits were exceeded for *Euphyllia ancora*, *Euphyllia glabrescens*, *Euphyllia paraancora* and *Lobophyllia hemprichii*. However, these levels of catch are considered acceptable as they are still low relative to the spatial distribution of each species within WA.

In October 2014, an ecological risk assessment (ERA) workshop was held to assess the impact of the MAFMF on the marine aquarium fish resource of Western Australia. Outcomes of the ERA are reported in DPIRD (2018b).

Compliance

On the 1st November 2018 an online detailed daily reporting system (Fisheye) was introduced for the MAFMF and replaces the old logbook system. Operators in the HCF are required to complete statutory catch and effort returns on a monthly basis. The low risks to the sustainability of the stocks imposed by these fisheries results in a **low** risk and low level of non-compliance.

Consultation

Consultation with licensees occurs directly on operational issues and through industry Management Meetings convened by the West Australian Fishing Industry Council (WAFIC) under a Service Level Agreement with the Department of Primary industries and Regional Development. The most recent Management Meeting for the MAFMF occurred in November 2020.

Consultation with non-fisher stakeholders is undertaken in accordance with the Department’s Stakeholder Engagement Guidelines.

Management Initiatives

A new management plan was introduced in 2018 that includes formal quota management arrangements for coral, *Tridacnid* clams, ‘live rock’ and syngnathiformes.

EXTERNAL DRIVERS

Fishers are typically limited by sea and weather conditions, and access to beaches. Consumer demand and unit prices also influence the target species and numbers landed. The external drivers pose a **negligible** risk to these fisheries.

MARINE AQUARIUM FISH TABLE 1

Summary of the reported catch (number of individuals) of the main fish (excluding Syngnathids) species landed from the Marine Aquarium Fish Managed Fishery for 2020, and catches over the previous four years.

Species	Common Name	2020	2019	2018	2017	2016
Ambassis vachellii	Vachell's Glassfish*	>13,000	<10	>4,000	>750	>3,000
Chaetodontoplus duboulayi	Scribbled Angelfish	1,961	2,657	3,553	3,602	2,670
Anampses lennardi	Blue And Yellow Wrasse	1,167	1,005	1,552	1,448	92
Chelmon marginalis	Margined Coralfish	1,116	711	1,934	1,888	943
Chromis cinerascens	Green Chromis*	<1,000	>400			
Valenciennea alleni	Allen's Glidergoby*	>900	>750	>750	>600	
Istiblennius meleagris	Spotted Blenny*	813	>100	>400	>600	1,222
Chromis atripectoralis	Black-axil Chromis*	>600	>900	>1,30	>300	2,106
Microcanthus strigatus	Stripey*	594		>20	>500	>20
Valenciennea puellaris	Orange-spotted Glidergoby*	>500	>300	1,046	1,039	<20

* the specific data cannot be reported due to confidentiality provisions.

MARINE AQUARIUM FISH TABLE 2

Summary of the reported catch (kg) of the main coral species landed from the Marine Aquarium Fish Managed Fishery for 2020, and catches over the previous four years.

Species	Common Name	2020	2019	2018	2017	2016
Corallimorphidae - undifferentiated	Corallimorphidae Coral-like Anemones*	2,754	2,616	362	>50	
Euphyllia ancora	Hammer Hard Coral	1,942.6	2,556.2	770.4	821	421.8
Euphyllia glabrescens	Torch Hard Coral	1,209.2	1,461.2	752.8	467.4	290.1
Order Zoantharia - undifferentiated	General Zoanthid Anemones*	1,007	1,251	470	>10	>300
Goniopora spp.	Goniopora Hard Corals	988.3	686.8	401	175.9	234.65
Euphyllia paraancora	Branching Hammer Hard Coral*	770	>300	>30	>10	>100
Duncanopsammia axifuga	Whisker Hard Coral	659.8	707.4	315.37	382.3	375.7
Lobophyllia hemprichii	Lobophyllia hemprichii*	606	277	>100		
Trachyphyllia geoffroyi	Trachyphyllia Hard Coral	569.4	729.9	326.6	528.5	272.9
Dipsastraea spp.	Dipsastraea Hard Coral	425.7	749.5	311.8	91.7	151.3
Acropora spp.	Acropora Staghorn Hard Corals	383.5	462	376.8	305.8	173.2
Lobophyllia spp.	Lobophyllia Hard Coral	382	441.8	422.6	168.9	145.4
Symphyllia wilsoni	Symphyllia wilsoni Hard Coral*	374.7	984.6	169.9	>200	>50
Order Corallimorpharia - undifferentiated	General Coral-like Anemones	374	225	331.2	49	369
Alveopora spp.	Alveopora Hard Corals*	344	286	>20	>10	31
Catalaphyllia jardinei	Catalaphyllia Elegant Hard Coral	308	782	306.2	106.5	164.7
Sarcophyton spp.	Toadstool Soft Corals	255.7	429.5	390.5	456	455.7
Acanthastrea lordhowensis	Lordhowensis Acanthastrea Hard Coral*	227.2	239.6	<10		>20
Acanthastrea echinata	Echinata Acanthastrea Hard Coral	164.8	156.4	24		
Sinularia spp.	Sinularia Soft Corals*	162	96	<10	<10	<10

* the specific data cannot be reported due to confidentiality provisions.

REFERENCES

Australian Government. 2016. CITES Non Detriment Finding Assessment Summary – WA MAFMF – Coral, Giant Clams and Seahorses (October 2016).

CSIRO. 2011. Review of the WA Department of Fisheries for the re-assessment of the WAMAFMF (December 2011).

Department of Fisheries. 1995. 'Management of the Marine Aquarium Fishery', Fisheries Management Paper 63.

Department of Fisheries. 2013. Marine Aquarium Fishery Daily Log Book.

DPIRD. 2018a. Marine Aquarium Fish Resource of Western Australia Harvest Strategy 2018 – 2022 Version 1.0. Fisheries Management Paper No. 292, September 2018, Department of Primary Industries and Regional Development, Perth, Western Australia. 37p.

DPIRD. 2018b. Ecosystem-Based Fisheries Management (EBFM): Risk Assessment of the Marine Aquarium Fish Managed Fishery 2014. Fisheries Management Paper No. 293, September 2018, Department of Primary Industries and Regional Development, Perth, Western Australia. 73p.

Penn J. 2011. Unpublished report on the status of CITES listed species groups harvested by the Western Australian Marine Aquarium Fishery (November 2011).

Pratchett, M., Caballes, C., Messmer, V., Wilson, S., Roelofs, A., Penny, S., Kelley, R. and Newman, S. 2020. Vulnerability of commercially harvested corals to fisheries exploitation versus environmental pressures. FRDC Project No. 2014-029 Final Report. James Cook University, Townsville. 80p.

Smith KA, Newman SJ, and Cliff GM. 2010. Marine Aquarium Managed Fishery: ESD Report Series No. 8. Department of Fisheries, Western Australia.

STATEWIDE SPECIMEN SHELL RESOURCE STATUS REPORT 2021

A. Hart, C. Bruce and A. Steele

OVERVIEW

The Specimen Shell Managed Fishery (SSMF) is based on the collection of individual shells for the purposes of display, collection, cataloguing, classification and sale.

About 200 species of Specimen Shell are collected each year, using a variety of methods. The main methods are via hand collection by small groups of divers operating from small boats in shallow coastal waters, by wading along coastal beaches below the high water mark or, in some instances, by use of remotely operated underwater vehicles. While the fishery covers the entire Western Australian coastline, some concentration of effort occurs in areas adjacent to population centres such as Broome, Exmouth, Shark Bay, Geraldton, Perth, Mandurah, the Capes area, Albany and Esperance.

This fishery is managed through input controls in the form of limited entry, gear restrictions and permanent closed areas. There are also operational limitations – depth, time and tide. The fishery has 30 licences with a maximum of 4 divers allowed in the water per licence at any one time, and specimens may only be collected by hand or by use of remotely operated underwater vehicles (limited to one per licence) under an exemption for the trial of this collection method.

There are a number of closed areas where the SSMF is not permitted to operate. These include within various marine parks and aquatic reserves and other closed waters such as Reef Observation Areas and Fish Habitat Protection Areas. Much of the west side of North-West Cape and the Ningaloo Marine Park are prohibited areas for the SSMF. The exclusion of Marmion Marine Park in the Perth metropolitan area is also important because of its populations of two rare cowrie species. There are no documented recreational fisheries.

SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (NA)	Total Catch 2020: Shells (n) – 4,258	Acceptable
Recreational fishery (NA)	Total Catch 2020: NA	Acceptable
EBFM		
Assessment Indicator		
Catch: 10,000 to 25,000 shells Catch rate: 10 – 40 shells per day	4,258 shells. 11 shells per day	Adequate Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Negligible Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (Level 1 GVP <$1 million)	Low Risk	Acceptable
Social (low amenity)	Low Risk	Acceptable
Governance	Stable	Acceptable
External Drivers	Negligible Risk	Acceptable

SPECIMEN SHELL FIGURE 1
Map showing the boundaries of the Specimen Shell Managed Fishery.

CATCH AND LANDINGS

In 2020, the total number of specimen shells collected was 4,258 distributed over 206 species. This is based on 100% of submitted catch returns. In the past 5 years, more than 430 separate species of molluscs have been collected, with an average of more than 200 species per year – the majority in low numbers per individual species.

There is some focus of effort on mollusc families that are most popular with shell collectors, such as cowries, cones, murexes and volutes. Cypraeidae or cowries are noted for their localised variations in both shape and colour, making them attractive to collectors.

Of the 30 licences in the fishery, 15 fished in 2020. Effort in 2020 was 375 days, which was 85 fishing days less than the number of fishing days reported in 2019 (460 days). Over the past five years, there was an annual average of around 546 days fished.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Statewide SSMF

During the 2020 season, the catch rate was approximately 11 shells per day.

Ponder and Grayson (1998) examined the specimen shell industry on a nationwide basis, rating vulnerability to over-exploitation on the basis of species biology, accessibility to collection, and rarity. Species collected in Western Australia which were identified by Ponder and Grayson (1998) as potentially vulnerable comprised a total of 6 cowries *(Cypraea (Austrocypraea) reevei, Cypraea (Zoila) friendii vercoi, Cypraea (Zoila) marginata (albanyensis), Cypraea (Zoila) marginata (consueta), Cypraea (Zoila) rosselli* and *Cypraea (Zoila) venusta)* and 2 volutes *(Amoria damoni (keatsiana)* and *Amoria damoni (reevei))*.

Shell sighting is the abundance category used to monitor the 8 vulnerable species. Of the 8 vulnerable species an overall average of approximately 51% of the shells sighted were not harvested in 2020. The measure of the number of shells sighted is reported correctly in about 99% of cases where one of the vulnerable species is reported. It is anticipated that current sightings are an under estimate of the available populations. Thus the breeding stocks of landed species are classified as **sustainable-adequate**.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

There is no bycatch in this fishery owing to the highly selective fishing methods This results in a **negligible** risk for bycatch interactions.

Protected species

The fishery reported no interactions with listed protected species during 2020. Reports of interactions with listed protected species are required to be recorded on monthly catch and effort returns This results in a **negligible** risk for protected species interactions.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat and ecosystem impacts are considered **negligible**. This is due to the small scale of the fishery and the hand collection methods. While the fisheries can potentially operate over large areas, catches are relatively low due to the special handling requirements. For example, specimens with slight visual imperfections are often overlooked by collectors, meaning their reproductive potential to the population can still be realised. This results in a **negligible** risk to the overall ecosystem from the fishery.

SOCIAL AND ECONOMIC OUTCOMES

Social

In 2020, around 5 licences recorded consistent activity, with around 16 people operating occasionally in the fishery. It is expected that approximately 12 people are employed regularly in this fishery. There is currently a **low** level of risk to these values.

Economic

The value per individual specimen shell can be relatively high but difficult to estimate as operators can sell direct to the public, to wholesalers or through vertically integrated businesses including export. Estimated annual economic value of this fishery is currently not assessed. There is currently a **low** level of economic risk to these values.

GOVERNANCE SYSTEM

The performance measures for the fishery relate to the maintenance of breeding stocks, as indicated by catch levels and catch rates. In 2020, the catch level of approximately 4,258 shells was below the catch range set, i.e. 10,000 – 25,000 shells and the catch rate of 11 shells/day was within the range set, i.e. 10 – 40 shells/day.

Harvest Strategy

The fishery currently operates under an informal harvest strategy based on a constant exploitation approach. There is no formal harvest strategy for this fishery.

Compliance

Operators in the SSMF are required to complete statutory catch and effort returns on a monthly basis. The low risks to the sustainability of the stocks imposed by the SSMF results in a **low** risk and low level of compliance.

Consultation

The Department undertakes consultation directly with licensees on operational issues as well as through the Professional Shell Fisherman's Association of Western Australia. Industry Management Meetings are convened by the Department through the Western Australian Fishing Industry Council (WAFIC), who also undertake consultation on statutory management plan amendments on behalf of the Department under a Service Level Agreement.

Management Initiatives

A review of the management arrangements for the SSMF is planned for 2020/2021.

EXTERNAL DRIVERS

Fishers are typically limited by sea and weather conditions and access to beaches. Consumer demand and unit prices also influence the target species and numbers landed. The external drivers pose a **low** risk to the SSMF.

REFERENCES

Ponder, W.F., & Grayson, J.E. (1998). The Australian marine molluscs considered to be potentially vulnerable to the shell trade. *A report prepared for Environment Australia*.

APPENDICES

APPENDIX 1

Science and Resource Assessment staff publications 2020/21

Scientific Papers

Afrifa-Yamoah, E., Taylor, S. M., Mueller, E, 2021. Trade-off assessments between reading cost and accuracy measures for digital camera monitoring of recreational boating effort. Fisheries Research (233), 105757

Afrifa-Yamoah, E., Mueller, U., Taylor, S. M., Fisher, A. 2020. Imputation of missing data from time-lapse cameras used in recreational fishing surveys. ICES Journal of Marine Science 77 (9-8): 2984-2994.

Alexander, J.B., Bunce, M., White, N., Wilkinson, S.P., Adam, A.A.S., Berry, T., Stat, M., Thomas, L., Newman, S.J., Laurence, D., Richards, Z.T. 2020. Development of a multi-assay approach for monitoring coral diversity using eDNA metabarcoding. Coral Reefs 39 (1): 159-171. doi: 10.1007/s00338-019-01875-9

Andrews, K.R., Copus, J.M., Wilcox, C., Williams, A.J., Newman, S.J., Wakefield, C.B. and Bowen, B.W. 2020. Range-wide population structure of 3 deepwater Eteline snappers across the Indo-Pacific basin. Journal of Heredity 111 (5): 471-485. doi: 10.1093/jhered/esaa029

Bosch, N.E., Monk, J., Goetze, J., Wilson, S., Babcock, R.C., Barrett, N., Clough, J., Currey-Randall, L.M., Fairclough, D.V., Fisher, R., Gibbons, B.A., Harasti, D., Harvey, E.S., Heupel, M.R., Hicks, J.L., Holmes, T.H., Huveneers, C., Ierodiaconou, D., Jordan, A., … Langlois, T. 2021. Effects of human footprint and biophysical factors on body-size structure of fished marine species. Conservation Biology; 1– 13. https://doi.org/10.1111/cobi.13807

Braccini, J.M., Blay, N., Harry, A. & Newman, S.J. 2020. Would ending shark meat consumption in Australia contribute to the conservation of white sharks in South Africa? Marine Policy 120: 104144.

Braccini, J.M., Hesp, A. & B. Molony. 2021. Risk-based weight of evidence assessment of commercial sharks in Western Australia. Ocean and Coastal Management 205: 05501.

Braccini, M., Kangas, M., and Newman, S. 2021. Quantifying the unreported and unaccounted domestic and foreign commercial catch of sharks and rays in Western Australia. Royal Swedish Academy of Sciences https://doi.org/10.1007/s13280-020-01495-6

Braccini, M., Lai, E.K.M., Ryan, K.L., Taylor, S.M. (2021). Recreational Harvest of Sharks and Rays in Western Australia Is Only a Minor Component of the Total Harvest. Sustainability 13: 6215 https://doi.org/10.3390/su13116215

Braccini, M., Molony B. & Blay, N. 2020. Patterns in abundance and size of sharks in northwestern Australia: cause for optimism. ICES Journal of Marine Science 71: 72–82

Braccini, J.M. & Newman, S. 2020. Limitations on inferring shark vulnerability from spatial habitat protection. Response to: Shark conservation hindered by lack of habitat protection. Global Ecology and Conservation 24: e01219.

Bradley, M., Nagelkerken, I., Baker, R., Travers, M. & Sheaves, M. 2021. Local Environmental Context Structures Animal-Habitat Associations Across Biogeographic Regions. Ecosystems, 1-15 https://doi.org/10.1007/s10021-021-00651-7.

Campbell, T., Tweedley, J., Johnston, D. and Loneragan, N. 2021. Blue Swimmer Crab diet in adjacent temperate estuaries and coastal embayments differs between systems and seasons. Frontiers Mar. Sci. 8: doi.org/10.3389/fmars.2021.564695

Caputi, N., Chandrapavan, A., Kangas, M., de Lestang, S., Hart, A., Johnston, D. and Penn, J., 2021. Stock-recruitment-environment relationships of invertebrate resources in Western Australia and their link to pro-active management harvest strategies. Marine Policy, 133, p.104728.

Caputi, N., de Lestang, S., Newman, S.J., Jackson, G., Smith, K. 2021. Stakeholder-government collaboration in developing cost-effective fishery-independent surveys in rights-based and co-managed fisheries. Marine Policy 128. https://doi.org/10.1016/j.marpol.2021.104510

Connolly, R.M., Fairclough, D.V., Jinks, E.L., Ditria, E.M., Jackson, G., Lopez-Marcano, S., Olds, A.D., Jinks, K.I. 2021. Improved accuracy for automated counting of a fish in baited underwater videos for stock assessment bioRxiv 2021.02.01.429285; doi: https://doi.org/10.1101/2021.02.01.429285

Coulson, P.G. and Newman, S.J. 2020. Age estimation and otolith characteristics of an extremely old Deepsea Black Cardinalfish (Epigonus telescopus) captured off the southern coast of Western Australia. Journal of Applied Ichthyology 36 (3): 352-354. doi: 10.1111/jai.14020

Desfosses, C., Blight, S., Denham, S., Taylor, S. M. 2021. Supplemented roving survey to quantify spatio-temporal recreational fishing effort in an estuarine Ramsar wetland. Fisheries Research 242 (2021) 106042.

Feng, M., Caputi, N., Chandrapavan, A., Chen, M., Hart, A., Kangas, M. 2020. Multi-year marine cold-spells off the west coast of Australia and effects on fisheries. Journal of Marine Systems 214. https://doi.org/10.1016/j.jmarsys.2020.103473

Goetze, J.S., Wilson, S., Radford, B., Fisher, R., Langlois, T.J., Monk, J., Knott, N.A., Malcolm, H., Currey-Randall, L.M., Ierodiaconou, D., Harasti, D., Barrett, N., Babcock, R.C., Bosch, N.E., Brock, D., Claudet, J., Clough, J., Fairclough, D.V., Heupel, M.R., Holmes, T.H., Huveneers, C., Jordan, A.R., McLean, D., Meekan, M., Miller, D., Newman, S.J., Rees, M.J., Roberts, K.E., Saunders, B.J., Speed, C.W., Travers, M.J., Treml, E., Whitmarsh, S.K., Wakefield, C.B. and Harvey, E.S. 2021, Increased connectivity and depth improve the effectiveness of marine reserves. Glob Change Biol, 27: 3432-3447. https://doi.org/10.1111/gcb.15635

Grace, M.K., Akçakaya, H.R., Bennett, E.L. *et al*. 2021. Testing a global standard for quantifying species recovery and assessing conservation impact. Conservation Biology; 1– 17. https://doi.org/10.1002/cobi.13756

Harvey, E.S., McLean, D.L., Goetz, J.S., Saunders, B.J., Langlois, T.J., Monk, J., Barrett, N., Wilson, S.K., Holmes, T.H., Ierodiaconou, D., Jordan, A.R., Meekan, M.G., Malcolm, H.A., Heupel, M.R., Harasti, D., Huveneers, C., Knott, N.A., Fairclough, D.V. …Newman, S.J. 2021. The BRUVs workshop – An Australia-wide synthesis of baited remote underwater video data to answer broad-scale ecological questions about fish, sharks and rays. Marine Policy 127, 104430

Hidalgo, F. and de Lestang, S., 2020, October. Underwater Automated Camera 'Potbot' for Marine Habitat Monitoring in Fishing. In Global Oceans 2020: Singapore–US Gulf Coast (pp. 1-4).

How, J.R., de la Mare, W.K., Coughran, D.K., Double, M.C., and de Lestang, S. 2021. Gear modifications reduced humpback whale entanglements in a commercial rock lobster fishery. Marine Mammal Science.1–25. DOI: 10.1111/mms.12774.

Johnston, D.J. and Yeoh, D.E. 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: ruab032. https://doi.org/10.1093/jcbiol/ruab032.

Johnston, D.J. and Yeoh, D.E. 2020. Carapace width-weight relationships of blue swimmer crab *Portunus armatus* (A. Milne-Edwards, 1861) (Crustacea: Brachyura: Portunidae) in south-western Australia: influences of sex, decadal change, environment, and season. Journal of Crustacean Biology, 40(5): 526–533. doi:10.1093/jcbiol/ruaa046.

Johnston, D.J., Yeoh, D.E. and Harris, D.C. 2021. Environmental drivers of commercial blue swimmer crab (Portunus armatus) catch rates in Western Australian fisheries. Fisheries Research, 235: 105827. https://doi.org/10.1016/j.fishres.2020.105827.

Kolbusz, J., de Lestang, S., Langlois, T. and Pattiaratchi, C. 2021. Changes in Panulirus cygnus settlement along Western Australia using a long time series. Frontiers in Marine Science, 8, p.718.

Kolbusz, J., Langlois, T., Pattiaratchi, C. and de Lestang, S. 2021. Using an oceanographic model to investigate the mystery of the missing puerulus. Biogeosciences Discussions pp.1-37.

Konzewitsch, N. and Evans, S.N., 2020. Examining the Movement of the Common Spider Conch Lambis lambis in Shallow Water of a Northeastern Indian Ocean Atoll Using Passive Acoustic Tracking. Journal of Shellfish Research, 39 (2): 389-397.

Lai, E. K. M., Ryan, K. L., Mueller, U., & Hyndes, G. A. 2021. Corroborating effort and catch from an integrated survey design for a boat-based recreational fishery in Western Australia. Fisheries Research, 236(April), 105865. https://doi.org/10.1016/j.fishres.2020.105865

Langlois, T., Goetze, J., Bond, T., Monk, J., Abesamis, R.A., Asher, J., Barrett, N., Bernard, A.T.F., Bouchet, P.J., Birt, M.J., Cappo, M., Currey-Randall, L.M., Fairclough, D.V., Fullwood, L.A.F., Gibbons, B.A., Harasti, D., Hicks, J., Holmes, T.H., Huveneers, C., Ierodiaconou, D., Jordan, A., Knott, N.A., Malcolm, H.A., McLean, D., Meekan, M., Miller, D., Mitchell, P.J., Newman, S.J., Radford, B., Rolim, F.A., Saunders, B.J., Stowar, M., Smith, A.N.H., Travers, M.J., Wakefield, C.B., Whitmarsh, S.K., Williams, J., Driessen, D. and Harvey, E.S. 2020. A field and video-annotation guide for baited remote underwater stereo-video surveys of demersal fish assemblages. Methods in Ecology and Evolution 11 (11): 1401-1409. doi: 10.1111/2041-210X.13470

Lédée, E.J.I., Heupel, M.R., Taylor, M.D., Harcourt, R.G., Huveneers, C., Udyawer, V., Campbell, H.A., Jaine, F.R.A., Babcock, R.C., Hoenner, X., Barnett, A., Braccini, J.M., *et al*. 2021. Continental-scale acoustic telemetry and network analysis reveal new insights into stock structure. Fish and Fisheries. 22: 987-1005.

MacNeil, M.A., Chapman, D., Heupel, M., Simpfendorfer, C.A., Heithaus, M., Meekan, M., Harvey, E.S., Goetze, J., Cinner, J.E., Kiszka, J., Bond, M., Currey-Randall, L.M., Speed, C., Sherman, C.S., Rees, M.J., Udyawer, V., Flowers, K.I., Clementi, G., Valentin-Albanese, J., Gorham, T., Adam, M.S., Ali, K., Pina-Amargós, F., Angulo-Valdés, J.A., Asher, J., Barcia, L.G., Beaufort, O., Benjamin, C., Bernard, A., Berumen, M., Bierwagen, S., Bonema, E., Bown, R.M.K., Bradley, D., Brooks, E., Brown, J., Buddo, D., Burke, P., Caceres, C., Cardenosa, D., Carrier, J., Caselle, J., Charloo, V., Claverie, T., Clua, E., Cochrane, J.E.M., Cook, N., Cramp, J., D'Alberto, B., de Graffe, M., Dornhege, M., Estep, A., Fanovich, L., Farabough, N.F., Fernando, D., Flam, A., Floros, C., Fourqurean, V., Garla, R., Gastrich, K., George, L., Graham, R., Guttridge, T., Hardenstine, R., Heck, S., Henderson, A., Hertler, H., Hueter, R., Johnson, M., Jupiter, S., Kessel, S., Kiilu, B., Kirata, T., Kuguru, B., Kyne, F., Langlois, T., Ledee, E., Lindfield, S., Maggs, J., Manjaji-Matsumoto, B.M., Marshall, A., Matich, P., McCombs, E., Mclean, D., Meggs, L., Moore, S., Murray, R., Muslimin, Newman, S.J., Nogués, J., Obuta, C., O'Shea, O., Osuka, K., Papastamatiou, Y., Perera, N., Peterson, B., Ponzo, A., Prasetyo, A., Qamar, L.M.S., Quinlan, J., Ruiz-Abierno, A., Sala, E., Samoilys, M., Scharer-Umpierre, M., Schlaff, A., Simpson, N., Smith, A., Sparks, L., Tadurrbannna, A., Torres, R., Travers, M.J., Van Zinnicq Bergmann, M., Vigliola, L., Ward, J., Watts, A.M., Wen, C., Whitman, E., Wirsing, A., Wothke, A. and Zarza, E. 2020. Global status and conservation potential of reef sharks. *Nature* **583**, 801-806.

Marks, R., Hesp, S. A., Denham, A., Loneragan, N. R., Johnston, D., Hall, N. 2021. Factors influencing the dynamics of a collapsed blue swimmer crab (Portunus armatus) population and its lack of recovery. Fisheries Research 242. 106035.

Norriss, J.V., Fisher, E.A. and Denham, A.M. 2020. Seabird bycatch in a sardine purse seine fishery. ICES Journal of Marine Science, 77: 2971–2983.

Pember, B., Chaplin, J.A., Loneragan, N.R. & Braccini, J.M. 2020. Population genetic structure of Indo-West Pacific carcharhinid sharks: what do we know and where to from here? Pacific Conservation Biology 26: 319–337.

Pérez, M., Braccini, J.M. & Cousseau, M.B. 2020. Marcación y recaptura del gatuzo (Mustelus schmitti) en el ecosistema costero bonaerense (Argentina). Marine and Fishery Sciences 33: 21–25 (in Spanish).

Pratchett, M.S., Caballes, C.F., Newman, S.J., Wilson, S.K., Messmer, V. and Pratchett, D.J. 2020. Bleaching susceptibility of aquarium corals collected across northern Australia. Coral Reefs 39 (3): 663-673. doi: 10.1007/s00338-020-01939-1

Ryan, K.L., Desfosses, C.J., Denham, A.M., Taylor, S.M., Jackson, G. 2021. Initial insights on the impact of COVID-19 on boat-based recreational fishing in Western Australia. Marine Policy 132: 104646 https://doi.org/10.1016/j.marpol.2021.104646

Schmidt-Roach, A., Bruels, C., Barnett, A., Miller, A., Sherman, C., Ebert, D., Schmidt-Roach, S., da Silva, C, Wilke, C., Thorburn, C., Mangel, J., Ezcurra, J., Irigoyen, A., Jaureguizar, A., Braccini, J.M., *et al*. 2021. Evidence of historical isolation and genetic structuring among broadnose sevengill sharks (*Notorynchus cepedianus*) from the world's major oceanic regions. Reviews in Fish Biology and Fisheries 31: 433–447.

Smallwood, C.B., Ryan, K.L. 2020. Benefits of a restricted spatial and temporal survey design for determining average weight of recreational catches. Fisheries Research 232: 105735. https://doi.org/10.1016/j.fishres.2020.105735

Smith, K.A. and Lenanton, R.C.J. 2021. Almost forgotten: historical abundance of eel-tail catfish populations in south-western Australian estuaries and their decline due to habitat loss and historical overfishing. Regional Studies in Marine Science 41: 101605. https://doi.org/10.1016/j.rsma.2020.101605

Takahashi, M., DiBattista, J.D., Jarman, S., Newman, S.J., Wakefield, C.B., Harvey, E.S. and Bunce, M. 2020. Partitioning of diet between species and life history stages of sympatric and cryptic snappers (Lutjanidae) based on DNA metabarcoding. Scientific Reports 10: 4319. doi: 10.1038/s41598-020-60779-9

Tate, A.C., Smallwood, C.B., 2021. Comparing the efficiency of paper-based and electronic data capture during face-to-face interviews. PLoS ONE 16, 1–13. https://doi.org/10.1371/journal.pone.0247570

Taylor, S.M., Smallwood, C.B., Desfosses, C.J., Ryan, K.L., Jackson, G. 2021. Corroborating catch estimates to inform monitoring of a small-scale marine recreational fishery in a World Heritage property. ICES Journal of Marine Science https://doi.org/10.1093/icesjms/fsab095

Tuffley, E., de Lestang, S., How, J., and Langlois, T. 2021. Size matters: large spiny lobsters reduce the catchability of small conspecifics. Marine Ecology Progress Series. 666: 99-113.

Vanderklift, M.A., Babcock, R.C., Barnes, P.B., Cresswell, A.K., Feng, M., Haywood, M.D.E., Holmes, T.H., Lavery, P.S., Pillans, R.D., Smallwood, C.B., Thomson, D.P., Tucker, A.D., Waples, K., Wilson, S.K., 2020. The oceanography and marine ecology of Ningaloo, a World Heritage Area. Oceanography and Marine Biology 143–178. https://doi.org/10.1201/9780429351495-4

Wakefield, C.B., Coulson, P.G., Loudon, L. and Newman, S.J. 2020. Latitudinal and sex-specific differences in growth and an exceptional longevity for the Maori snapper Lutjanus rivulatus from north-western Australia. Fisheries Research 230: 105634. doi: 10.1016/j.fishres.2020.105634

Wakefield, C.B., Williams A.J., Fisher, E.A., Hall, N.G., Hesp, S.A., Halafihi, T., Kaltavara, J., Vourey, E., Taylor, B.M., O'Malley, J.M., Nicol, S.J., Wise, B.S. and Newman, S.J. 2020. Variations in life history characteristics of the deep-water giant ruby snapper (Etelis sp.) between the Indian and Pacific Oceans and application of a data-poor assessment. Fisheries Research 230: 105651. doi: 10.1016/j.fishres.2020.105651

Walker, T.I., Day, R.W., Awruch, C.A., Bell, J.D., Braccini, J.M., et al. 2021. Ecological vulnerability of the chondrichthyan fauna in southern Australia to the stressors of climate change, fishing, and other anthropogenic hazards. Fish and Fisheries. 22: 1105-1135.

West, K.M., Stat, M., Harvey, E.S., Skepper, C.L., DiBattista, J.D., Richards, Z.T., Travers, M.J., Newman S.J. and Bunce, M. 2020. eDNA metabarcoding survey reveals fine-scale coral reef community variation across a remote, tropical island ecosystem. Molecular Ecology 29 (6): 1069-1086. doi: 10.1111/mec.15382

West, K., Travers, M. J., Stat, M., Harvey, E. S., Richards, Z. T., DiBattista, J. D., Newman, S. J., Harry, A. V., Skepper, C. L., Heydenrych, M. & Bunce, M. 2021. Large-scale eDNA metabarcoding survey reveals marine biogeographic break and transitions over tropical north-western Australia. *Diversity and Distributions* 27, 1942-1957

Reports

Chandrapavan, A., Kangas, M. and Caputi, N. 2020. Understanding recruitment variation (including the collapse) of Ballot's saucer scallop stocks in Western Australia and assessing the feasibility of assisted recovery measures for improved management in a changing environment. Fisheries Research Report No. 308 Department of Primary Industries and Regional Development, Western Australia. 76pp.

de Lestang, S., Pember, M., Hoenig, J., and How, J. 2021. An industry-based mark recapture program to provide stock assessment inputs for the Western Rock Lobster Fishery following introduction of quota management. Fisheries Research Report No. 312. Department of Primary Industries and Regional Development, Western Australia. 84pp.

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

Fletcher, W.J. 2020. A review of the application of the Ecosystem Approach to Fisheries (EAF) Management within Areas Beyond National Jurisdictions (ABNJ). Fisheries Technical Report 2020/10. 280pp. Food And Agriculture Organisation. Rome. https://doi.org/10.4060/cb1509en

Johnston, D., Harris, D. and Yeoh, D. 2020. Blue Swimmer Crab (Portunus armatus) Resource in the West Coast Bioregion, Western Australia. Part 2: Warnbro Sound, Comet Bay, Mandurah to Bunbury, Leschenault Estuary, Geographe Bay and Hardy Inlet. Fisheries Research Report No. 309. Department of Primary Industries and Regional Development, Western Australia. 93 pp.

Johnston, D., Harris, D. and Yeoh, D. 2020. Blue Swimmer Crab (Portunus armatus) and Two Spot Sand Crab (Ovalipes australiensis) Resource in the South Coast Bioregion of Western Australia. Fisheries Research Report No. 310. Department of Primary Industries and Regional Development, Western Australia. 62 pp.

Kangas, M., Chandrapavan, A., Wilkin, S., Fisher, E. and Evans, S. 2021. Resource Assessment Report Abrolhos Islands and Mid-West Trawl Managed Fishery Resource. Western Australian Marine Stewardship Council Report Series 20: 75pp.

Toby Piddocke, Crispian Ashby, Klaas Hartmann, Alex Hesp, Patrick Hone, Joanne Klemke, Stephen Mayfield, Anthony Roelofs, Thor Saunders, John Stewart, Brent Wise and James Woodhams (eds) 2021, *Status of Australian fish stocks reports 2020*, Fisheries Research and Development Corporation, Canberra.

Popular Articles

Caputi, N., Wahle, R., Moore, J., Orminski, N. 2020. (Ed.) The Lobster Newsletter. 33(2). Department of Primary Industries and Regional Development, Western Australia. December 2020. http://www.fish.wa.gov.au/Documents/rock_lobster/the_lobster_newsletter/lobster_newsletter_v33_no2.pdf

APPENDIX 2

The following tables contain data reported for commercial catches, estimated recreational and charter catches, aquaculture production, reported bycatch of protected and listed species from commercial fisheries and fish prices reported from land based processors. The reporting period is dependent on the most recent data available.

Table of catches from commercial fishers' statutory returns for 2019/20

This table contains the estimated live weight[1] of species recorded in the compulsory catch and fishing effort returns provided by commercial fishers each month. These data include the catch taken as by-product as well as the targeted catch.

These catch data may differ slightly from some of the catch estimates presented for specific fisheries as the latter may include additional data from other sources, such as research log books and processors. The figures may also differ slightly from previously reported figures, as additional data may have been received by the Department of Primary Industries and Regional Development. The table represents the latest year for which a complete set of data is available.

While scientific names have been included wherever possible, it should be noted that many fish recorded under a common name cannot be identified as belonging to a particular single species and therefore must be reported as being part of a commercial grouping of several species. For example, the common name 'Redfish' may be used for several species of the genus Centroberyx.

Data for species with live weight catches of less than 500 kg have been combined into the general or 'other' category within each class. Data for the Marine Aquarium fish Fishery, Specimen Shell Fishery and Hermit Crab Fishery are presented in the next table. Data for the Indian Ocean Territories Fishery have not been included.

Category Family Scientific Name	Common Name	Scientific Name	Live Weight (tonnes)
FISH			
SCALEFISH			
Acropomatidae, Percichthyidae, Serranidae, Polyprionidae, Moronidae, Callanthiidae, Centrogeniidae, Ostracoberycidae	Temperate Basses & Rockcods	Percichthyidae, Serranidae - undifferentiated	87
Ariidae	Forktail Catfishes	Ariidae - undifferentiated	8
Arripidae	Australian Herring	*Arripis georgianus*	81
Arripidae	Western Australian Salmon	*Arripis truttaceus*	97
Atherinidae	Hardyheads & Tusked Silversides	Atherinidae, Dentatherinidae - undifferentiated	2
Balistidae, Monacanthidae	Triggerfishes & Leatherjackets	Balistidae, Monacanthidae - undifferentiated	25
Berycidae	Bight Redfish	*Centroberyx gerrardi*	47
Berycidae	Redfishes	Berycidae - undifferentiated	5
Berycidae	Yelloweye Redfish	*Centroberyx australis*	14
Carangidae	Amberjack	*Seriola dumerili*	12
Carangidae	Black Pomfret	*Parastromateus niger*	4
Carangidae	Giant Queenfish	*Scomberoides commersonnianus*	1
Carangidae	Golden Trevally	*Gnathanodon speciosus*	23
Carangidae	Samsonfish	*Seriola hippos*	26
Carangidae	Silver Trevally	*Pseudocaranx georgianus spp. complex*	1
Carangidae	Trevallies	Carangidae - undifferentiated	239
Carangidae	Yellowtail Kingfish	*Seriola lalandi*	4
Carangidae	Yellowtail Scad	*Trachurus novaezelandiae*	5
Centrolophidae	Blue-Eye Trevalla	*Hyperoglyphe antarctica*	6
Cheilodactylidae	Blue Morwong	*Nemadactylus valenciennesi*	36
Clupeidae	Australian Sardine	*Sardinops sagax*	1,637
Clupeidae	Perth Herring	*Nematalosa vlaminghi*	1
Clupeidae	Sandy Sprat	*Hyperlophus vittatus*	11

Category Family Scientific Name	Common Name	Scientific Name	Live Weight (tonnes)
Clupeidae	Scaly Mackerel	*Sardinella lemuru*	271
Fishes (multi-family groups)	Flounders	Bothidae, Psettodidae & Pleuronectidae	3
Glaucosomatidae	Northern Pearl Perch	*Glaucosoma buergeri*	39
Glaucosomatidae	West Australian Dhufish	*Glaucosoma hebraicum*	74
Haemulidae	Grunter Breams	Haemulidae - undifferentiated	5
Haemulidae	Javelinfishes	*Pomadasys spp.*	33
Haemulidae	Painted Sweetlips	*Diagramma labiosum*	112
Hemiramphidae	Garfishes	Hemiramphidae - undifferentiated	1
Hemiramphidae	Southern Garfish	*Hyporhamphus melanochir*	10
Kyphosidae, Scorpididae	Drummers & Sweeps	Kyphosidae, Scorpididae - undifferentiated	3
Labridae	Baldchin Groper	*Choerodon rubescens*	10
Labridae	Foxfish	*Bodianus frenchii*	1
Labridae	Pigfishes	*Bodianus spp.*	1
Labridae	Tuskfishes	*Choerodon spp.*	12
Labridae	Western Blue Groper	*Achoerodus gouldii*	35
Latidae	Barramundi	*Lates calcarifer*	48
Lethrinidae	Bluespotted Emperor	*Lethrinus punctulatus*	501
Lethrinidae	Drab Emperor	*Lethrinus ravus*	4
Lethrinidae	Grass Emperor	*Lethrinus laticaudis*	2
Lethrinidae	Longnose Emperor	*Lethrinus olivaceus*	12
Lethrinidae	Mozambique Seabream	*Wattsia mossambica*	3
Lethrinidae	Redspot Emperor	*Lethrinus lentjan*	63
Lethrinidae	Redthroat Emperor	*Lethrinus miniatus*	41
Lethrinidae	Robinson's Seabream	*Gymnocranius grandoculis*	48
Lethrinidae	Spangled Emperor	*Lethrinus nebulosus*	103
Lethrinidae	Yellowtail Emperor	*Lethrinus atkinsoni*	6
Lobotidae	Tripletail	*Lobotes surinamensis*	1
Lutjanidae	Brownstripe Snapper	*Lutjanus vitta*	213
Lutjanidae	Chinamanfish	*Symphorus nematophorus*	11
Lutjanidae	Crimson Snapper	*Lutjanus erythropterus*	235
Lutjanidae	Darktail Snapper	*Lutjanus lemniscatus*	16
Lutjanidae	Fiveline Snapper	*Lutjanus quinquelineatus*	2
Lutjanidae	Goldband Snapper	*Pristipomoides multidens*	887
Lutjanidae	Mangrove Jack	*Lutjanus argentimaculatus*	16
Lutjanidae	Moses' Snapper	*Lutjanus russellii*	68
Lutjanidae	Red Emperor	*Lutjanus sebae*	407
Lutjanidae	Rosy Snapper	*Pristipomoides filamentosus*	10
Lutjanidae	Ruby Snapper	*Etelis carbunculus*	13
Lutjanidae	Saddletail Snapper	*Lutjanus malabaricus*	336
Lutjanidae	Sharptooth Snapper	*Pristipomoides typus*	32
Lutjanidae	Stripey Snapper	*Lutjanus carponotatus*	1
Mugilidae	Sea Mullet	*Mugil cephalus*	231
Mugilidae	Yelloweye Mullet	*Aldrichetta forsteri*	15
Mullidae	Blacksaddle Goatfish	*Parupeneus spilurus*	27
Nemipteridae	Rainbow Monocle Bream	*Scolopsis monogramma*	6
Nemipteridae	Threadfin Breams	Nemipteridae - undifferentiated	239

Category Family Scientific Name	Common Name	Scientific Name	Live Weight (tonnes)
Oplegnathidae	Knifejaw	*Oplegnathus woodwardi*	1
Pentacerotidae	Boarfishes	Pentacerotidae - undifferentiated	4
Platycephalidae	Flatheads	Platycephalidae - undifferentiated	12
Plotosidae	Estuary Cobbler	*Cnidoglanis macrocephalus*	41
Polynemidae	Blue Threadfin	*Eleutheronema tetradactylum*	2
Polynemidae	King Threadfin	*Polydactylus macrochir*	17
Polyprionidae	Bass Groper	*Polyprion americanus*	3
Polyprionidae	Hapuku	*Polyprion oxygeneios*	43
Pomatomidae	Tailor	*Pomatomus saltatrix*	17
Pricanthidae	Bigeyes	Priacanthidae - undifferentiated	27
Psettodidae	Australian Halibut	*Psettodes erumei*	2
Rachycentridae	Cobia	*Rachycentron canadum*	17
Scaridae	Parrotfishes	Scaridae - undifferentiated	5
Sciaenidae	Black Jewfish	*Protonibea diacanthus*	6
Sciaenidae	Mulloway	*Argyrosomus japonicus*	12
Scombridae	Bonitos	*Sarda australis & Cybiosarda elegans*	5
Scombridae	Grey Mackerel	*Scomberomorus semifasciatus*	10
Scombridae	Oriental Bonito	*Sarda orientalis*	2
Scombridae	Spanish Mackerel	*Scomberomorus commerson*	279
Scorpididae	Sea Sweep	*Scorpis aequipinnis*	1
Serranidae	Banded Grouper	*Epinephelus amblycephalus*	5
Serranidae	Barcheek Coral Trout	*Plectropomus maculatus*	22
Serranidae	Birdwire Rockcod	*Epinephelus merra*	1
Serranidae	Blackspotted Rockcod	*Epinephelus malabaricus*	33
Serranidae	Breaksea Cod	*Epinephelides armatus*	5
Serranidae	Chinaman Rockcod	*Epinephelus rivulatus*	1
Serranidae	Common Coral Trout	*Plectropomus leopardus*	1
Serranidae	Duskytail Grouper	*Epinephelus bleekeri*	12
Serranidae	Eightbar Grouper	*Hyporthodus octofasciatus*	7
Serranidae	Goldspotted Rockcod	*Epinephelus coioides*	39
Serranidae	Radiant Rockcod	*Epinephelus radiatus*	1
Serranidae	Rankin Cod	*Epinephelus multinotatus*	285
Serranidae	Spotted Cod	*Epinephelus Microdon/Areolatus/Bilobatus*	70
Serranidae	Tomato Rockcod	*Cephalopholis sonnerati*	2
Serranidae	Yellowspotted Rockcod	*Epinephelus areolatus*	10
Sillaginidae	King George Whiting	*Sillaginodes punctatus*	18
Sillaginidae	Whitings	Sillaginidae - undifferentiated	49
Sillaginidae	Yellowfin Whiting	*Sillago schomburgkii*	89
Sparidae	Black Bream	*Acanthopagrus butcheri*	71
Sparidae	Breams	Sparidae - undifferentiated	1
Sparidae	Frypan Bream	*Argyrops spinifer*	76
Sparidae	Pink Snapper	*Chrysophrys auratus*	154
Sparidae	Tarwhine	*Rhabdosargus sarba*	11
Sparidae	Western Yellowfin Bream	*Acanthopagrus morrisoni*	20
Sphyraenidae	Pikes	Sphyraenidae - undifferentiated	2
Sphyraenidae	Snook	*Sphyraena novaehollandiae*	3

Category Family Scientific Name	Common Name	Scientific Name	Live Weight (tonnes)
Terapontidae	Striped Grunters	Terapontidae - undifferentiated	1
TOTAL SCALEFISH			8,074
SHARKS & RAYS			
Carcharhinidae	Bronze Whaler	*Carcharhinus brachyurus*	52
Carcharhinidae	Dusky Whaler	*Carcharhinus obscurus*	139
Carcharhinidae	Sandbar Shark	*Carcharhinus plumbeus*	36
Carcharhinidae	Spinner Shark	*Carcharhinus brevipinna*	14
Carcharhinidae	Tiger Shark	*Galeocerdo cuvier*	4
Lamnidae	Shortfin Mako	*Isurus oxyrinchus*	2
Orectolobidae	Wobbegong	Orectolobidae - undifferentiated	25
Pristiophoridae	Common Sawshark	*Pristiophorus cirratus*	4
Rajidae	Skates	Rajidae, Arhynchobatidae - undifferentiated	27
Sphyrnidae	Hammerhead Sharks	Sphyrnidae - undifferentiated	43
Triakidae	Gummy Shark	*Mustelus antarcticus*	289
Triakidae	School Shark	*Galeorhinus galeus*	5
Triakidae	Whiskery Shark	*Furgaleus macki*	135
	Other Sharks	Sharks - undifferentiated	9
TOTAL SHARKS & RAYS			784
OTHER FISH	Other Fish		174
TOTAL FISH			9,032
INVERTEBRATES			
CRABS			
Geryonidae	Crystal Crab	*Chaceon bicolor*	140
Hypothalassiidae	Champagne Crab	*Hypothalassia spp.*	6
Menippidae	Giant Crab	*Pseudocarcinus gigas*	8
Portunidae	Blue Swimmer Crab	*Portunus armatus*	773
Portunidae	Brown Mud Crab	*Scylla olivacea*	1
TOTAL CRABS			928
LOBSTERS			
Palinuridae	Southern Rock Lobster	*Jasus edwardsii*	19
Palinuridae	Western Rock Lobster	*Panulirus cygnus*	4,772
Scyllaridae	Moreton Bay Bug	*Thenus spp.*	9
TOTAL LOBSTERS			4,800
MOLLUSCS			
Cephalopoda	Squid	Order Teuthoidea - undifferentiated	41
Haliotidae	Brownlip Abalone	*Haliotis conicopora*	13
Haliotidae	Greenlip Abalone	*Haliotis laevigata*	18
Haliotidae	Roe's Abalone	*Haliotis roei*	38
Octopodidae	Octopuses	Octopodidae - undifferentiated	372
Pteriidae	Silverlip Pearl Oyster	*Pinctada maxima*	166
Sepiidae	Cuttlefish	*Sepia spp.*	48
Veneridae	Ballot's Saucer Scallop	*Ylistrum balloti*	1,965
TOTAL MOLLUSCS			2,661
PRAWNS			
Penaeidae	Banana Prawn	*Penaeus merguiensis*	462
Penaeidae	Blue Endeavour Prawn	*Metapenaeus endeavouri*	227

Category Family Scientific Name	Common Name	Scientific Name	Live Weight (tonnes)
Penaeidae	Brown Tiger Prawn	*Penaeus esculentus*	1,043
Penaeidae	Velvet Prawn	*Metapenaeopsis spp.*	83
Penaeidae	Western King Prawn	*Melicertus latisulcatus*	906
Stomatopoda	Mantis Shrimps	Order Stomatopoda - undifferentiated	47
TOTAL PRAWNS			2,768
OTHER INVERTEBRATES	Other Invertebrates		8
TOTAL INVERTEBRATES			11,165
GRAND TOTAL			20,197

1. Live weight: refers to the landings converted to a live weight basis. This is often referred to as the 'live weight equivalent of the landings', shortened to the 'live weight'. Although live weight may be the preferred unit it is rarely obtained as a direct measure. Live weight has to be derived and this is usually done by applying a conversion factor to the landed weight. Landed weight: refers to the mass (or weight) of a product at the time of landing, regardless of the state in which it is landed. That is, the fish may be whole, gutted or filleted etc. This unit is of limited use for further analysis except where it is known that the product is very homogenous in nature. Where more detailed analysis of the data is required the landed weight is generally converted to a more meaningful measure, the most frequently used being termed live or whole weight or 'nominal catch'.
2. Weight figures are round off to the nearest tonnage.
3. Common names are from the CAAB – Codes for Australian Biota database.

More information may be obtained from the 'CWP Handbook of Fishery Statistical Standards' at the website http://www.fao.org/fishery/cwp/handbook/B/en .

Table of catches from marine aquarium fish, specimen shell and hermit crab commercial fishers' statutory returns for 2019/20

Common Name	Quantity (numbers)	Weight (kg)	Volume (litres)
MARINE AQUARIUM FISH FISHERY			
Fish	13,176		
Syngnathidae (not included in Fish)	281		
Invertebrates (not including Corals)	54,762		
Hard Coral		12,844.80	
Soft Coral *		5,496.10	
Living Rock & Living Sand		19,799	
Sponges	2,460		
Algae/Seagrasses			13
SPECIMEN SHELL FISHERY			
Specimen Shells - Mollusca	6,152		
HERMIT CRAB FISHERY			
Land Hermit Crabs only - *Coenobita variabilis*	**		

* The 'Soft coral' category for the Marine Aquarium Fish Fishery includes 4,998.50 kg of coral like anemone groups such as corallimorphs and zoanthids in the Class Anthozoa. These are not part of the annual coral TAC.

** Industry figures have not been included to protect the confidentiality of individual authorisation holders, as there are less than three active authorisation holders.

Table of catches from charter returns for 2019/20

This table contains the number[1] and estimated weight[2] of species retained in the charter returns for 2019/20 financial year. The table represents the latest year for which a complete set of data is available.

Category / Family	Common Name	Scientific Name	Charter Kept Catch (number)	Charter Estimated Kept Catch (tonnes)
FISH				
SCALEFISH				
Acropomatidae, Percichthyidae, Serranidae, Polyprionidae, Moronidae, Callanthiidae, Centrogeniidae, Ostracoberycidae	Temperate Basses & Rockcods	Percichthyidae, Serranidae - undifferentiated	70	< 0.5
Ariidae	Forktail Catfishes	Ariidae - undifferentiated	9	N/A
Ariidae	Giant Sea Catfish	*Netuma thalassina*	Confidential	Confidential
Ariidae	Silver Cobbler	*Neoarius midgleyi*	Confidential	Confidential
Arripidae	Australian Herring	*Arripis georgianus*	53	Neg
Aulopidae	Sergeant Baker	*Latropiscis purpurissatus*	43	Neg
Balistidae, Monacanthidae	Triggerfishes & Leatherjackets	Balistidae, Monacanthidae - undifferentiated	57	Neg
Belonidae	Longtoms	Belonidae - undifferentiated	Confidential	Confidential
Berycidae	Bight Redfish	*Centroberyx gerrardi*	1,333	2
Berycidae	Swallowtail	*Centroberyx lineatus*	647	< 0.5
Berycidae	Yelloweye Redfish	*Centroberyx australis*	85	Neg
Bramidae	Southern Ray's Bream	*Brama australis*	Confidential	Confidential
Caesiondae, Lutjanidae, Symphysanodontidae	Fusiliers, Tropical Snappers & Slopefishes	Caesionidae, Lutjanidae, Symphysanodontidae - undifferentiated	79	N/A
Carangidae	Amberjack	*Seriola dumerili*	21	< 0.5
Carangidae	Bludger Trevally	*Carangoides gymnostethus*	3	Neg
Carangidae	Blue Trevally	*Carangoides ferdau*	Confidential	Confidential
Carangidae	Bluefin Trevally	*Caranx melampygus*	Confidential	Confidential
Carangidae	Bluespotted Trevally	*Caranx bucculentus*	3	N/A
Carangidae	Brassy Trevally	*Caranx papuensis*	Confidential	Confidential
Carangidae	Diamond Trevally	*Alectis indica*	Confidential	Confidential
Carangidae	Giant Queenfish	*Scomberoides commersonnianus*	Confidential	Confidential
Carangidae	Giant Trevally	*Caranx ignobilis*	67	< 0.5
Carangidae	Golden Trevally	*Gnathanodon speciosus*	44	< 0.5
Carangidae	Longnose Trevally	*Carangoides chrysophrys*	Confidential	Confidential
Carangidae	Queenfish	*Scomberoides spp.*	139	N/A
Carangidae	Samsonfish	*Seriola hippos*	210	2
Carangidae	Silver Trevally	*Pseudocaranx georgianus spp. complex*	669	< 1
Carangidae	Skipjack Trevally	*Pseudocaranx wrighti*	Confidential	Confidential
Carangidae	Trevallies	Carangidae - undifferentiated	296	< 0.5
Carangidae	Turrum	*Carangoides fulvoguttatus*	24	Neg
Carangidae	Yellowtail Kingfish	*Seriola lalandi*	181	1
Centrolophidae	Blue-Eye Trevalla	*Hyperoglyphe antarctica*	Confidential	Confidential
Chaetodontidae, Pomacanthidae	Butterflyfishes & Angelfishes	Chaetodontidae, Pomacanthidae - undifferentiated	Confidential	Confidential
Cheilodactylidae	Blue Morwong	*Nemadactylus valenciennesi*	556	2
Cheilodactylidae	Dusky Morwong	*Dactylophora nigricans*	Confidential	Confidential

Category / Family	Common Name	Scientific Name	Charter Kept Catch (number)	Charter Estimated Kept Catch (tonnes)
Cheilodactylidae	Morwongs	Cheilodactylidae - undifferentiated	Confidential	Confidential
Clupeidae & Pristigasteridae	Herrings & Ilishas	Clupeidae, Pristigasteridae - undifferentiated	Confidential	Confidential
Coryphaenidae	Mahi Mahis	*Coryphaena spp.*	58	< 0.5
Fishes (multi-family groups)	Flounders	Bothidae, Psettodidae & Pleuronectidae	83	N/A
Glaucosomatidae	Northern Pearl Perch	*Glaucosoma buergeri*	1,298	3
Glaucosomatidae	West Australian Dhufish	*Glaucosoma hebraicum*	1,494	9
Haemulidae	Barred Javelin	*Pomadasys kaakan*	Confidential	Confidential
Haemulidae	Goldspotted Sweetlips	*Plectorhinchus flavomaculatus*	91	< 0.5
Haemulidae	Javelinfishes	*Pomadasys spp.*	63	N/A
Haemulidae	Painted Sweetlips	*Diagramma labiosum*	184	< 1
Hemiramphidae	Garfishes	Hemiramphidae - undifferentiated	Confidential	Confidential
Hemiramphidae	Southern Garfish	*Hyporhamphus melanochir*	Confidential	Confidential
Istiophoridae	Black Marlin	*Makaira indica*	Confidential	Confidential
Istiophoridae	Blue Marlin	*Makaira nigricans*	Confidential	Confidential
Istiophoridae	Marlins	Istiophoridae - undifferentiated	Confidential	Confidential
Istiophoridae	Sailfish	*Istiophorus platypterus*	Confidential	Confidential
Istiophoridae	Striped Marlin	*Tetrapturus audax*	Confidential	Confidential
Kyphosidae	Silver Drummer	*Kyphosus sydneyanus*	Confidential	Confidential
Labridae	Baldchin Groper	*Choerodon rubescens*	2,918	9
Labridae	Blackspot Tuskfish	*Choerodon schoenleinii*	96	< 0.5
Labridae	Bluespotted Tuskfish	*Choerodon cauteroma*	Confidential	Confidential
Labridae	Brownspotted Wrasse	*Notolabrus parilus*	50	Neg
Labridae	Foxfish	*Bodianus frenchii*	257	< 0.5
Labridae	Pigfishes	*Bodianus spp.*	202	< 0.5
Labridae	Saddleback Pigfish	*Bodianus bilunulatus*	42	Neg
Labridae	Senator Wrasse	*Pictilabrus laticlavius*	Confidential	Confidential
Labridae	Southern Maori Wrasse	*Ophthalmolepis lineolatus*	Confidential	Confidential
Labridae	Tuskfishes	*Choerodon spp.*	16	N/A
Labridae	Western Blue Groper	*Achoerodus gouldii*	8	Neg
Labridae	Western King Wrasse	*Coris auricularis*	101	Neg
Labridae	Western Pigfish	*Bodianus vulpinus*	42	Neg
Labridae	Wrasses	Labridae - undifferentiated	19	Neg
Labrinae	Sunburnt Pigfish	*Bodianus solatus*	Confidential	Confidential
Latidae	Barramundi	*Lates calcarifer*	601	2
Leptobramidae	Beach Salmon	*Leptobrama muelleri*	Confidential	Confidential
Lethrinidae	Bigeye Seabream	*Monotaxis grandoculis*	Confidential	Confidential
Lethrinidae	Bluespotted Emperor	*Lethrinus punctulatus*	329	< 0.5
Lethrinidae	Drab Emperor	*Lethrinus ravus*	13	N/A
Lethrinidae	Emperors	Lethrinidae - undifferentiated	146	< 0.5
Lethrinidae	Grass Emperor	*Lethrinus laticaudis*	1,772	2
Lethrinidae	Longnose Emperor	*Lethrinus olivaceus*	626	N/A
Lethrinidae	Mozambique Seabream	*Wattsia mossambica*	Confidential	Confidential
Lethrinidae	Redthroat Emperor	*Lethrinus miniatus*	3,061	4
Lethrinidae	Robinson's Seabream	*Gymnocranius grandoculis*	892	3
Lethrinidae	Seabreams	*Gymnocranius spp.*	Confidential	Confidential
Lethrinidae	Spangled Emperor	*Lethrinus nebulosus*	3715	9
Lethrinidae	Spotcheek Emperor	*Lethrinus rubrioperculatus*	Confidential	Confidential
Lethrinidae	Yellowtail Emperor	*Lethrinus atkinsoni*	Confidential	Confidential
Lobotidae	Tripletail	*Lobotes surinamensis*	6	N/A
Lutjanidae	Brownstripe Snapper	*Lutjanus vitta*	93	Neg
Lutjanidae	Chinamanfish	*Symphorus nematophorus*	279	1
Lutjanidae	Crimson Snapper	*Lutjanus erythropterus*	841	1
Lutjanidae	Darktail Snapper	*Lutjanus lemniscatus*	307	< 1
Lutjanidae	False Fusilier	*Paracaesio xanthura*	Confidential	Confidential

Category / Family	Common Name	Scientific Name	Charter Kept Catch (number)	Charter Estimated Kept Catch (tonnes)
Lutjanidae	Flame Snapper	*Etelis coruscans*	Confidential	Confidential
Lutjanidae	Goldband Snapper	*Pristipomoides multidens*	4,142	16
Lutjanidae	Golden Snapper	*Lutjanus johnii*	2,782	4
Lutjanidae	Green Jobfish	*Aprion virescens*	8	N/A
Lutjanidae	Indonesian Snapper	*Lutjanus bitaeniatus*	Confidential	Confidential
Lutjanidae	King Snappers	*Pristipomoides spp.*	Confidential	Confidential
Lutjanidae	Lavender Snapper	*Pristipomoides sieboldii*	Confidential	Confidential
Lutjanidae	Mangrove Jack	*Lutjanus argentimaculatus*	979	< 1
Lutjanidae	Maori Snapper	*Lutjanus rivulatus*	19	N/A
Lutjanidae	Moses' Snapper	*Lutjanus russellii*	289	N/A
Lutjanidae	Red Bass	*Lutjanus bohar*	Confidential	Confidential
Lutjanidae	Red Emperor	*Lutjanus sebae*	2,324	8
Lutjanidae	Rosy Snapper	*Pristipomoides filamentosus*	1,533	3
Lutjanidae	Ruby Snapper	*Etelis carbunculus*	140	< 1
Lutjanidae	Rusty Jobfish	*Aphareus rutilans*	Confidential	Confidential
Lutjanidae	Saddletail Snapper	*Lutjanus malabaricus*	1,390	3
Lutjanidae	Sailfin Snapper	*Symphorichthys spilurus*	Confidential	Confidential
Lutjanidae	Sharptooth Snapper	*Pristipomoides typus*	1,376	3
Lutjanidae	Stripey Snapper	*Lutjanus carponotatus*	867	< 1
Lutjanidae	Tang's Snapper	*Lipocheilus carnolabrum*	9	N/A
Monacanthidae	Horseshoe Leatherjacket	*Meuschenia hippocrepis*	33	N/A
Monacanthidae	Ocean Jacket	*Nelusetta ayraud*	43	N/A
Mugilidae	Diamondscale Mullet	*Liza vaigiensis*	Confidential	Confidential
Mugilidae	Mullets	Mugilidae - undifferentiated	Confidential	Confidential
Mullidae	Blacksaddle Goatfish	*Parupeneus spilurus*	Confidential	Confidential
Mullidae	Bluespotted Goatfish	*Upeneichthys vlamingii*	Confidential	Confidential
Mullidae	Goatfishes	Mullidae - undifferentiated	16	N/A
Nemipteridae	Western Butterfish	*Pentapodus vitta*	Confidential	Confidential
Neosebastidae	Bighead Gurnard Perch	*Neosebastes pandus*	5	Neg
Oplegnathidae	Knifejaw	*Oplegnathus woodwardi*	10	N/A
Platycephalidae	Flatheads	Platycephalidae - undifferentiated	146	N/A
Platycephalidae	Southern Bluespotted Flathead	*Platycephalus speculator*	26	Neg
Platycephalidae	Yellowtail Flathead	*Platycephalus westraliae*	Confidential	Confidential
Plesiopidae	Southern Blue Devil	*Paraplesiops meleagris*	18	Neg
Polynemidae	Blackfin Threadfin	*Polydactylus nigripinnis*	Confidential	Confidential
Polynemidae	Blue Threadfin	*Eleutheronema tetradactylum*	481	1
Polynemidae	King Threadfin	*Polydactylus macrochir*	172	< 1
Polynemidae	Threadfin Salmons	Polynemidae - undifferentiated	162	N/A
Polyprionidae	Bass Groper	*Polyprion americanus*	11	< 0.5
Polyprionidae	Hapuku	*Polyprion oxygeneios*	Confidential	Confidential
Pomatomidae	Tailor	*Pomatomus saltatrix*	108	Neg
Rachycentridae	Cobia	*Rachycentron canadum*	321	2
Scaridae	Parrotfishes	Scaridae - undifferentiated	9	N/A
Scaridae	Surf Parrotfish	*Scarus rivulatus*	Confidential	Confidential
Sciaenidae	Black Jewfish	*Protonibea diacanthus*	74	< 0.5
Sciaenidae	Mulloway	*Argyrosomus japonicus*	359	1
Scombridae	Bigeye Tuna	*Thunnus obesus*	Confidential	Confidential
Scombridae	Blue Mackerel	*Scomber australasicus*	Confidential	Confidential
Scombridae	Bonitos	*Sarda australis & Cybiosarda elegans*	39	N/A
Scombridae	Dogtooth Tuna	*Gymnosarda unicolor*	Confidential	Confidential
Scombridae	Grey Mackerel	*Scomberomorus semifasciatus*	25	< 0.5

Category / Family	Common Name	Scientific Name	Charter Kept Catch (number)	Charter Estimated Kept Catch (tonnes)
Scombridae	Leaping Bonito	*Cybiosarda elegans*	Confidential	Confidential
Scombridae	Longtail Tuna	*Thunnus tonggol*	111	< 1
Scombridae	Mackerel Tuna	*Euthynnus affinis*	45	< 0.5
Scombridae	Mackerels	Scombridae - undifferentiated	Confidential	Confidential
Scombridae	Oriental Bonito	*Sarda orientalis*	Confidential	Confidential
Scombridae	School Mackerel	*Scomberomorus queenslandicus*	68	< 0.5
Scombridae	Shark Mackerel	*Grammatorcynus bicarinatus*	29	< 0.5
Scombridae	Skipjack Tuna	*Katsuwonus pelamis*	34	< 0.5
Scombridae	Southern Bluefin Tuna	*Thunnus maccoyii*	159	< 1
Scombridae	Spanish Mackerel	*Scomberomorus commerson*	1,116	10
Scombridae	Spotted Mackerel	*Scomberomorus munroi*	22	Neg
Scombridae	Wahoo	*Acanthocybium solandri*	36	N/A
Scombridae	Yellowfin Tuna	*Thunnus albacares*	62	< 1
Scorpaenidae	Western Red Scorpionfish	*Scorpaena sumptuosa*	120	N/A
Scorpididae	Banded Sweep	*Scorpis georgiana*	28	Neg
Scorpididae	Footballer Sweep	*Neatypus obliquus*	Confidential	Confidential
Scorpididae	Moonlighter	*Tilodon sexfasciatus*	22	N/A
Scorpididae	Sea Sweep	*Scorpis aequipinnis*	295	< 0.5
Scorpididae	Sweep	Scorpididae - undifferentiated	Confidential	Confidential
Serranidae	Banded Grouper	*Epinephelus amblycephalus*	Confidential	Confidential
Serranidae	Banded Seaperch	*Hypoplectrodes nigroruber*	Confidential	Confidential
Serranidae	Barcheek Coral Trout	*Plectropomus maculatus*	894	2
Serranidae	Barramundi Cod	*Chromileptes altivelis*	6	N/A
Serranidae	Birdwire Rockcod	*Epinephelus merra*	497	N/A
Serranidae	Blackspotted Rockcod	*Epinephelus malabaricus*	28	< 0.5
Serranidae	Bluespotted Coral Trout	*Plectropomus laevis*	Confidential	Confidential
Serranidae	Breaksea Cod	*Epinephelides armatus*	2,451	3
Serranidae	Camouflage Grouper	*Epinephelus polyphekadion*	Confidential	Confidential
Serranidae	Chinaman Rockcod	*Epinephelus rivulatus*	1,205	< 1
Serranidae	Comet Grouper	*Epinephelus morrhua*	7	N/A
Serranidae	Common Coral Trout	*Plectropomus leopardus*	241	< 1
Serranidae	Coral Rockcod	*Cephalopholis miniata*	41	N/A
Serranidae	Duskytail Grouper	*Epinephelus bleekeri*	22	N/A
Serranidae	Eightbar Grouper	*Hyporthodus octofasciatus*	104	< 0.5
Serranidae	Flowery Rockcod	*Epinephelus fuscoguttatus*	47	N/A
Serranidae	Frostback Rockcod	*Epinephelus bilobatus*	Confidential	Confidential
Serranidae	Goldspotted Rockcod	*Epinephelus coioides*	255	1
Serranidae	Harlequin Fish	*Othos dentex*	135	< 0.5
Serranidae	Longfin Rockcod	*Epinephelus quoyanus*	Confidential	Confidential
Serranidae	Passionfruit Coral Trout	*Plectropomus areolatus*	Confidential	Confidential
Serranidae	Radiant Rockcod	*Epinephelus radiatus*	35	N/A
Serranidae	Rankin Cod	*Epinephelus multinotatus*	4,165	17
Serranidae	Tomato Rockcod	*Cephalopholis sonnerati*	461	< 1
Serranidae	Vermicular Cod	*Plectropomus oligacanthus*	Confidential	Confidential
Serranidae	Western Wirrah	*Acanthistius serratus*	Confidential	Confidential
Serranidae	Yellowedge Coronation Trout	*Variola louti*	80	< 0.5
Serranidae	Yellowspotted Rockcod	*Epinephelus areolatus*	306	N/A

Category / Family	Common Name	Scientific Name	Charter Kept Catch (number)	Charter Estimated Kept Catch (tonnes)
Sillaginidae	King George Whiting	*Sillaginodes punctatus*	210	< 0.5
Sillaginidae	Whitings	Sillaginidae - undifferentiated	461	Neg
Sparidae	Black Bream	*Acanthopagrus butcheri*	Confidential	Confidential
Sparidae	Frypan Bream	*Argyrops spinifer*	561	< 1
Sparidae	Northwest Black Bream	*Acanthopagrus palmaris*	Confidential	Confidential
Sparidae	Pink Snapper	*Chrysophrys auratus*	7,664	19
Sparidae	Tarwhine	*Rhabdosargus sarba*	53	Neg
Sparidae	Western Yellowfin Bream	*Acanthopagrus morrisoni*	Confidential	Confidential
Sphyraenidae	Pikes	Sphyraenidae - undifferentiated	13	N/A
Sphyraenidae	Snook	*Sphyraena novaehollandiae*	Confidential	Confidential
Terapontidae	Striped Grunters	Terapontidae - undifferentiated	Confidential	Confidential
Terapontidae	Western Sooty Grunter	*Hephaestus jenkinsi*	Confidential	Confidential
Triglidae	Latchet	*Pterygotrigla polyommata*	Confidential	Confidential
Triglidae	Red Gurnard	*Chelidonichthys kumu*	6	N/A
Triglidae	Searobins & Armour Gurnards	Triglidae & Peristediidae - undifferentiated	3	N/A
SHARKS & RAYS				
Brachaeluridae, Ginglymostomatidae, Hemiscylliidae, Orectolobidae, Parascylliidae, Stegastomatidae	Blind, Nurse, Carpet & Zebra Sharks	Brachaeluridae & related families - undifferentiated	Confidential	Confidential
Carcharhinidae	Blacktip Reef Shark	*Carcharhinus melanopterus*	Confidential	Confidential
Carcharhinidae	Blacktip Shark	*Carcharhinus, Loxodon & Rhizoprionodon spp.*	Confidential	Confidential
Carcharhinidae	Sandbar Shark	*Carcharhinus plumbeus*	16	< 0.5
Carcharhinidae, Hemigaleidae	Whaler & Weasel Sharks	Carcharhinidae, Hemigaleidae - undifferentiated	58	N/A
Orectolobidae	Wobbegong	Orectolobidae - undifferentiated	Confidential	Confidential
Sphyrnidae	Hammerhead Sharks	Sphyrnidae - undifferentiated	Confidential	Confidential
Squalidae	Dogfishes	Squalidae - undifferentiated	Confidential	Confidential
Triakidae	Gummy Shark	*Mustelus antarcticus*	9	< 0.5
Triakidae	School Shark	*Galeorhinus galeus*	Confidential	Confidential
Triakidae	Whiskery Shark	*Furgaleus macki*	24	< 0.5
INVERTEBRATES				
CRABS				
Portunidae	Blue Swimmer Crab	*Portunus armatus*	Confidential	Confidential
Portunidae	Brown Mud Crab	*Scylla olivacea*	893	< 1
Portunidae	Green Mud Crab	*Scylla serrata*	23	Neg
Portunidae	Mud Crab	*Scylla spp.*	18	N/A
LOBSTERS				
Palinuridae	Ornate Rock Lobster	*Panulirus ornatus*	Confidential	Confidential
Palinuridae	Painted Rock Lobster	*Panulirus versicolor*	46	N/A
Palinuridae	Southern Rock Lobster	*Jasus edwardsii*	Confidential	Confidential
Palinuridae	Western Rock Lobster	*Panulirus cygnus*	25,701	14
MOLLUSCS				
Cephalopoda	Squid	Order Teuthoidea - undifferentiated	775	N/A
Octopodidae	Octopuses	Octopodidae - undifferentiated	23	Neg
Ostreidae	Oysters	Ostreidae - undifferentiated	639	N/A
Sepiidae	Cuttlefish	*Sepia spp.*	17	N/A
Stichopodidae	Prickly Redfish (Sea Cucumber)	*Thelenota ananas*	Confidential	Confidential

Kept catch (number): refers to the reported number of retained fish in the Tour Operator Returns (Charter Logbooks). "Confidential" indicates insufficient data where <3 Tour Operator licensees.

Kept catch (tonnes): refers to the kept catch (number) converted to a weight from estimates of average weight based on the Tour Operator Returns. Weight estimates are round off to the nearest tonnage. N/A indicates estimate of average weight is unavailable. "Neg" indicates negligible catch (< 0.1 tonnes).

Common names are from the CAAB – Codes for Australian Biota database.

Table of catches from boat-based recreational fishers and charter returns for 2017/18

This table contains the estimated number[1] and weight[2] of species retained in the state-wide survey of boat-based recreational fishers and charter returns for 2017/18 (1 September 2017 – 31 August 2018). These estimates include catch from targeted and non-targeted recreational fishing. Estimates are reported at species level where adequate sample size and precision were obtained, otherwise species were grouped to general or 'other' categories within each class. Uncertainty around estimates from the state-wide survey is not included in this table (refer to Ryan *et al*. 2019 for this information). Estimates of shore-based recreational catches are not available. The table represents the latest year for which a complete set of data is available.

Category / Family	Common Name	Scientific Name	Est Kept Catch (number)	Est Kept Catch (tonnes)	Charter Kept Catch (number)	Charter Est Kept Catch (tonnes)
FISH						
SCALEFISH						
Acropomatidae, Percichthyidae, Serranidae, Polyprionidae, Moronidae, Callanthiidae, Centrogeniidae, Ostracoberycidae	Temperate Basses & Rockcods	Percichthyidae, Serranidae - undifferentiated	4,277	N/A	1,913	N/A
Apistidae, Neosebastidae, Pteroidae, Scorpaenidae, Sebastidae, Setarchidae, Synanceiidae, Tetrarogidae	Scorpionfishes	Apistidae, Neosebastidae, Pteroidae, Scorpaenidae, Sebastidae, Setarchidae, Synanceiidae & Tetrarogidae - undifferentiated	id	id	58	N/A
Ariidae	Forktail Catfishes	Ariidae - undifferentiated	id	id	113	N/A
Arripidae	Australian Herring	*Arripis georgianus*	94,991	17	38	Neg
	Western Australian Salmon	*Arripis truttaceus*	1,717	7	13	Neg
Aulopidae	Sergeant Baker	*Latropiscis purpurissatus*	2,057	2	133	< 0.5
Berycidae	Bight Redfish	*Centroberyx gerrardi*	12,209	16	2,819	4
	Swallowtail	*Centroberyx lineatus*	2,550	2	912	< 1
Caesiondae, Lutjanidae, Symphysanodontidae	Fusiliers, Tropical Snappers & Slopefishes	Caesionidae, Lutjanidae, Symphysanodontidae - undifferentiated	id	id	N/A	N/A
Carangidae	Amberjack	*Seriola dumerili*	id	id	48	< 0.5
	Golden Trevally	*Gnathanodon speciosus*	2,085	10	216	1
	Queenfish	Scomberoides spp.	199	N/A	303	N/A
	Samsonfish	*Seriola hippos*	1,718	13	307	2
	Silver Trevally	*Pseudocaranx georgianus*	25,556	23	657	< 1
	Trevallies	Carangidae - undifferentiated	2,953	N/A	949	N/A
	Yellowtail Kingfish	*Seriola lalandi*	1,102	7	49	< 0.5
Cheilodactylidae	Blue Morwong	*Nemadactylus valenciennesi*	4,336	14	388	1
Clupeidae & Pristigasteridae	Herrings & Ilishas	Clupeidae, Pristigasteridae - undifferentiated	id	id	id	id
Glaucosomatidae	Northern Pearl Perch	*Glaucosoma buergeri*	478	< 1	1,692	4
	West Australian Dhufish	*Glaucosoma hebraicum*	27,926	161	2,172	12
Haemulidae	Grunter Breams	Haemulidae - undifferentiated	id	id	84	< 0.5
	Painted Sweetlips	*Diagramma labiosum*	1,092	3	172	< 1

Category / Family	Common Name	Scientific Name	Est Kept Catch (number)	Est Kept Catch (tonnes)	Charter Kept Catch (number)	Charter Est Kept Catch (tonnes)
Hemiramphidae	Garfishes	Hemiramphidae - undifferentiated	id	id	35	Neg
Labridae	Baldchin Groper	Choerodon rubescens	16,551	51	3,896	12
	Blackspot Tuskfish	*Choerodon schoenleinii*	3,200	9	224	< 1
	Blue Tuskfish	*Choerodon cyanodus*	1,980	6	N/A	N/A
	Brownspotted Wrasse	*Notolabrus parilus*	3,799	2	30	Neg
	Foxfish	*Bodianus frenchii*	1,471	1	242	< 0.5
	Western King Wrasse	*Coris auricularis*	5,345	3	94	Neg
	Wrasses	Labridae - undifferentiated	2,241	N/A	338	N/A
Latidae	Barramundi	*Lates calcarifer*	1,587	6	1,124	5
Lethrinidae	Bluespotted Emperor	*Lethrinus punctulatus*	id	id	640	< 0.5
	Emperors	Lethrinidae - undifferentiated	id	id	55	Neg
	Grass Emperor	*Lethrinus laticaudis*	13,726	18	2,023	3
	Longnose Emperor	*Lethrinus olivaceus*	id	id	779	N/A
	Redthroat Emperor	*Lethrinus miniatus*	7,899	9	3,919	4
	Robinson's Seabream	*Gymnocranius grandoculis*	971	3	1,186	4
	Spangled Emperor	*Lethrinus nebulosus*	8,290	20	4,153	10
Lutjanidae	Chinamanfish	*Symphorus nematophorus*	id	id	403	2
	Crimson Snapper	*Lutjanus erythropterus*	1,301	2	799	1
	Goldband Snapper	*Pristipomoides multidens*	3,876	15	3,204	13
	Golden Snapper	*Lutjanus johnii*	1,181	2	3,414	5
	Mangrove Jack	*Lutjanus argentimaculatus*	1,941	2	2,139	2
	Moses' Snapper	*Lutjanus russellii*	753	N/A	431	N/A
	Red Emperor	*Lutjanus sebae*	7,909	28	2,965	10
	Rosy Snapper	*Pristipomoides filamentosus*	id	id	1,713	3
	Ruby Snapper	*Etelis carbunculus*	id	id	260	2
	Saddletail Snapper	*Lutjanus malabaricus*	id	id	2,037	4
	Sharptooth Snapper	*Pristipomoides typus*	id	id	1,939	4
	Stripey Snapper	*Lutjanus carponotatus*	5,132	4	1,196	1
Mugilidae	Mullets	Mugilidae - undifferentiated	id	id	1,359	N/A
Mullidae	Goatfishes	Mullidae - undifferentiated	626	N/A	N/A	N/A
Nemipteridae	Threadfin Breams	Nemipteridae - undifferentiated	id	id	N/A	N/A
	Western Butterfish	*Pentapodus vitta*	3,887	2	id	id
Platycephalidae	Flatheads	Platycephalidae - undifferentiated	4,866	N/A	187	N/A
Polynemidae	Threadfin Salmons	Polynemidae - undifferentiated	2,062	7	966	N/A
Pomatomidae	Tailor	*Pomatomus saltatrix*	5,427	4	39	Neg
Rachycentridae	Cobia	*Rachycentron canadum*	1,206	8	287	2
Scaridae	Parrotfishes	*Scaridae - undifferentiated*	id	id	15	N/A
Sciaenidae	Black Jewfish	*Protonibea diacanthus*	id	id	167	< 1
	Mulloway	*Argyrosomus japonicas*	394	2	384	1
Scombridae	Bonitos	*Sarda australis & Cybiosarda elegans*	id	id	4	N/A
	Longtail Tuna	*Thunnus tonggol*	id	id	111	< 1
	Mackerel Tuna	*Euthynnus affinis*	576	3	67	< 0.5
	Mackerels	Scombridae - undifferentiated	2,961	N/A	689	N/A
	School Mackerel	*Scomberomorus queenslandicus*	682	1	87	< 0.5
	Shark Mackerel	*Grammatorcynus bicarinatus*	421	2	43	< 0.5
	Southern Bluefin Tuna	*Thunnus maccoyii*	1,823	8	76	< 0.5
	Spanish Mackerel	*Scomberomorus commerson*	5,221	48	1,437	13
	Spotted Mackerel	*Scomberomorus munroi*	id	id	31	Neg
	Yellowfin Tuna	*Thunnus albacares*	606	6	135	1
Scorpididae	Sea Sweep	*Scorpis aequipinnis*	2,491	3	346	< 0.5

Category / Family	Common Name	Scientific Name	Est Kept Catch (number)	Est Kept Catch (tonnes)	Charter Kept Catch (number)	Charter Est Kept Catch (tonnes)
	Sweep	Scorpididae - undifferentiated	604	< 1	N/A	N/A
Serranidae	Breaksea Cod	*Epinephelides armatus*	15,892	20	2,557	3
	Chinaman Rockcod	*Epinephelus rivulatus*	9,962	7	1,196	< 1
	Coral Trout	*Plectropomus maculatus & P leopardus*	8,096	21	1,672	4
	Goldspotted Rockcod	*Epinephelus coioides*	2,597	12	359	2
	Harlequin Fish	*Othos dentex*	2,953	6	169	< 0.5
	Rankin Cod	*Epinephelus multinotatus*	6,477	27	4,230	17
Sillaginidae	King George Whiting	*Sillaginodes punctata*	42,239	29	180	< 0.5
	School Whiting	*Sillago bassensis, vittata and schomburgkii*	196,341	24	N/A	N/A
	Whitings	Sillaginidae - undifferentiated	id	id	568	N/A
Sparidae	Black Bream	*Acanthopagrus butcheri*	6,406	4	N/A	N/A
	Breams	*Sparidae - undifferentiated*	id	id	312	N/A
	Pink Snapper	*Chrysophrys auratus*	30,889	77	9,916	25
	Tarwhine	*Rhabdosargus sarba*	1,300	< 1	42	Neg
	Western Yellowfin Bream	*Acanthopagrus morrisoni*	id	id	N/A	N/A
Sphyraenidae	Pikes	Sphyraenidae - undifferentiated	id	id	21	N/A
	Snook	*Sphyraena novaehollandiae*	1,181	1	33	Neg
SHARKS & RAYS						
Carcharhinidae, Hemigaleidae	Whaler & Weasel Sharks	Carcharhinidae, Hemigaleidae - undifferentiated	778	N/A	90	N/A
	Sharks	Sharks - undifferentiated	1,546	N/A	79	N/A
INVERTEBRATES						
CRABS						
Portunidae	Blue Swimmer Crab	*Portunus armatus*	278,299	63	238	Neg
	Mud Crab	Scylla spp.	3,423	3	1,849	N/A
LOBSTERS						
Palinuridae	Tropical Rock Lobster	Panulirus spp. except P. cygnus	id	id	N/A	N/A
	Western Rock Lobster	*Panulirus cygnus*	454,604	274	15,985	10
MOLLUSCS						
Cephalopoda	Squid	Order Teuthoidea - undifferentiated	85,565	N/A	397	N/A
Octopodidae	Octopuses	Octopodidae - undifferentiated	1,752	N/A	10	N/A
Sepiidae	Cuttlefish	*Sepia spp.*	3,058	N/A	15	N/A

Kept catch (number): refers to the estimated number of retained fish in the state-wide survey of boat-based recreational fishing (Ryan *et al*, 2019), or reported number of retained fish in the Tour Operator Returns (Charter Logbooks). "id" indicates insufficient data where relative standard error > 40% (i.e. standard error > 40% of estimate) and < 30 diarists recorded catches of the species for the state-wide survey, or <3 licensees for the Tour Operator Returns.

Kept catch (tonnes): refers to the kept catch (number) converted to a weight from estimates of average weight based on state-wide biological surveys or the Tour Operator Returns. Weight estimates are round off to the nearest tonnage. N/A indicates estimate of average weight is unavailable. "Neg" indicates negligible catch (< 0.1 tonnes).

Common names are from the CAAB – Codes for Australian Biota database.

Table of growout production for the Western Australian aquaculture industry in 2019/20

This table contains the data collected on annual production returns received from all Western Australian aquaculture licence holders.

Some species produced in Western Australian aquaculture have been grouped together and reported under 'Other' as they are produced by less than three contributing licences, so making the data confidential. Species in this category in 2019/20 include abalone, barramundi, Murray cod, mussels, western rock oysters and yellowtail kingfish.

Common name	Productive licences	Quantity	Units*	Average price/ kg or individual	Value
Marron	172	54	Tonnes	$37.58	$2,027,298
Yabbies	5	7	Tonnes	$29.48	$196,857
Silver Perch	10	10	Tonnes	$23.36	$223,481
Goldfish & Koi carp	3	43,842	No.	n/a	$136,505
Ornamental Fish	6	57,149	No.	n/a	$246,997
Ornamental Invertebrates	6	13,061	No.	n/a	$2,880,285
Rainbow Trout	4	8	Tonnes	$15.43	$117,150
Other Species**		1654	Tonnes	n/a	$19,071,467
Algae	< 3	**			**
Total (not including algae or pearls)					$22,198,749

* Tonnes refer to whole weight.

** Industry figures have not been included to protect the confidentiality of individual producers, as there are less than three productive licensees

Table of reported bycatch of protected and listed species from commercial fisheries for 2020

This table contains the numbers of accidental captures and fate of protected and listed animals by commercial fishers, as reported in statutory fishing returns and Catch Disposal Records, during calendar year 2020[1]. To the extent possible, other types of recorded interactions (primarily sightings) with protected and listed species have been excluded. For the purpose of this report, protected and listed species (or taxa) are defined as those listed as: Totally Protected Fish[2] under the WA Fish Resources Management Act 1994 (FRMA); Specially Protected Fauna under the Biodiversity Conservation Act 2014 (WCA); cetaceans and species that are listed as Threatened under the Australian Environment Protection and Biodiversity Conservation Act 1999 (EPBC). As other reports may include records that do not meet these definitions, these data may differ from other accounts.

Class	Common Name	Scientific Name	Release Condition (number)		
			ALIVE	DEAD	UNKNOWN
Birds	Bird (Unspecified)	*Aves*	0	1	0
	Australian Darter	*Anhinga novaehollandiae*	0	1	0
	Cormorant (Unspecified)	*Phalacrocoracidae*	5	8	0
	Flesh-footed Shearwater	*Ardenna carneipes*	53	77	0
	Duck	*Anatidae*	1	0	0
Fish	Green Sawfish	*Pristis zijsron*	33	25	0
	Grey nurse Shark	*Carcharias taurus*	24	18	0
	Narrow Sawfish	*Anoxypristis cuspidata*	7	4	0
	Dwarf Sawfish	*Pristis clavata*	0	1	0
	Sawfish (Unspecified)	Pristidae	24	0	0
	Syngnathids (Unspecified)	Syngnathidae	152	40	0
	White Shark	*Carcharodon carcharia*	13	4	0
Mammals	Dolphin (Unspecified)	*Delphinidae*	5	10	0
	Humpback Whale	Megaptera novaengliae	6	0	6
	Crocodile (Unspecified)	*Crocodylus*	108	48	0
Reptiles	Freshwater crocodile	*Crocodylus johnstoni*	5	10	0
	Turtle (Unspecified)	*Cheloniidae*	53	1	0
	Green Turtle	Chelonia mydas	6	0	0
	Loggerhead Turtle	Caretta caretta	7	0	0
	Freshwater turtle	Chelidae	9	26	0
	Seasnake (Unspecified)	Hydrophiinae	4012	327	0

1. Reports by other sources (eg. members of public and Government officials) of whale entanglements in fishing gear, dead seabirds that have washed ashore, etc. are usually not attributable to particular fishers, fisheries, dates or locations. Although these ancillary interaction records are reported in Annual Reports to Parliament and elsewhere, they are inconsistent with the more-detailed information from statutory fishing records and are therefore not included here.

2. Except those listed as Totally Protected Fish in reference to their sex, size, weight, reproductive cycle, area from which they are taken or specific period of time.

Table of Fish Prices for 2019/20

This table contains the average price per kilogram paid for each marine species caught in Western Australia in 2019/20. The prices are based on prices reported by WA land based processors; the average prices reported are weighted and are based on whole weight. Where prices aren't available for a financial year a default price, based on the average of prices reported in previous years, is used. The prices have been adjusted to reflect the beach price paid. That is, the beach price is the price paid per kilogram to commercial fishers for their catch when they first land and excludes any marketing, transport or handling costs.

Category Family Scientific Name	Common Name	Scientific Name	Price per Kilogram
FISH			
SCALEFISH			
Acropomatidae, Percichthyidae, Serranidae, Polyprionidae, Moronidae, Callanthiidae, Centrogeniidae, Ostracoberycidae	Temperate Basses & Rockcods	*Percichthyidae, Serranidae - undifferentiated*	$10.42
Albulidae	Pacific Bonefish	*Albula argentea*	$3.04
Apistidae, Neosebastidae, Pteroidae, Scorpaenidae, Sebastidae, Setarchidae, Synanceiidae, Tetrarogidae	Scorpionfishes	*Apistidae, Neosebastidae, Pteroidae, Scorpaenidae, Sebastidae, Setarchidae, Synanceiidae & Tetrarogidae - undifferentiated*	$6.12
Ariidae	Forktail Catfishes	*Ariidae - undifferentiated*	$3.29
Ariidae	Silver Cobbler	*Neoarius midgleyi*	$4.16
Arripidae	Australian Herring	*Arripis georgianus*	$2.96
Arripidae	Western Australian Salmon	*Arripis truttaceus*	$1.19
Balistidae, Monacanthidae	Triggerfishes & Leatherjackets	*Balistidae, Monacanthidae - undifferentiated*	$3.84
Belonidae	Longtoms	*Belonidae - undifferentiated*	$4.02
Berycidae	Bight Redfish	*Centroberyx gerrardi*	$7.67
Berycidae	Redfishes	*Berycidae - undifferentiated*	$8.50
Berycidae	Swallowtail	*Centroberyx lineatus*	$4.56
Berycidae	Yelloweye Redfish	*Centroberyx australis*	$5.71
Caesiondae, Lutjanidae, Symphysanodontidae	Fusiliers, Tropical Snappers & Slopefishes	*Caesionidae, Lutjanidae, Symphysanodontidae - undifferentiated*	$4.02
Carangidae	Amberjack	*Seriola dumerili*	$3.08
Carangidae	Black Pomfret	*Parastromateus niger*	$8.96
Carangidae	Bludger Trevally	*Carangoides gymnostethus*	$2.95
Carangidae	Giant Queenfish	*Scomberoides commersonnianus*	$3.70
Carangidae	Golden Trevally	*Gnathanodon speciosus*	$2.80
Carangidae	Longnose Trevally	*Carangoides chrysophrys*	$3.35
Carangidae	Rainbow Runner	*Elagatis bipinnulata*	$4.24
Carangidae	Samsonfish	*Seriola hippos*	$3.26
Carangidae	Silver Trevally	*Pseudocaranx georgianus spp. complex*	$3.20
Carangidae	Trevallies	*Carangidae - undifferentiated*	$3.35
Carangidae	Yellowtail Kingfish	*Seriola lalandi*	$6.03
Carangidae	Yellowtail Scad	*Trachurus novaezelandiae*	$3.25
Centrolophidae	Blue-Eye Trevalla	*Hyperoglyphe antarctica*	$8.15
Cheilodactylidae	Blue Morwong	*Nemadactylus valenciennesi*	$4.00
Cheilodactylidae	Morwongs	*Cheilodactylidae - undifferentiated*	$1.50
Clupeidae	Australian Sardine	*Sardinops sagax*	$1.07
Clupeidae	Blue Sprat	*Spratelloides robustus*	$7.65
Clupeidae	Hairback Herring	*Nematalosa come*	$3.71
Clupeidae	Maray	*Etrumeus teres*	$1.19
Clupeidae	Sandy Sprat	*Hyperlophus vittatus*	$5.88

Category Family Scientific Name	Common Name	Scientific Name	Price per Kilogram
Clupeidae	Scaly Mackerel	*Sardinella lemuru*	$1.25
Coryphaenidae	Mahi Mahis	*Coryphaena spp.*	$6.39
Elopidae	Hawaiian Giant Herring	*Elops hawaiensis*	$5.89
Fishes (multi-family groups)	Flounders	*Bothidae, Psettodidae & Pleuronectidae*	$11.60
Gempylidae	Gemfish	*Rexea solandri*	$2.71
Gerreidae	Common Silverbiddy	*Gerres subfasciatus*	$4.67
Glaucosomatidae	Northern Pearl Perch	*Glaucosoma buergeri*	$8.07
Glaucosomatidae	West Australian Dhufish	*Glaucosoma hebraicum*	$15.28
Haemulidae	Goldspotted Sweetlips	*Plectorhinchus flavomaculatus*	$5.17
Haemulidae	Grunter Breams	*Haemulidae - undifferentiated*	$5.17
Haemulidae	Javelinfishes	*Pomadasys spp.*	$4.25
Haemulidae	Painted Sweetlips	*Diagramma labiosum*	$5.17
Hemiramphidae	Southern Garfish	*Hyporhamphus melanochir*	$7.16
Istiophoridae	Marlins	*Istiophoridae - undifferentiated*	$6.23
Labridae	Baldchin Groper	*Choerodon rubescens*	$12.98
Labridae	Bluespotted Tuskfish	*Choerodon cauteroma*	$6.66
Labridae	Goldspot Pigfish	*Bodianus perditio*	$6.96
Labridae	Pigfishes	*Bodianus spp.*	$6.96
Labridae	Tuskfishes	*Choerodon spp.*	$6.66
Labridae	Western Blue Groper	*Achoerodus gouldii*	$4.99
Labridae	Wrasses	*Labridae - undifferentiated*	$3.60
Latidae	Barramundi	*Lates calcarifer*	$8.51
Lethrinidae	Bluespotted Emperor	*Lethrinus punctulatus*	$4.57
Lethrinidae	Drab Emperor	*Lethrinus ravus*	$4.39
Lethrinidae	Emperors	*Lethrinidae - undifferentiated*	$4.98
Lethrinidae	Grass Emperor	*Lethrinus laticaudis*	$6.82
Lethrinidae	Longnose Emperor	*Lethrinus olivaceus*	$5.82
Lethrinidae	Mozambique Seabream	*Wattsia mossambica*	$5.20
Lethrinidae	Paddletail Seabream	*Gymnocranius euanus*	$3.55
Lethrinidae	Redspot Emperor	*Lethrinus lentjan*	$5.33
Lethrinidae	Redthroat Emperor	*Lethrinus miniatus*	$7.57
Lethrinidae	Robinson's Seabream	*Gymnocranius grandoculis*	$5.32
Lethrinidae	Seabreams	*Gymnocranius spp.*	$3.55
Lethrinidae	Spangled Emperor	*Lethrinus nebulosus*	$6.55
Lethrinidae	Spotcheek Emperor	*Lethrinus rubrioperculatus*	$4.59
Lethrinidae	Yellowtail Emperor	*Lethrinus atkinsoni*	$4.49
Lobotidae	Tripletail	*Lobotes surinamensis*	$12.17
Lutjanidae	Brownstripe Snapper	*Lutjanus vitta*	$4.28
Lutjanidae	Chinamanfish	*Symphorus nematophorus*	$5.53
Lutjanidae	Crimson Snapper	*Lutjanus erythropterus*	$5.51
Lutjanidae	Darktail Snapper	*Lutjanus lemniscatus*	$5.49
Lutjanidae	Fiveline Snapper	*Lutjanus quinquelineatus*	$4.28
Lutjanidae	Goldband Snapper	*Pristipomoides multidens*	$9.48
Lutjanidae	Golden Snapper	*Lutjanus johnii*	$4.79
Lutjanidae	Indonesian Snapper	*Lutjanus bitaeniatus*	$4.56

Category Family Scientific Name	Common Name	Scientific Name	Price per Kilogram
Lutjanidae	King Snappers	*Pristipomoides spp.*	$8.50
Lutjanidae	Mangrove Jack	*Lutjanus argentimaculatus*	$5.60
Lutjanidae	Moses' Snapper	*Lutjanus russellii*	$5.04
Lutjanidae	Red Emperor	*Lutjanus sebae*	$11.58
Lutjanidae	Rosy Snapper	*Pristipomoides filamentosus*	$9.43
Lutjanidae	Ruby Snapper	*Etelis carbunculus*	$7.84
Lutjanidae	Saddletail Snapper	*Lutjanus malabaricus*	$5.63
Lutjanidae	Sharptooth Snapper	*Pristipomoides typus*	$8.64
Lutjanidae	Stripey Snapper	*Lutjanus carponotatus*	$4.28
Lutjanidae	Tang's Snapper	*Lipocheilus carnolabrum*	$7.17
Lutjanidae	Tropical Snappers	*Lutjanus spp.*	$4.28
Mugilidae	Sea Mullet	*Mugil cephalus*	$2.54
Mugilidae	Yelloweye Mullet	*Aldrichetta forsteri*	$1.47
Mullidae	Goatfishes	*Mullidae - undifferentiated*	$3.83
Nemipteridae	Rainbow Monocle Bream	*Scolopsis monogramma*	$2.95
Nemipteridae	Threadfin Breams	*Nemipteridae - undifferentiated*	$4.10
Neosebastidae	Bighead Gurnard Perch	*Neosebastes pandus*	$3.14
Ophidiidae	Pink Ling	*Genypterus blacodes*	$5.95
Oplegnathidae	Knifejaw	*Oplegnathus woodwardi*	$1.72
Pentacerotidae	Boarfishes	*Pentacerotidae - undifferentiated*	$3.93
Platycephalidae	Deepwater Flathead	*Platycephalus conatus*	$5.95
Platycephalidae	Flatheads	*Platycephalidae - undifferentiated*	$5.52
Platycephalidae	Rock Flathead	*Platycephalus laevigatus*	$7.68
Pleuronectidae	Longsnout Flounder	*Ammotretis rostratus*	$25.27
Plotosidae	Estuary Cobbler	*Cnidoglanis macrocephalus*	$3.56
Polynemidae	King Threadfin	*Polydactylus macrochir*	$12.33
Polynemidae	Threadfin Salmons	*Polynemidae - undifferentiated*	$5.20
Polyprionidae	Bass Groper	*Polyprion americanus*	$8.52
Polyprionidae	Hapuku	*Polyprion oxygeneios*	$8.25
Pomatomidae	Tailor	*Pomatomus saltatrix*	$5.30
Pricanthidae	Bigeyes	*Priacanthidae - undifferentiated*	$2.66
Psettodidae	Australian Halibut	*Psettodes erumei*	$7.74
Rachycentridae	Cobia	*Rachycentron canadum*	$4.51
Scaridae	Parrotfishes	*Scaridae - undifferentiated*	$7.03
Scatophagidae	Striped Scat	*Selenotoca multifasciata*	$4.24
Sciaenidae	Black Jewfish	*Protonibea diacanthus*	$5.78
Sciaenidae	Mulloway	*Argyrosomus japonicus*	$5.01
Scombridae	Albacore	*Thunnus alalunga*	$3.87
Scombridae	Bigeye Tuna	*Thunnus obesus*	$7.29
Scombridae	Blue Mackerel	*Scomber australasicus*	$10.51
Scombridae	Grey Mackerel	*Scomberomorus semifasciatus*	$9.39
Scombridae	Longtail Tuna	*Thunnus tonggol*	$3.66
Scombridae	Mackerel Tuna	*Euthynnus affinis*	$8.02
Scombridae	Mackerels	*Scombridae spp. (tribes Scomberomorini & Scombrini)*	$3.40
Scombridae	Northern Bluefin Tuna	*Thunnus orientalis*	$3.66

Category Family Scientific Name	Common Name	Scientific Name	Price per Kilogram
Scombridae	Oriental Bonito	*Sarda orientalis*	$13.91
Scombridae	School Mackerel	*Scomberomorus queenslandicus*	$11.51
Scombridae	Shark Mackerel	*Grammatorcynus bicarinatus*	$3.45
Scombridae	Skipjack Tuna	*Katsuwonus pelamis*	$5.83
Scombridae	Spanish Mackerel	*Scomberomorus commerson*	$11.32
Scombridae	Spotted Mackerel	*Scomberomorus munroi*	$13.16
Scombridae	Tunas	*Scombridae spp. (tribes Sardini & Thunnini)*	$3.87
Scombridae	Wahoo	*Acanthocybium solandri*	$5.91
Scombridae	Yellowfin Tuna	*Thunnus albacares*	$14.71
Scorpididae	Banded Sweep	*Scorpis georgiana*	$1.08
Scorpididae	Moonlighter	*Tilodon sexfasciatus*	$4.24
Scorpididae	Sea Sweep	*Scorpis aequipinnis*	$1.96
Serranidae	Banded Grouper	*Epinephelus amblycephalus*	$10.42
Serranidae	Barcheek Coral Trout	*Plectropomus maculatus*	$14.62
Serranidae	Birdwire Rockcod	*Epinephelus merra*	$10.42
Serranidae	Blackspotted Rockcod	*Epinephelus malabaricus*	$7.76
Serranidae	Breaksea Cod	*Epinephelides armatus*	$10.17
Serranidae	Chinaman Rockcod	*Epinephelus rivulatus*	$7.43
Serranidae	Comet Grouper	*Epinephelus morrhua*	$8.32
Serranidae	Common Coral Trout	*Plectropomus leopardus*	$14.62
Serranidae	Convict Grouper	*Epinephelus septemfasciatus*	$7.85
Serranidae	Coral Rockcod	*Cephalopholis miniata*	$10.42
Serranidae	Coral Trout	*Plectropomus spp. & Variola spp.*	$14.62
Serranidae	Duskytail Grouper	*Epinephelus bleekeri*	$6.21
Serranidae	Eightbar Grouper	*Hyporthodus octofasciatus*	$8.72
Serranidae	Flowery Rockcod	*Epinephelus fuscoguttatus*	$5.68
Serranidae	Frostback Rockcod	*Epinephelus bilobatus*	$5.68
Serranidae	Goldspotted Rockcod	*Epinephelus coioides*	$6.98
Serranidae	Harlequin Fish	*Othos dentex*	$4.24
Serranidae	Radiant Rockcod	*Epinephelus radiatus*	$8.32
Serranidae	Radiant Rockcod/Comet Grouper	*Epinephelus Radiatus/Morrhua*	$8.32
Serranidae	Rankin Cod	*Epinephelus multinotatus*	$8.25
Serranidae	Spotted Cod	*Epinephelus Microdon/Areolatus/Bilobatus*	$5.68
Serranidae	Striped Grouper	*Epinephelus latifasciatus*	$10.42
Serranidae	Tomato Rockcod	*Cephalopholis sonnerati*	$8.76
Serranidae	White-Edge Coronation Trout	*Variola albimarginata*	$14.62
Serranidae	Yellowedge Coronation Trout	*Variola louti*	$10.42
Serranidae	Yellowspotted Rockcod	*Epinephelus areolatus*	$5.68
Siganidae	Rabbitfish	*Siganus spp.*	$4.68
Sillaginidae	Goldenline Whiting	*Sillago analis*	$2.59
Sillaginidae	King George Whiting	*Sillaginodes punctatus*	$12.78
Sillaginidae	Southern School Whiting	*Sillago bassensis*	$7.40
Sillaginidae	Whitings	*Sillaginidae - undifferentiated*	$1.51
Sillaginidae	Yellowfin Whiting	*Sillago schomburgkii*	$4.22
Sparidae	Black Bream	*Acanthopagrus butcheri*	$5.45

Category Family Scientific Name	Common Name	Scientific Name	Price per Kilogram
Sparidae	Frypan Bream	*Argyrops spinifer*	$5.37
Sparidae	Pink Snapper	*Chrysophrys auratus*	$8.81
Sparidae	Tarwhine	*Rhabdosargus sarba*	$3.94
Sparidae	Western Yellowfin Bream	*Acanthopagrus morrisoni*	$6.32
Sparidae	Yellowback Bream	*Dentex spariformis*	$6.06
Sphyraenidae	Pikes	*Sphyraenidae - undifferentiated*	$3.86
Sphyraenidae	Snook	*Sphyraena novaehollandiae*	$6.83
Terapontidae	Striped Grunters	*Terapontidae - undifferentiated*	$0.86
Terapontidae	Yellowtail Grunter	*Amniataba caudavittata*	$1.28
Xiphiidae	Swordfish	*Xiphias gladius*	$8.70
Zeidae	John Dory	*Zeus faber*	$7.90
Sillaginidae	Goldenline Whiting	*Sillago analis*	$2.59
SHARKS & RAYS			
Alopiidae	Thresher Shark	Alopias vulpinus	$2.19
Carcharhinidae	Bronze Whaler	*Carcharhinus brachyurus*	$2.94
Carcharhinidae	Dusky Whaler	*Carcharhinus obscurus*	$4.36
Carcharhinidae	Grey Reef Shark	*Carcharhinus amblyrhynchos*	$1.22
Carcharhinidae	Sandbar Shark	*Carcharhinus plumbeus*	$2.75
Carcharhinidae	Spinner Shark	*Carcharhinus brevipinna*	$1.36
Carcharhinidae	Tiger Shark	*Galeocerdo cuvier*	$0.68
Hexanchidae	Sevengill Sharks	*Heptranchias spp.*	$2.19
Lamnidae	Shortfin Mako	*Isurus oxyrinchus*	$0.72
Orectolobidae	Wobbegong	*Orectolobidae - undifferentiated*	$1.50
Pristiophoridae	Common Sawshark	*Pristiophorus cirratus*	$0.73
Rajidae	Skates	*Rajidae, Arhynchobatidae - undifferentiated*	$3.63
Sphyrnidae	Hammerhead Sharks	*Sphyrnidae - undifferentiated*	$1.19
Squatinidae	Angel Shark	*Squatina spp.*	$2.19
Triakidae	Gummy Shark	*Mustelus antarcticus*	$4.49
Triakidae	Pencil Shark	*Hypogaleus hyugaensis*	$1.46
Triakidae	School Shark	*Galeorhinus galeus*	$4.28
Triakidae	Whiskery Shark	*Furgaleus macki*	$4.05
Trygonorrhinidae	Banjo Rays	*Trygonorrhinidae - undifferentiated*	$0.51
	Shark Fins	*NULL*	$11.04
	Other Sharks	*Sharks - undifferentiated*	$2.19
OTHER FISH	Other Fish		$4.24
INVERTEBRATES			
CRABS			
Geryonidae	Crystal Crab	Chaceon bicolor	$48.81
Hypothalassiidae	Champagne Crab	*Hypothalassia spp.*	$20.49
Menippidae	Giant Crab	*Pseudocarcinus gigas*	$63.91
Portunidae	Blue Swimmer Crab	*Portunus armatus*	$8.10
Portunidae	Brown Mud Crab	*Scylla olivacea*	$30.00
Portunidae	Common Sand Crab	*Ovalipes australiensis*	$12.72
Portunidae	Coral Crab	*Charybdis feriata*	$9.61
Portunidae	Green Mud Crab	*Scylla serrata*	$45.00

Category Family Scientific Name	Common Name	Scientific Name	Price per Kilogram
LOBSTERS			
Palinuridae	Southern Rock Lobster	Jasus edwardsii	$52.20
Palinuridae	Western Rock Lobster	*Panulirus cygnus*	$56.97
Scyllaridae	Moreton Bay Bug	*Thenus spp.*	$20.44
MOLLUSCS			
	Molluscs	Mollusca - undifferentiated	$6.24
Arcidae	Cockle	Anadara spp.	$7.65
Cephalopoda	Squid	*Order Teuthoidea - undifferentiated*	$16.75
Haliotidae	Brownlip Abalone	*Haliotis conicopora*	$53.86
Haliotidae	Greenlip Abalone	*Haliotis laevigata*	$63.83
Haliotidae	Roe's Abalone	Haliotis roei	$27.23
Octopodidae	Octopuses	*Octopodidae - undifferentiated*	$10.85
Sepiidae	Cuttlefish	Sepia spp.	$5.30
Veneridae	Ballot's Saucer Scallop	*Ylistrum balloti*	$4.68
PRAWNS			
Penaeidae	Banana Prawn	Penaeus merguiensis	$11.19
Penaeidae	Black Tiger Prawn	Penaeus monodon	$25.20
Penaeidae	Blue Endeavour Prawn	*Metapenaeus endeavouri*	$5.08
Penaeidae	Brown Tiger Prawn	*Penaeus esculentus*	$13.10
Penaeidae	Velvet Prawn	*Metapenaeopsis spp.*	$4.38
Penaeidae	Western King Prawn	Melicertus latisulcatus	$12.53
Stomatopoda	Mantis Shrimps	*Order Stomatopoda - undifferentiated*	$0.83
Penaeoidea & Caridea	Other Prawns	Penaeoidea & Caridea - undifferentiated	$2.41
SEA CUCUMBERS			
Holothuriidae	Deepwater Redfish (Sea Cucumber)	*Actinopyga echinites*	$7.88
Holothuriidae	Sandfish (Sea Cucumber)	Holothuria scabra	$11.00

APPENDIX 3

INDIAN OCEAN TERRITORIES RESOURCE STATUS REPORT 2021

S. Newman, C. Skepper, S. Evans and L. Wiberg

OVERVIEW

In November 2002, the territorial seas (out to 12 nautical miles) of the Cocos (Keeling) Islands and Christmas Island were declared as ‘excepted waters’ from the Commonwealth’s *Fisheries Management Act 1991*. Management responsibilities were transferred from the Australian Fisheries Management Authority to the Commonwealth Government. The Government of Western Australia had the management responsibilities for the marine territorial waters of the Indian Ocean Territories (IOTs) on behalf of the Commonwealth Department of Infrastucture, Transport, Regional Development and Communications (DITRDC). The location of the IOTs and their proximity to the Western Australian coast are illustrated in Indian Ocean Territories Figure 1.

Under a Service Delivery Agreement with the DITRDC, the Western Australian Department of Primary Industries and Regional Development (DPIRD) manages commercial, recreational and aquaculture activities at Cocos (Keeling) Islands (Indian Ocean Territories Figure 2) and Christmas Island (Indian Ocean Territories Figure 3), and also provides fish health diagnostic, biosecurity, fish pathology and licensing services. The Commonwealth Minister for the DITRDC holds responsibility for these excepted waters under the *Fish Resources Management Act 1994 (WA) (CI/CKI)* (the ‘Applied Acts’).

The commercial Christmas Island Line Fishery (CILF) primarily targets pelagic species, mainly wahoo (*Acanthocybium solandri*) and yellowfin tuna (*Thunnus albacares*). In addition, demersal fishing activities are also undertaken targeting deepwater demersal fish, mainly the deepwater snappers.

The Cocos (Keeling) Islands Marine Aquarium Fish Fishery (CKIMAFF) primarily targets the endemic Cocos Angelfish or Yellowheaded Angelfish (*Centropyge joculator*), and to a lesser extent the lemonpeel angelfish (*Centropyge flavissima*).

Recreational and artisanal fishing are undertaken around the Cocos (Keeling) and Christmas Islands targeting both finfish and invertebrate species. The Cocos (Keeling) Islands consist of a diverse range of aquatic environments that include a sheltered lagoon, fringing reefs and offshore ‘blue water’. These environments support a range of demersal and pelagic finfish species, as well as various crustaceans (e.g. lobsters, crabs) and molluscs (e.g. gong gong, clams) that are highly sought after by fishers for both individual and community purposes. Christmas Island has no lagoon and a limited range of environments available for fishing; these are the fringing reef surrounding the island and offshore ‘blue water’, both of which primarily support pelagic fish species, a limited range of demersal finfish species and some invertebrates (e.g. lobster, clams).

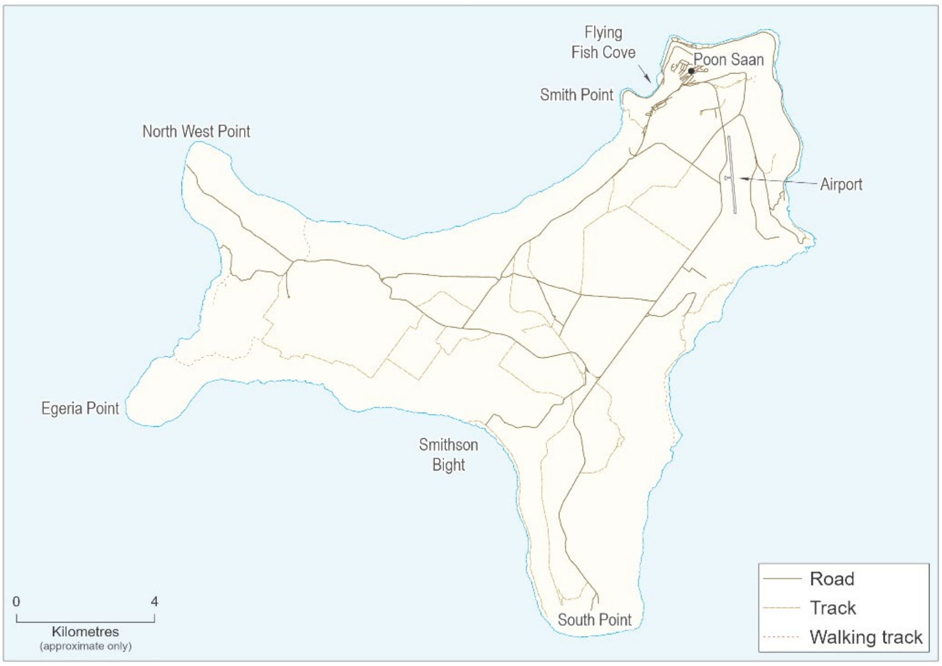
SUMMARY FEATURES

Asset (Allowable catch &/or effort)	Outcome	Status
CILF (NA) CKIMAFF (NA)	Total Catch 2020: Not reportable* Total Catch 2020: Not reportable*	Acceptable Acceptable
Recreational fishery (NA)	Total Catch 2020: NA	Acceptable
EBFM		
Indicator species		
Wahoo (CILF)	Catch is low	Adequate
Cocos Angelfish (CKIMAFF)	Catch is within historical range	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Negligible Risk	Adequate
Habitat	Negligible Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (GVP $ <1 m)	Low Risk	Acceptable
Social (low amenity)	Low Risk	Acceptable
Governance	Stable	Acceptable
External Drivers	Negligible Risk	Acceptable

* Activities in these fisheries involved less than three licence holders in 2020 and cannot be reported for confidentially reasons.

INDIAN OCEAN TERRITORIES FIGURE 1
Location of the Cocos (Keeling) Islands and Christmas Island comprising the Indian Ocean Territories within the Indian Ocean, illustrating their proximity to the Western Australian coast.

INDIAN OCEAN TERRITORIES FIGURE 2
Location of the major Islands and landmarks within the Cocos (Keeling) Islands in the Indian Ocean.



INDIAN OCEAN TERRITORIES FIGURE 3
Location of the key landmarks around Christmas Island in the Indian Ocean.

CATCH AND LANDINGS

Pelagic species dominate the catch of the CILF, comprising 100% of the total reported catch in 2020. Wahoo (*Acanthocybium solandri*) is the main target species of the CILF, comprising 83% of the total reported catch in 2020. Other pelagic species are also targeted during the trolling operations and primarily include yellowfin tuna (*Thunnus albacares*) and other tunas (except southern bluefin tuna *(Thunnus maccoyii),* which may not be taken), and to a lesser extent mahi mahi (*Coryphaena* spp.). Some commercial fishing activities are also undertaken for demersal fish species, mainly deep slope species such as ruby snapper (*Etelis* spp.) although no demersal species were reported as part of the catch in 2020. The commercial catch for Christmas Island usually consists of catch data from only two vessels and catch data are not reportable due to confidentiality provisions. The total reported catch for this fishery has been less than 10 t per annum over the last ten years.

There is no commercial line fishery at the Cocos (Keeling) Islands.

The CKIMAFF targets the endemic Cocos Angelfish or Yellowheaded Angelfish (*Centropyge joculator*), and to a lesser extent the lemonpeel angelfish (*Centropyge flavissima*). As there is currently only one active license in the CKIMAFF the catch data is not reportable due to confidentiality provisions. The catch is within the historical catch range.

Recreational and artisanal fishing vessels operate around the Cocos (Keeling) Islands and Christmas Island. The amount and magnitude of the recreational fishing catch and effort at these islands has not been assessed.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

IOT Finfish & IOT Invertebrate

Finfish:

Data on the abundance of finfish species is being collected and collated to determine changes over time.

The pelagic species that are targeted by the CILF (e.g. wahoo, yellowfin tuna) are part of a wider Indian Ocean stock. However, the demersal species are likely to be localised stocks that are reliant upon self-recruitment.

There is anecdotal evidence of potential localised depletion of some deep slope species like rosy snapper (*Pristipomoides filamentosus*) and ruby snapper (*Etelis spp.*) around Christmas Island.

Recreational fishers use electric-powered lines to target deep-slope demersal finfish species at the IOTs, thereby increasing the fishing efficiency for these species.

The primary target of the CKIMAFF is *Centropyge joculator* which is endemic to the Cocos (Keeling) Islands and Christmas Island, inhabiting fringing reefs between 15 and 70 m. The biology of *C. joculator* has not been examined, although Allen *et al*. (2007) reported this species as being abundant on Christmas Island.

Invertebrates:

Holothurians: The holothurian community is strongly influenced by habitat and although some species are wide-ranging and found in relatively high densities, they tend to be of low economic value. In contrast, species of moderate to high economic value were recorded at densities too low to support commercial fisheries and typically had very restricted distributions. The holothurian community found at the Cocos (Keeling) Islands is near to pristine due to a lack of historical fishing pressure. Holothurian stocks are sensitive to fishing exploitation and have been overexploited in other areas of the Indian and Pacific Oceans.

Gong Gong: The common spider conch or gong gong (*Lambis lambis*) is a recreationally-targeted gastropod inhabiting shallow waters of the lagoon of Cocos (Keeling) Islands. This species is vulnerable to over-fishing as it is highly accessible and presumably shares biological traits with other exploited conch species, including slow growth and late maturity. Monitoring data indicates that the current abundance of gong gong is lower than historically recorded. While heavy fishing pressure has presumably contributed to the reduction in gong gong numbers, further monitoring is required to determine the role of recruitment variability in maintaining gong gong populations at the Cocos (Keeling) Islands and changes in the lagoon system.

Giant Clams: Three species of giant clams (*Tridacna gigas*, *Tridacna derasa* and *Tridacna maxima*) have historically been reported at the Cocos (Keeling) Islands. Monitoring data indicates that currently only *T. maxima* occurs in sufficient numbers to be assessed. This data also shows a decline in relative stock abundance of *T. maxima* before they reach the size of sexual maturity (150mm). Heavy fishing pressure is presumed to contribute to this reduction, with further monitoring required to monitor sustainability of these stocks.

Reef Health: On-going reef monitoring has been established to monitor natural and anthropogenic impacts on the reef and lagoon communities at Cocos (Keeling) Islands and Christmas Island.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

Fishing in the CILF for pelagic species such as wahoo uses specialised trolling gear to target the fish and involves limited discarding. Species occasionally caught but generally discarded include billfish, barracuda, shark and trevally. A high proportion of the above species are expected to survive capture and release by the fishery. Consequently, it is considered likely that the pelagic fishery has a **negligible** impact on stocks of discarded species.

Fishing for demersal species in the CILF particularly those in the deep slope waters involves limited discarding as most species are retained for processing. However, catches can be lost to sharks (depredation).

Protected species

The line fishing methods used in CILF are not known to interact with any listed species. However, there is some potential for low levels of seabird bycatch at Christmas Island. Overall, it is considered that the pelagic fishery has a **negligible** impact on listed species.

The fishing techniques used to capture fish in the CKIMAFF involves using hand or scoop nets, or a small seine net of specific dimensions (the seine net cannot exceed 16 metres in length, must have a mesh of less than or equal to 28mm and a drop of not more than 3 metres) and fishers may use SCUBA equipment. Thus, the CKIMAFF has **negligible** bycatch due to the highly selective nature of fishing activities.

No listed species interactions have been reported for the CKIMAFF. Therefore, it is considered that the CKIMAFF has a **negligible** impact on listed species.

HABITAT AND ECOSYSTEM INTERACTIONS

Habitat impacts are considered **negligible**. The line fishing methods used in the CILF and the hand collection method used in the CKIMAFF are likely to have minimal impact on the habitat. This results in a **negligible risk** to the overall ecosystem from these fisheries.

SOCIAL AND ECONOMIC OUTCOMES

Social

At least two people were employed in the CILF around Christmas Island during 2020. This estimate is based on the number of vessels reporting catches and the average number of crew on each boat.

At least two people were employed in the CKIMAFF around Cocos (Keeling) Islands during 2020.

Due to their sport fishing and eating qualities, wahoo and other pelagic species are popular target species for recreational anglers and fishing charter operators at the IOTs, particularly at Christmas Island. They are usually captured from small boats, although shore-based fishing is also undertaken.

A large variety of demersal and lagoon finfish and invertebrate species are caught by artisanal and recreational fishers at Cocos (Keeling) Islands involving the use of a large number of small vessels. Similarly, recreational fishers at Christmas Island undertake fishing activities from small vessels and also from the shore and catch a large variety of demersal finfish species, including a large number of deep slope species. **Low** risk.

Economic

The value of the CILF is not reportable. The value of the CKIMAFF is also not reportable, although *C. joculator* commands a high price on the international market (reported retail prices in excess of $1000.00 each in 2017). The combined score value of these fisheries in 2020 was estimated to be Level 1 (i.e. Risk level – **Low**; Economic value – < $1 million). There is limited social amenity value for these fisheries. There is currently a **low** level of risk to these values.

GOVERNANCE SYSTEM

The potential recreational fishing effort for both pelagic and demersal fish species at both the Cocos (Keeling) Islands and at Christmas Island is high with a capacity to operate over the entire extent of the fishable area at each island group. Given the restricted amount of habitat and fishing area available it is expected that fishing pressure on some species in some locations at Cocos (Keeling) Islands or Christmas Island may be above sustainable levels. However, overall stocks levels are considered to be **adequate**.

The catch of the CKIMAFF has been small since its inception in 1993. There is little incentive for the single licensee to increase catch or effort since market viability and high prices are maintained by only having small numbers of fish available for sale. Catches are derived from a limited area of species distribution. The current level of fishing activity is considered to be **adequate**.

Harvest Strategy

Recreational fishing rules and limitations have been developed using a constant catch strategy (maintaining but not increasing catches), although a formal harvest strategy is not currently in place for this resource.

Compliance

Operators in the CILF and CKIMAFF are required to complete statutory catch and effort returns on a monthly basis. The low risks to the sustainability of the stocks imposed by these fisheries results in a **low risk** and low level of compliance.

Consultation

Extensive community engagement and consultation has taken place to develop a proposed set of dedicated recreational fishing arrangements for the IOTs. More recently community engagement has focussed on the development and agreement to the Cocos Malay Cultural Fishing Arrangements and commercial fishing policy and arrangements.

For the CILF and CKIMAFF consultation occurs directly with operators at Christmas Island and the Cocos (Keeling) Islands, with additional community consultation undertaken where applicable.

Direct community consultation is undertaken regularly at the Cocos (Keeling) Islands and Christmas Island in regard to fisheries science and resource assessment, recreational fishing rules and regulations.

Management Initiatives/Outlook Status

The key IOTs management initiative is the sustainable management of the aquatic resources at the IOTs for the benefit of the on-island communities. Island-specific fisheries management arrangements for the IOTs are currently being scoped and developed.

DPIRD will not be renewing the IOTs Fisheries Service Delivery Agreeement after the 30 June 2021. As of 1 July 2021, the resposibility of the marine territorial seas of the IOTs will return to the Commonwealth Government DITRDC.

EXTERNAL DRIVERS

The demersal fish and invertebrate populations of Cocos (Keeling) Islands and Christmas Island are likely to consist of small, isolated populations that are expected to experience highly variable recruitment due to environmental fluctuations.

In the summer of 2015/16 widespread thermal coral bleaching was recorded at Christmas Island. No coral bleaching was recorded at Cocos (Keeling) Islands over the same period. Monitoring is ongoing to assess the long-term impact of this event on the coral reef, finfish and invertebrate communities of Christmas Island.

The external drivers pose a **negligible** risk.

REFERENCES

Bellchambers, L.M., Meeuwig, J.J., Evans, S.N., Legendre, P. 2011. Modelling habitat associations of 14 species of holothurians from an unfished coral atoll: implications for fisheries management. Aquatic Biology. 14:57-66

Bellchambers, L.M., Meeuwig, J.J., Evans, S.N., Legendre, P. 2011. Modelling habitat associations of the common spider conch in the Cocos (Keeling) Islands. Marine Ecology Progress Series. 432:83-90

Bellchambers, L.M. and Evans, S.N. 2013. A summary of the Department of Fisheries, Western Australia Invertebrate Research at Cocos (Keeling) Islands 2006 – 2011. Fisheries Research Report No. 239. Department of Fisheries, Western Australia. 72p

Bennett, S., Halford, A.R., Choat, J.H., Hobbs, J-P.A., Santana-Garcon, J., Ayling, A.M., Harvey, E.S., Newman, S.J. 2018. Geography and island geomorphology shape fish assemblage structure on isolated coral reef systems. Ecology and Evolution 8 (12): 6242-6252.

Bentley, B.C., Harvey, E.S., Newman, S.J., Welch, D.J., Smith, A.K. and Kennington, W.J. 2014. Local genetic patchiness but no regional differences between Indo-West Pacific populations of the dogtooth tuna *Gymnosarda unicolor*. Marine Ecology Progress Series 506: 267-277.

Evans, S.N., Konzewitsch, N. and Bellchambers, L.M. 2016. An update of the Department of Fisheries, Western Australia, Invertebrate and Reef Health Research and Monitoring at Cocos (Keeling) Islands. Fisheries Reseaerch Report No. 272. Department of Fisheries, Western Australia 64p.

Hobbs, J-P.A., Coker, D.J., Green, P.T., James, D.J., Humphreys, W.F., McAllan, I.A.W., Newman, S.J., Pratchett, M.S., Staeudle, T.M., Whiting, S.D. 2014. An annotated bibliography of the research on marine organisms and environments at Christmas Island and the Cocos (Keeling) Islands. Raffles Bulletin of Zoology Supplement 30: 419-468.

Hobbs, J-P.A., Frisch, A.J., Newman, S.J. and Wakefield, C.B. 2015. Selective impact of disease on coral communities: outbreak of white syndrome causes significant total mortality of Acropora plate corals. PLoS ONE 10(7): e0132528.

Hobbs, J-P.A. and Newman, S.J. 2016. Darwin's atolls revisited: lagoon infilling and closure has ecological consequences to North Keeling Atoll. Marine Biodiversity 46 (1): 21-22.

Hobbs, J-P.A., Newman, S.J., Mitsopoulos, G.E.A., Travers, M.J., Skepper, C.L., Gilligan, J.J., Allen, G.R., Choat, J.H. and Ayling, A.M. 2014. Fishes of the Cocos (Keeling) Islands: new records, community composition and biogeographic significance. Raffles Bulletin of Zoology Supplement 30: 203-219.

Hobbs, J-P.A., Newman, S.J., Mitsopoulos, G.E.A., Travers, M.J., Skepper, C.L., Gilligan, J.J., Allen, G.R., Choat, J.H. and Ayling, A.M. 2014. Checklist and new records of Christmas Island fishes: the influence of isolation, biogeography and habitat availability on species abundance and community composition. Raffles Bulletin of Zoology Supplement 30: 184-202.

Kennington, W.J., Keron, P.W., Harvey, E.S., Wakefield, C.B., Williams, A.J., Halafihi, T. and Newman, S.J. 2017. High intra-ocean, but limited inter-ocean genetic connectivity in populations of the deep-water oblique-banded snapper *Pristipomoides zonatus* (Pisces: Lutjanidae). Fisheries Research 193: 242-249

Konzewitsch, N. and Evans, S.N. 2019. Invertebrate and Reef Health Research and Monitoring at Cocos (Keeling) Islands – 2019 Update. Fisheries Research Report No. 303 Department of Primary Industries and Regional Development, Western Australia. 41p.

Konzewitsch, N. and Evans, S.N., 2020. Examining the Movement of the Common Spider Conch *Lambis lambis* in Shallow Water of a Northeastern Indian Ocean Atoll Using Passive Acoustic Tracking. Journal of Shellfish Research, 39 (2): 389-397.

Payet, S.D., Hobbs, J-P.A., DiBattista, J.D., Newman, S.J., Sinclair-Taylor, T., Berumen, M.L. and McIlwain, J.L. 2016. Hybridisation among groupers (genus *Cephalopholis*) at the eastern Indian Ocean suture zone: taxonomic and evolutionary implications. Coral Reefs 35 (4): 1157-1169.

APPENDIX 4

Annual performance for commercial fisheries subject to export approval under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act 1999*

The following table provides a summary of the issues, performance measures and any conditions for fisheries subject to the above Act and their annual performance. The period assessed in each case is the most recent season for which complete data are available. As a result of the duration required for data collection and analysis, the years being assessed in this volume are the 2019/20 season or the calendar year 2020 for fisheries data but up to June 2019 for relevant research or management actions projects and actions.

In addition to this summary, more detailed information on the annual performance of each fishery is provided in the relevant status reports presented throughout this volume. Within the individual status reports, each performance measure assessed is shown in a highlighted box to assist the reader.

It should also be noted that where naturally occurring fluctuations in fish stocks have required management adjustments or where improvements have been made to methods of analysis, these have in some cases (asterisked) required a revision of the performance measure this year.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2019/20 or 2020	Comment
Fishery: Abalone *Approval type:* Accredited Export Exempt Fishery Initial accreditation: August 2004 Current accreditation: August 2015 Expiry date: August 2025	Greenlip/brownlip abalone Areas 2/3 (spawning stock)	Effort range 907–1,339 diver days; minimum meat weight 140 g greenlip, 160 g brownlip	Inadequate	Performance indicator for Greenlip abalone below threshold in Area 2 and open regions of Area 3. Spatial closures enforced in Area 3 for 2020.
	Roe's abalone Area 1 (spawning stock)	Effort range 14–43 diver days; total catch 5 t	Acceptable	Exploratory quota.
	Roe's abalone Area 2 (spawning stock)	Effort range 80–106 diver days; total catch 13.2 t	Acceptable	Total catch indicator not met in regional areas. This is due to poor economic and weather conditions.
	Roe's abalone Area 5 (spawning stock)	Effort range 100–140 diver days; total catch 15 t	Acceptable	
	Roe's abalone Area 6 (spawning stock)	Effort range 50-80 diver days; total catch 7.5 t	Acceptable	
	Roe's abalone Area 7 (spawning stock)	Effort range 230–270 diver days; total catch 32.8 t	Acceptable	Total catch indicator set annually by stock prediction model. Catch indicator not met due to economic impacts of COVID-19.
	Roe's abalone Area 8 (spawning stock)	Effort range 0 diver days; total catch 0 t	Inadequate due to environmental conditions	Closed since 2012 due to environmentally induced mortality.
Fishery: Abrolhos Islands and Mid West Trawl *Approval type:* Accredited Export Exempt Fishery Initial accreditation: March 2005 Current accreditation: August 2015 *Expiry date*: August 2025	Scallops (spawning stock)	The survey stock abundance index determines a predicted catch that sets the length of the next season and the fishing season ceases at a catch rate threshold level,	Acceptable	Catch within acceptable range. In 2020, Recruitment levels in parts of the Abrolhos Islands continued to improve.
Fishery: Beche-de-mer *Approval type:* Wildlife Trade Operation Exemption Initial accreditation: December 2004	Beche-de-mer species (spawning stock)	Sandfish acceptable catch range: 20-100 t. Catch rate above 25 kg/hr. Redfish acceptable catch range: 40-100 t. Catch rate above 60 kg/hr.	Acceptable	Harvest strategy is being reviewed and updated. It will specify new performance and condition indicators.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2019/20 or 2020	Comment
Current accreditation: August 2017 Expiry date: May 2025				
Fishery: Broome Prawn *Approval type:* Accredited Export Exempt Fishery Initial accreditation: August 2004 Current accreditation: August 2015 Expiry date: August 2025	Western king prawn (spawning stock)	Annual exploitation rate of king prawns to not exceed 60% in any one year	Acceptable	Minimal fishing occurred in 2020.
	Coral prawns (spawning stock)	Total catch within acceptable range of 20–90 t (7-year catch range)	Acceptable	As above.
Fishery: Exmouth Gulf Prawn *Approval Type:* Accredited Export Exempt Fishery Initial accreditation: March 2003 Current accreditation: August 2015 *Expiry date:* August 2025	Tiger prawn (spawning stock)	Catch rate above 25 kg/hr (6 fathom quad gear) revised from original 8–10 kg/hr (7.5 fathom twin gear)	Acceptable	Catch rate above target level.
	King prawn (spawning stock)	Catch rate above 25 kg/hr (6 fathom quad gear).Total catch within acceptable revised (2017) range of 100–450 t	Acceptable	Catch rate above target level. Catch within revised range.
	Endeavour prawn (spawning stock)	Catch rate above 9 kg/hr(6 fathom quad gear). Total catch within acceptable range of 120–300 t	Acceptable	Catch rate above target level. Catch within range.
	Banana prawn (spawning stock)	Total catch within acceptable range of 10–60 t for years with significant rainfall and 0–2 t for years with low rainfall	Acceptable	
	Coral prawns (spawning stock)	Total catch within acceptable range of 20–100 t	Acceptable	Catch just below range.
	Non –Retained species	The major species of bycatch are found in significant numbers outside of the trawled areas	Acceptable	
	Impact to mud/shell (habitat)	< 40% of mud/shell habitat in Exmouth Gulf trawled	Acceptable	
Fishery: Gascoyne Demersal Scalefish Managed Fishery *Approval type:* Wildlife Trade Operation Exemption Initial accreditation: June 2004 Current accreditation: August 2015 *Expiry date:* August 2025	Pink snapper (spawning stock)	Spawning biomass > 30% of unexploited spawning biomass, catch rate not to fall below 500 kg/standard June–July boat day	Unacceptable	Performance measures were reviewed as part of Harvest Strategy (in 2017). Further reductions in quota and spatial closures were implemented in 2018 under a Recovery Plan. To be reviewed based on results of next stock assesment (in 2022).
Fishery: Kimberley Prawn *Approval Type:* Accredited Export Exempt Fishery Initial accreditation: November 2004 Current accreditation: August 2015 *Expiry date:* August 2025	Banana prawn (spawning stock)	Total catch within acceptable range of 200–450 t	Acceptable	Catch within range and catch prediction.
	Brown tiger prawn (spawning stock)	Total catch within acceptable range of 15–60 t	Acceptable	Low landings due to targeting on higher catch rates of banana prawns.
	Endeavour prawn (spawning stock)	Total catch within acceptable range of 7–80 t	Acceptable	As above
	Coral prawns (spawning stock)	Total catch within acceptable range of 0–6 t (10-year catch range)	Acceptable	As above
	Black tiger prawn (spawning stock)	Total catch within acceptable range of 0–1 t	Acceptable	
	Squid (spawning stock)	Total catch within acceptable range of 1–50 t	Acceptable	Nil reported landings since 2004.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2019/20 or 2020	Comment
Fishery: Mackerel *Approval type*: Accredited Export Exempt Fishery Initial accreditation: November 2004 Current accreditation: August 2015 *Expiry date:* August 2025	Spanish mackerel (spawning stock)	Total catch within acceptable range of 246-410 t: acceptable regional catch ranges: Kimberley 110–205 t: Pilbara 80–126 t: Gascoyne/West Coast 56–79 t	Acceptable	Total catch within acceptable range Higher level assessment underway, monitor closely.
Fishery: Marine Aquarium Managed Fishery Approval type: Wildlife Trade Operation Exemption Initial accreditation: October 2005 Current accreditation: October 2016 Expiry date: October 2019	There are specific performance measures for CITES species taken by the MAFMF, these include hard corals, tridacnid clams, seahorses and syngnathids (total)	The MAFMF is operating in accordance with the 2018-2022 MAFMF Harvest Strategy. A risk assessment was completed in 2014 for the MAFMF. Catches of CITES species in 2017 were below the WTO limits.	Acceptable	
Fishery: Northern Demersal Scalefish *Approval type:* Accredited Export Exempt Fishery Initial accreditation: November 2004 Current accreditation: August 2015 *Expiry date:* August 2025	Indicator species spawning stock (red emperor and goldband snapper)	The NDSMF is operating in accordance with the North Coast demersal scalefish resource harvest strategy 2017 – 2021.	Acceptable	
Fishery: Onslow and Nickol Bay Prawn *Approval Type:* Accredited Export Exempt Fishery Initial accreditation: November 2004 Current accreditation: August 2015 Expiry date: August 2025	Banana prawns (spawning stock)	Nickol Bay: total catch in high rainfall years within acceptable range of 150–220 t: in low rainfall years within acceptable range of 0–40 t. Onslow: total catch within acceptable range of 2–90 t	Acceptable Acceptable	Banana prawns within predicted catch range. Limited fishing in Onslow.
	Brown tiger prawn (spawning stock)	Acceptable catch ranges of Nickol Bay 2–40 t and Onslow 10–120 t	Acceptable	Limited fishing in Onslow.
	Western king prawn (spawning stock)	Acceptable catch ranges of Nickol Bay 20–70 t and Onslow 10–55 t	Acceptable	Low effort in Nickol Bay as targeting banana prawns. Limited fishing in Onslow.
	Endeavour prawn (spawning stock)	Total catch within acceptable ranges; Nickol Bay 1-10 t and Onslow 5-20 t.	Acceptable	As above
	Coral prawns (spawning stock)	Total catch within acceptable range of Nickol Bay 1–15 t (10-year catch range) and Onslow 4–20 t	Acceptable	As above
	Black tiger prawn (spawning stock)	Total catch within acceptable range of 0–2 t	Acceptable	
Fishery: Octopus *Approval type:* Accredited Export Exempt Fishery Initial accreditation: September 2011 Current accreditation: August 2017 Expiry date: August 2025	Octopus (*Octopus* aff. *tetricus*)	Formal harvest strategy with biological reference points (Target, Threshold, and Limit). These based on standardised catch rate per unit effort (kg per potlift)	Acceptable	Catch rates are above the target level

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2019/20 or 2020	Comment
Fishery: Pearl Oyster *Approval type:* Accredited Export Exempt Fishery Initial accreditation: September 2003 Current accreditation: August 2015 Expiry date: August 2025	Silver-lipped (gold-lipped) pearl oyster (spawning stock)	Fished area should be < 60% of species distribution; catch rates should not decrease by > 50% from historical averages of 29.5 oysters/hr (Zone 2) and 34.8 oysters/hr (Zone 3); > 30% of Zone 1 catch should be > 150 mm shell length	Acceptable	Catch rates are above the target performance indicators.
Fishery: Pilbara Trawl *Approval type:* Wildlife Trade Operation Exemption Initial accreditation: November 2004 Current accreditation: May 2014 Expiry date: November 2018	Indicator species spawning stock (red emperor, Rankin cod, bluespotted emperor)	The Pilbara Fish Trawl Fishery is operating in accordance with the North Coast demersal scalefish resource harvest strategy 2017 – 2021.	Acceptable	
	Bycatch of listed species - dolphins	All skippers to maintain records of the time, date, shot duration and location of each incidental capture	Acceptable	Dolphin mortalities reported in statutory logbooks have reduced since 2006. An industry code of practice has been developed to address interactions with dolphins.
	Bycatch of listed species – turtles	All skippers to maintain records of the time, date, shot duration and location of each incidental capture	Acceptable	Mitigation devices implemented in nets in 2006 has reduced the incidental captures of turtles by >95%.
	Bycatch of listed species – syngnathids	All skippers to maintain records of the time, date, shot duration and location of each incidental capture	Acceptable	Pipefish and seahorses are released alive.
	Bycatch of listed species – sawfish	All skippers to maintain records of the time, date, shot duration and location of each incidental capture	Acceptable	Number of sawfish caught should be < 120/yr; number of sawfish released alive should be increased to 50% of captures by 2008
	General ecosystem – large epibenthos	The total area of the Pilbara demersal fish fishery (encompassing both trawl and trap fisheries) that is closed to trawling is 80%; the total area of the Pilbara demersal fish fishery between depths of 30 m and 120 m should remain at or below the current level of 60%	Acceptable	
Fishery: Salmon *Approval type:* Accredited Export Exempt Fishery Initial accreditation: November 2004 Current accreditation: August 2015 Expiry date: August 2025	Western Australian salmon (spawning stock)	Expected catch range under the current management regime is 0-1,200 t	Acceptable	2018 catch was 191 t. Catches continue to be low relative to historic levels, due to low effort in response to limited market demand. Stock level is acceptable, based on age-based assessment completed in 2017.
Fishery: Shark Bay Crab Managed Fishery *Approval type:* Wildlife Trade Operation Exemption Initial accreditation: November 2004 Current accreditation: August 2015 *Expiry date:* August 2025	Blue swimmer crab (breeding stock)	CPUE to remain above 1 kg/trap lift	Acceptable	A TACC of 650 tonnes was set in 2019/20 of which 98% was achieved. The commercial catch rate was well above the target.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2019/20 or 2020	Comment
Fishery: Shark Bay Prawn *Approval type:* Accredited Export Exempt Fishery Initial accreditation: February 2003 Current accreditation: August 2015 *Expiry date:* August 2025	Tiger prawn (spawning stock)	Level of spawning stock present based on fishery independent surveys during the spawning season at a target of 25 kg/hr (5.5 fathom quad gear)	Acceptable	
	King prawn (spawning stock)	Level of spawning stock present based on fishery independent surveys during the spawning season at a target of 25 kg/hr (5.5 fathom quad gear)Total catch within historical acceptable range of 950–1,450 t, given no change in effort	Acceptable	Breeding stock was just below the target but well above the limit. Total catch was below the acceptable range. Currently under investigation with recruitment surveys higlighting a declining trend in size.
	Coral and endeavour prawns (spawning stock)	Total catch within historical acceptable ranges given no change in effort: coral 80–280 t, endeavour 1–30 t	Acceptable	
	Loggerhead turtles (captures)	90% of turtles captured from non-BRD nets returned alive	Acceptable	BRDs are mandatory in all nets so this performance measure is no longer valid. For the 2020 season, 46 turtles were recorded as caught in nets and with all recorded as being returned to the sea alive.
	Discarded fish (abundance)		Acceptable	Majority of bycatch species are found in relatively significant numbers outside of trawled areas
	Impact to sand/shell (habitat)	< 40% of sand/shell habitat in Shark Bay trawled	Acceptable	
	Impact to coral/sponge (habitat)	<20% of the remaining coral/sponge habitat in Shark Bay to be contained within the legally trawled area	Acceptable	
	Discarding fish (provisioning)		Acceptable	Reduction in amount of discards and ratio of discards to target catch from pre-catch reduction device levels and in water hopper system increasing survival of some bycatch species.
Fishery: Shark Bay Scallop *Approval type:* Accredited Export Exempt Fishery Initial accreditation: February 2003 Current accreditation: August 2015 Expiry date: August 2025	Scallop (spawning stock)	Monitoring of recruit/ residual stock in northern Shark Bay and Denham Sound to ensure the start date of the season is set so that there is adequate level of breeding stock present when spawning commences.	Acceptable in Denham Sound. Inadequate in northern Shark Bay.	Fishery re opened in 2015. A revised TACC of 180 t (meat weight) was set in 2020/21 and 98% of the quota was achieved. Catches from northern Shark Bay were below expectations surveys indicated very low abundance. This part of the fishery is assessed to be inadequate in 2020 and subject to stock recovery strategies.
	Loggerhead turtles (captures)	90% of turtles captured from non-BRD nets returned alive	Acceptable	As for Shark Bay prawn, however, no turtle captures were reported.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2019/20 or 2020	Comment
Fishery: South Coast Crustacean *Approval type:* Wildlife Trade Operation Exemption Initial accreditation: September 2004 Current accreditation: January 2017 Expiry date: January 2024	Southern rock lobster & crystal crab biomass	* Finalise and implement a formal harvest strategy * ensure finer-scale catch and effort used in stock assessment * develop management measures to rebuild stock levels	Un-Acceptable	Southern rock lobster stock indicator (CPUE) is above the limit reference levels in Zones 3&4 (Esperance and Bight) but crystal crab is below its limit reference point..
Fishery: Specimen Shell *Approval type:* Accredited Export Exempt Fishery Initial accreditation: 25 May 2005 Current accreditation: August 2015 *Expiry date:* August 2025	Specimen shell species (spawning stock)	Preliminary acceptable catch range is from 10,000–25,000 shells; acceptable catch rate 10–40 shells per day	Acceptable	Both catch and catch rate within acceptable ranges
Fishery: Temperate Demersal Gillnet and Demersal Longline (Shark) Fisheries *Approval type:* Accredited Export Exempt Fishery Initial accreditation: February 2006 Current accreditation: August 2018 *Expiry date*: August 2021	Dusky and sandbar sharks	Continue to review and report outcomes of actions taken to rebuild stocks	On-going	Recovery of dusky and sandbar sharks is highly likely. Stock assessments completed late 2017.Resource Assessment Report published September 2019. Next stock assessment due in 2022.
	Australian sea lions	Continue monitoring fishing effort around Australian sea lion colonies following implementation of Gillnet Exclusion Zones and investigate potential management measures to further limit the overlap of gillnet fishing and Australian sea lion foraging areas to support recovery of the species. These management measures could include independent validation of interaction rates	Underway and ongoing	A network of Gillnet Exclusion Zones was established on 29 June 2018 to protect Australian sea lion breeding colonies, covering a total of 17,300 square kilometres along the Western Australian coast. A pilot FRDC-funded project (FRDC 2017-119) is currently developing novel remote camera approaches to assess and monitor the population status of ASLs. The Department continues monitoring spatio-temporal levels of gillnet effort
Fishery: West Coast Rock Lobster *Approval Type*: Wildlife Trade Operation Exemption Initial accreditation:	Western rock lobster (spawning stock)	Spawning biomass at Abrolhos Islands and coastal regions to remain above respective levels during the early 1980s with 75% certainty	Acceptable	Current spawning stock levels in all four breeding stock management areas are well above their respective threshold levels

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2019/20 or 2020	Comment
August 2002 Current accreditation: May 2018 Expiry date: May 2025	Octopus (spawning stock)	Catch rate (cpue) not to drop outside of historic range by > 10%	Acceptable	In 2013 the recording of octopus catch was altered with the adoption of Catch Disposal Records (CDR). Octopus cpue is now determined as the catch (kg) per pot lift in waters < 20 fm from CDRs (standardised for month and latitude). Since 2013 the cpue of octopus has ranged from 0.023 to 0.027 kg/potlift. In 2018 the cpue was 0.026, which is within 10% of the historical range.
	Sea lion (captures)	No increase in rate of capture	Acceptable	No sea lion captures were reported.
	Leatherback turtle (entanglements)	No increase in rate of interactions	Acceptable	No entanglements were reported.
	Whales and dolphins (entanglements)	No increase in rate of interactions	Unacceptable	There were 8 confirmed whale entanglements in WRL gear during the 2018 humpback whale migration season. While mitigation measures have reduced whale entanglements by ~2/3 the increase in entanglements necessitates a review of current management measures.
Fishery: West Coast Deep Sea Crustacean Managed Fishery *Approval type*: List of Exempt native Species Initial accreditation: March 2004 Current accreditation: August 2015 *Expiry date*: August 2025	Champagne and Giant crab biomass	Unitisation of the fishery has permitted a maximum of 14 t of Champagne crab and Giant crab to be taken in a season	Acceptable	
	Crystal Crab biomass	The fishery is quota based with catches limited to 154 t of crystal crab per season	Acceptable	The standardised catch rate has fallen below the threshold level with TAC reductions to be implimented for the following seasons.

APPENDIX 5

Aquatic Science and Assessment staff adjunct positions and supervision of students

Staff Member	Position
Lynda Bellchambers	Adjunct Researcher, Faculty of Natural and Agricultural Sciences, University of Western Australia.
	PhD co-supervision, University of Western Australia, supervises Scott Evans -'' Understanding the relationships between fishery recruitment and essential benthic habitats within an ecosystem based fisheries management framework for prawn fisheries
Matias Braccini	PhD co-supervision, Murdoch University, supervises Robiul Hasan - 'On the consumption of shark products: stock sustainability, trade mislabelling, human health and fishing slavery'.
	PhD co-supervision, Murdoch University, supervises Brenton Pember - 'A multi-disciplinary analysis of connectivity of the sandbar shark (*Carcharhinus plumbeus*) in the Indo-West Pacific'.
	MSc co-supervision, Curtin University, supervises Abbey Shuttleworth - 'Comparative catch efficiency of demersal shark gillnets and longlines fisheries in South Western Australia'.
	MSc co-supervision, Curtin University, supervises Taylor Grosse - 'An integrated approach for assessing the survival of discarded sandbar sharks, *Carcharhinus plumbeus*, captured in longlines'.
	Associate Researcher, School of Molecular and Life Sciences, Curtin University
	Associate Researcher, Centre for Fish and Fisheries Research, Murdoch University
Peter Coulson	Adjunct Lecturer. School of Veterinary and Life Sciences, Murdoch University.
Simon de Lestang	PhD co- supervision, University of Western Australia, supervises Emma Jade-Tuffley ' Determining variation in catchability of western rock lobsters (*Panulirus cygnus*)'.
	PhD co- supervision, University of Western Australia, supervises Michael Brooker - ' An investigation into unexpectedly low catch rates of *Panulirus cygnus* from an area of historical high catch rates'.
	PhD co-supervision; Emma-Jade Tuffley, University of Western Australia, "Accounting for variability in western rock lobster (*Panulirus cygnus*) catchability".
	PhD co-supervision; Michael Brooker, University of Western Australia, "Low catch rates of Western Rock Lobster (*Panulirus cygnus*) from an area of historically high catch in the centre of the fishery".
	PhD co-supervision; Jessica Kolbutz, University of Western Australia, "The role of oceanographic processes in the recruitment of Western Rock Lobster".
	Masters co-supervision; Daphne Oh, University of Western Australia, "Impacts of seismic testing on post-puerulus Western Rock Lobster".
	Masters co-supervision; Ash MIller, University of Western Australia, "Fine-scale variability in catch and growth rates of western rock lobsters, *Panulirus cygnus* George, reveal heterogeneous life-history parameters".
Rodney Duffy	Masters co-supervision, Edith Cowen University, Emily Lette – "Metabalomic profiling of marron haemolymph"
David Fairclough	Adjunct Senior Lecturer. Department of Environment and Agriculture, Faculty of Science and Engineering. Curtin University.
	PhD co-supervision, Brett Crisafulli, Edith Cowan University, "Understanding Recreational Fishing in the advent of the catch and release era"
Norman Hall	Emeritus Professor, Murdoch University.
Alex Hesp	PhD co-supervision, Murdoch University, Rachel Marks – "Key factors affecting the biology and population dynamics of the blue swimmer crab (*Portunus armatus*) in southwest Western Australia."
	PhD co-supervision Murdoch University, Inigo Koefoed – "The biology and life history of the endeavour prawn *Metapenaeus endeavouri*, and the influence of the environment on the life histories and stock dynamics of three species of Penaeid prawn in arid Western Australia.
	Honours co-supervision Murdoch University, Ruby Evans-Powell – "The importance of big old fat fecund female fish (BOFFFFs) in sustaining the Western Australian dhufish population"
Jason How	Adjunct Research Fellows, University of Western Australia
Danielle Johnston	PhD co-supervision, Murdoch University, Rachel Marks – "Key factors affecting the biology and population dynamics of the blue swimmer crab (*Portunus armatus*) in southwest Western Australia."
	Honours 2021, University of Western Australia. Jeremy Briggs – "Genetic connectivity of blue-swimmer crab (*Portunus armartus*) populations throughout Western Australia using singular nucleotide polymorphisms (SNPs)."
	PhD co-supervision, Murdoch University, Sheilah Kwambai – "*Alexandrium* spp. in Western Australia: characterisation, toxin mobility and control options."
Mervi Kangas	PhD co-supervision Murdoch University, Inigo Koefoed – "The biology and life history of the endeavour prawn *Metapenaeus endeavouri*, and the influence of the environment on the life histories and stock dynamics of three species of Penaeid prawn in arid Western Australia.
Stephen Newman	Adjunct Professor – Department of Environment and Agriculture, Faculty of Science and Engineering, Curtin University.

Staff Member	Position
Karina Ryan	Adjunct Supervisor, Eva Lai "Integrating multiple sources of data to construct a time series of recreational catch/effort for the West Coast Bioregion of Western Australia". PhD, Edith Cowan University.
	Adjunct Supervisor, Brett Crisafulli "Understanding Recreational Fishing in the advent of the catch and release era". PhD, Edith Cowan University
	Adjunct Supervisor, Shannon Burchert "A spatio-temporal analysis of recreational fishing data to inform fine scale fisheries management in Western Australia". PhD, Edith Cowan University.
Lachlan Strain	Adjunct Research Fellow, Faculty of Science and Engineering, Department of Environment and Agriculture, Curtin University of Technology.
	PhD co-supervision, Curtin University of Technology, supervises Aisling Fontanini – 'Impacts of marine climate change on two commercially and recreationally important Western Australian species: *Pagrus auratus* and *Haliotis roei'*.
Stephen Taylor	PhD co-supervision, Edith Cowen University, Ebenezer Afrifa-Yamoah – "Imputations, modelling and optimal sampling design for remote camera surveys"
Michael Travers	Adjunct Research Scientist, Australian Institute of Marine Science.
	PhD co-supervision, Curtin University, Sarah Hearne. Ontogenetic niche separation in extinct and extant fishes from the west Kimberly region, Western Australia.
Corey Wakefield	Masters co-supervision, Curtin University of Technology, supervises Dion Boddington – 'Comparison of the life history characteristics, habitat partitioning and stock status of three groupers off the north-western coast of Australia'.
Brent Wise	Adjunct Associate Professor, School of Engineering, Faculty of Health, Engineering and Science, Edith Cowan University.

GLOSSARY OF ACRONYMS

AIAWA	Abalone Industry Association of Western Australia
AIMS	Australian Institute of Marine Science
AIMWTMF	Abrolhos Islands and Mid-West Trawl Managed Fishery
ALC	Automatic Location Communicator
ASL	Australian sea lion
BPMF	Broome Prawn Managed Fishery
BRD	Bycatch Reduction Device
BSC	Blue Swimmer Crab
CAES	Catch and Effort Statistics
CALM	Department of Conservation and Land Management (now Department of Biodiversity, Conservation and Attractions)
CDR	Catch and disposal record
CI	Confidence Interval
CI/CKI	Christmas Island and Cocos (Keeling) Island
CILF	Christmas Island Line Fishery
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CKIMAFF	Cocos (Keeling) Islands Marine Aquarium Fish Fishery
CL	Confidence Limits
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSLPMF	Cockburn Sound (Line and Pot) Managed Fishery
CW	Carapace Width
DOF	Department of Fisheries now Department of Primary Industries and Regional Development
DPIRD	Department of Primary Industries and Regional Development
DITRDC	Department of Infrastucture, Transport, Regional Development and Communications (Commonwealth)
EBFM	Ecosystem Based Fisheries Management

EGP	Exmouth Gulf Prawn
EGPMF	Exmouth Gulf Prawn Managed Fishery
ENSO	El Niño/Southern Oscillation
EPBC	(Commonwealth Government) Environment Protection and Biodiversity Conservation (Act 1999)
ERA	Ecological Risk Assessment
ESD	Ecologically Sustainable Development
ETP	Endangered, Threatened and Protected
FBL	Fishing Boat License
FED	Fish escapement device
FFS	Flesh-footed shearwaters
FHPA	Fish Habitat Protection Area
FRDC	Fisheries Research and Development Corporation
FRMA	Fish Resources Management Act
FRR	Fisheries Research Report
FTO	Fishing Tour Operator
GAB	Great Australian Bight
GCB	Gascoyne Coast Bioregion
GDSMF	Gascoyne Demersal Scalefish Managed Fishery
GDSR	Gascoyne Demersal Scalefish Resource
GVP	Gross Value of Product
HCF	Hermit Crab Fishery
HMAS	Her Majesty's Australian Ship
HS	Harvest Strategy
IFM	Integrated Fisheries Management
IMCRA	Interim Marine and Coastal Regionalisation for Australia
ISO	International Organisation for Standardisation
ITQ	Individually Transferable Quota
IUCN	International Union for the Conservation of Nature
JASDGDLF	Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery

KCMF	Kimberley Crab Managed Fishery
KGBF	Kimberley Gillnet and Barramundi Managed Fishery
KPMF	Kimberley Prawn Managed Fishery
LASCF	Lake Argyle Silver Cobbler Fishery
MAFMF	Marine Aquarium Fish Managed Fishery
MMF	Mackeral Managed Fishery
MOP	Mother-of-Pearl
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MSC	Marine Stewardship Council
MSY	Maximum Sustainable Yield
NBPMF	Nickol Bay Prawn Managed Fishery
NCB	North Coast Bioregion
NDSMF	Northern Demersal Scalefish Managed Fishery
OIMF	Octopus Interim Managed Fishery
OPMF	Onslow Prawn Managed Fishery
PCMF	Pilbara Crab Managed Fishery
PDSF	Pilbara Demersal Scalefish Fisheries
PFRC	Pemberton Freshwater Research Centre
PFTIMF	Pilbara Fish Trawl (Interim) Managed Fishery
PI	performance indicator
RAR	Resource Assessment Report
RFBL	Recreational Fishing from Boat Licence
RFFSS	Recreational Freshwater Fisheries Stakeholder Subcommittee
SBBSMNF	Shark Bay Beach Seine and Mesh Net Managed Fishery
SBPMF	Shark Bay Prawn Managed Fishery
SBCMF	Shark Bay Crab Managed Fishery
SBSMF	Shark Bay Scallop Managed Fishery
SCB	South Coast Bioregion
SCCMF	South Coast Crustacean Managed Fishery
SCDSR	South Coast Demersal Scalefish Resource
SCPUE	standardised catch per unit effort
SCPSMF	South Coast Purse Seine Managed Fishery
SCTF	South Coast Trawl Fishery
SDGDLF	Southern Demersal Gillnet and Demersal Longline Managed Fishery
SL	Standard Length
SLED	Sea Lion Exclusion Device
SPR	Spawning Potential Ratio
SSMF	Specimen Shell Managed Fishery
SSPA	Southern Seafood Producers Association WA
SST	sea surface temperature
SWRFA	South West Recreational Freshwater Angling
SWTMF	South West Trawl Managed Fishery
TAC	Total Allowable Catch
TACC	Total Allowable Commercial Catch
TAE	Total Allowable Effort
TARC	Total Allowable Recreational Catch
TDGDLF	Western Australian Temperate Demersal Gillnet and Demersal Longline Fisheries
VFAS	Voluntary Fisheries Adjustment Schemes
VMS	Vessel Monitoring System
WAFIC	Western Australian Fishing Industry Council
WAMSI	Western Australian Marine Science Institute
WCB	West Coast Bioregion
WCDGDLF	West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery
WCDSR	West Coast Demersal Scalefish Resource
WCDSMF	West Coast Demersal Scalefish Managed Fishery
WCEMF	West Coast Estuarine Managed Fishery
WCRLMF	West Coast Rock Lobster Managed Fishery
WDWTF	Western Deepwater Trawl Fishery
WTO	Wildlife Trade Operation

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