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Status reports of the fisheries and aquatic resources of Western Australia **2018/19**

State of the fisheries

Department of
Primary Industries and
Regional Development

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WESTERN AUSTRALIA

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Edited by D.J. Gaughan and K. Santoro

Produced by the Fisheries Science and Resource Assessment and

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TABLE OF CONTENTS

GENERAL 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 2018/19 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 contributions of the many stakeholders that work with the Department to achieve sustainable fisheries, valuable industries and healthy ecosystems remain an invaluable part of the ongoing successful management of fisheries in 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**. Both the Shark Bay crab and Shark Bay scallop resources were classified as sustainable-adequate in 2017/18 as they were considered to have recovered after strong management actions to mitigate the impacts of the heat wave event[1, 2].

It also includes several resources that 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 southern garfish (supporting nearshore fisheries of the south and west coasts), Cockburn Sound crab stock, fishery resources supporting the West Coast Demersal Scalefish Fishery (WCDSF), dusky and sandbar shark stocks that support the Temperate Demersal Gillnet Demersal Longline Fishery (TDGDLF) and the Wilson Inlet cobbler stock of the South Coast nearshore and estuarine fisheries.

Only two resources were classified as **inadequate** – the West Coast whitebait stock and the snapper stock of the Gascoyne Demersal Scalefish Fishery – and both appear to be impacted by environmental changes (e.g. Heat wave events), at least in part. Management options have been implemented to address these issues.

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. *ARMA* is based on the principles of Ecologically Sustainable Development (ESD), and will provide the legal framework for improved governance. As part of preparation for implementation, it was identified that the Act requires some modifications to meet its intention. This has necessitated a delay in the timing of migration to the new Act.

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.

In 2017, the Western Rock Lobster Fishery (WRLF) was again recertified under the Marine Stewardship Council (MSC) standard for sustainable fisheries. The other MSC certified fisheries in Western Australia are West Coast Deep Sea Crab, West and South Coast Abalone, Shark Bay prawn, Exmouth Gulf prawn, Peel-Harvey sea mullet and blue swimmer crab fisheries and Pearl Oyster fishery. This results in more than 90% of the State's fishery value coming from independently certified sustainable fisheries.

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.

EDITOR'S INTRODUCTION

I again thank the many staff at Department of Primary Industries and Regional Development (DPIRD) who have contributed to the production of this report, along with the stakeholders who contributed to managing the state's aquatic resources. The ongoing involvement by our commercial, recreational and aquaculture stakeholders in specific research projects and monitoring programs remains critical. Logbook data, voluntary participation in recreational fishing surveys, provision of biological samples, and access to vessels and 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.

The summary table at the start of each chapter displays the stock and fishery performance levels, along with current performance and risk levels for each of the other Ecosystem Based Fisheries Management (EBFM) outcomes (e.g. bycatch, listed species, economics etc.). The Departments' risk based EBFM framework is the State government's basis for management of all Western Australia's aquatic resources.

The introductory section for each Bioregion outlines the key ecological resources (assets) and summarises their current overall (cumulative) risk status. Assets that are examined in each bioregion include each of the meso-scale ecosystems (as determined by the Integrated Marine and Coastal Regionalisation - IMCRA - process[1]) plus key habitats, captured species and listed species categories. There is also a section for major external drivers, such as climate change, coastal development and introduced pests/diseases, which may impact the Department's ability to effectively manage WA's aquatic resources.

This volume provides the general public, fishers and other stakeholders with a starting reference source. This meets the reporting requirements of the Department, including the need to annually report to the WA Parliament on "*the state of fisheries and aquatic resources managed under this Act*"[2].

Key species can also be found in 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 2018/19* 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.

The plan to have a comprehensive Resource Assessment Report (RAR) for all key resources is progressing, with 19 of these now published online. Links to RARs are now included in the *Status Reports of the Fisheries and Aquatic Resources of Western Australia*. These links will be provided as the RARs are completed.

Dr DAN GAUGHAN
Director, Fisheries Science and Resource Assessment

December 2019

1 Commonwealth of Australia. 2006. A guide to the Integrated Marine and Coastal Regionalisation of Australia - version 4.0 June 2006 (IMCRA v4.0). http://www.environment.gov.au/coasts/mbp/publications/imcra/pubs/imcra4.pdf

2 Section 266 Aquatic Resources Management Act. 2016. Government of Western Australia

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 outlines 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* 2018/19 to Parliament) and the ecological resource level reports.

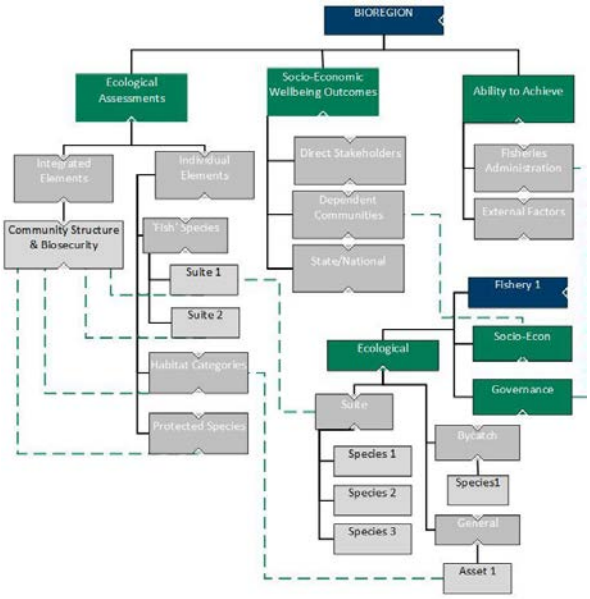
The terms and headings are a combination of the reporting structures first outlined in the National Ecologically Sustainable Development (ESD) reporting structure (Fletcher *et al.* 2002)[1], plus the Ecosystem Based Fisheries Management (EBFM) framework (Fletcher *et al.* 2010, 2012)[2] and the Resource 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, direct 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.

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.

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.

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 (2010) 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 Department of Fisheries. 2011. Resource Assessment Framework for Finfish Resources in Western Australia. Fisheries Occasional Publication. No. 85.

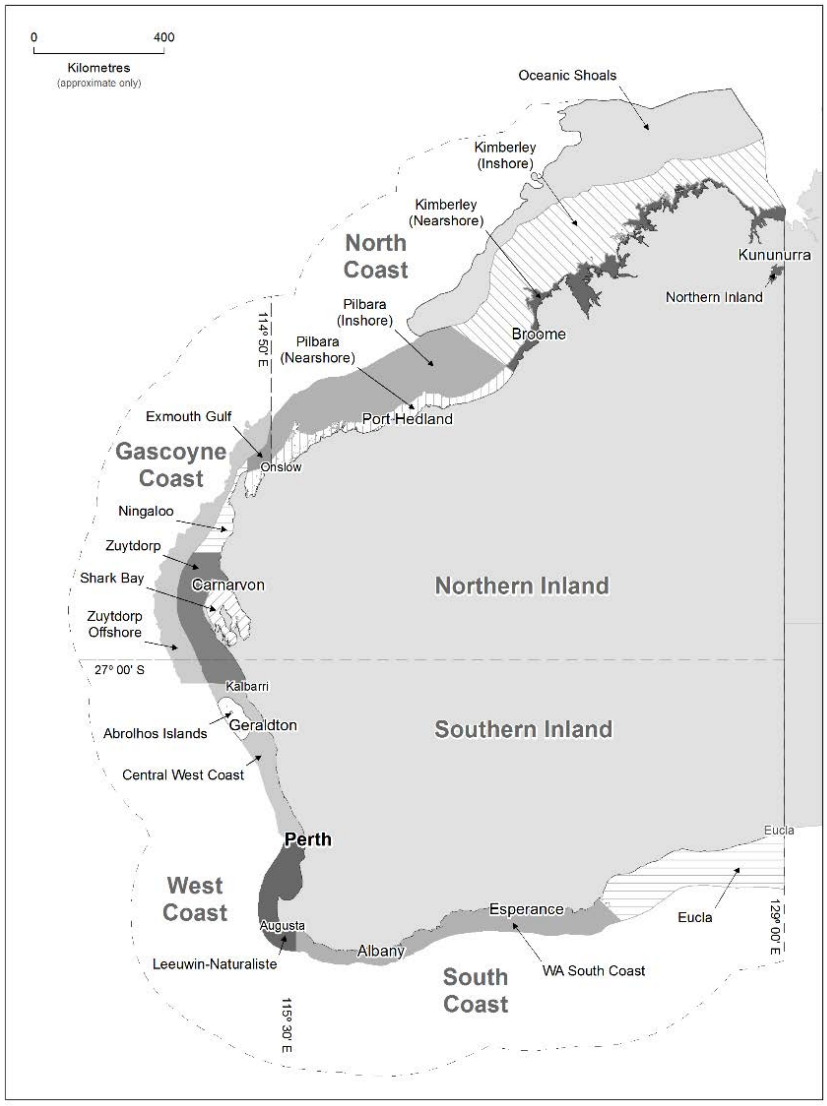
4 Flood *et al.* 2016. Status of Key Australian Fish Stocks. Fisheries Research & Development Corporation, Canberra. 420 pp.

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).

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).

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.



INTRODUCTION FIGURE 2:
Map of WA showing the boundaries of the Bioregions and IMCRA ecosystems.

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) (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 Requirement	Likely Management Response
Negligible	Not an issue	Minimal	Nil
Low	Acceptable; no specific control measures needed	Justification required	None specific
Moderate	Acceptable; with current risk control measures in place (no new management required)	Full performance report	Specific management and/or monitoring required
High	Not desirable; continue strong management actions OR new and/or further risk control measures to be introduced in near future	Full Performance Report – regular monitoring	Increases to management activities needed
Significant	Unacceptable; major changes required to management in immediate future	Recovery strategy (within a Harvest Strategy) and detailed monitoring	Increases to 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. 72:1043-1056pp.

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 2017/18 financial year or the 2018 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 2019.

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 WA Department of Primary Industries and Regional Development (DPIRD) has implemented an integrated survey design to monitor recreational fisheries in a cost effective way[1]. These surveys provide biennial estimates of recreational catch by boat-based recreational fishers at both state-wide and bioregional levels. These surveys utilise the Recreational Fishing from Boat Licence (RFBL) as the sampling frame to provide estimates of catch and effort and provide information 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 (including a state-wide Biological Survey and a Perth metropolitan Validation Survey); and (iii) remote Camera Surveys. The most recent (third) survey was undertaken from 1 September 2015 to 31 August 2016.

Estimates of the recreational catch and effort range at state-wide and bioregional levels from the fourth survey presented in Ryan *et al*. (2019[1]) provide the data for the catch and effort by the recreational sector throughout this report.

The state-wide survey of boat-based recreational fishing has been repeated biennially between 2011/12 and 2017/18. The next statewide survey will commence in mid-2020. Methods to cost effectively monitor shore-based recreational fishing as part of the integrated survey are currently under development.

Stock Assessment Methodologies

Each of the stock assessment reports now clearly identifies what type of assessment method(s) 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 methods therefore vary from the relatively simple analysis of catch levels and catch rates, through to more sophisticated analyses that involve sampling of the catch (fishing mortality), direct surveys up to highly complex age and/or size structured simulation models. These are categorised into five levels.

Level	Description
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; or standardised fishery-dependent relative abundance data.
Level 5	Levels 1 to 3 and/or 4 plus outputs from integrated simulation, stock assessment model.

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.

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 by the fishing operation. 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, 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 fish 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', 'moderate', 'high' or 'significant') provided. More details on the information used within these risk assessments will become available in the Resource Assessment Reports (RARs) being developed.

Social Effects

The Department has categorised the different level of social amenity generated be each aquatic asset. Note, by definition, there is no asset that has no 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. 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.

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 2018/19[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.dpird.wa.gov.au/sites/default/files/2019-10/DPIRD%20Annual%20Report%202019%20-%20PDF.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: 6300t Recreational: 506t (TARC)	Commercial: 6,400t Recreational: 387-557t	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: 68t (Q) (530–640 days) Recreational: 18–22t Perth Metro area	Commercial: 48t (469 days) Recreational: 21–25t Perth Metro area; 14t Other	Acceptable Commercial: Catch was below TACC due to low catches in regional areas resulting from economic and accessibility issues. Recreational: Perth Metro catch range overlaps with the upper end of the acceptable range due to larger size of abalone taken.
Statewide Cephalopod	Octopus Interim Managed Fishery	Annual: Level 2	Sustainable: Adequate	Commercial: 200–500t Recreational: Not developed	Commercial: 314t Recreational: 1t	Acceptable Commercial: Catch within acceptable range. The commercial fishery is in a planned expansion phase. Recreational: Catch levels are not considered a risk to stocks.
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: 774t	Acceptable Commercial: Catch within acceptable range. Recruitment in the Abrolhos Islands continued to improve.
West Coast Estuarine, Nearshore and Embayment Scalefish and Invertebrates	Cockburn Sound Crab Managed Fishery	Annual: Level 4	Inadequate	Commercial: Under revision Recreational: Under revision	Commercial: 0t Recreational: 0t	NA Cockburn Sound fishery closed since 2014. In 2018 recruitment and egg production were below limit reference levels. Decline is consistent with an environmentally limited stock.
West Coast Estuarine, Nearshore and Embayment 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: Not developed	Commercial: 97t (Peel Harvey crab) 143t (Peel Harvey finfish) 16t (other West Coast estuaries, crabs and finfish) Recreational: NA	Acceptable Commercial: Catch and catch rates within acceptable ranges. Recreational: 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, Nearshore and Embayment Scalefish and Invertebrates	Cockburn Sound Fish Net Managed Fishery South West Beach Seine South West Coast Herring Managed Fishery	Annual: Levels 1 and 2 Periodic: Level 3 – Herring 2017	Sustainable: Adequate- Whiting/ Salmon/ Tailor Sustainable: Recovering – Herring Inadequate: Whitebait/ Southern Garfish	Commercial: Under revision Recreational: Not developed	Commercial: 272t (Nearshore fisheries, total finfish) Recreational: 58–77t (95% CI, boat only, top 10 species)	NA Metro Zone Garfish fishery closed in 2017. Declines in Garfish and Whitebait consistent with an environmentally limited stock. 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: 0–3000t (Q) Recreational: NA	Commercial: 340t (all species)	Acceptable Commercial: Low catch for this year due to damage at fish processing plant.
South Coast and West Coast Demersal Finfish	West Coast Demersal Scalefish Managed Fishery	Annual: Level 1 Periodic: Level 3 – 2017	Sustainable: Recovering	Commercial: <450t Recreational ≥250t	Commercial: 244t Recreational: 193–230t (95% CLs, private boats, top 15 species; 2015/16) 62t (charter 2017/18, top 15 species)	Commercial: Acceptable Commercial: Demersal suite catch within range. Recreational: Not acceptable Recreational: Snapper and Baldchin groper catches were above recovery benchmarks.
Gascoyne Coast Bioregion						
Shark Bay Invertebrate	Shark Bay Prawn Managed Fishery (MSC)	Annual: Level 4	Sustainable: Adequate	Commercial: 1350–2150t Recreational: NA	Commercial: 1091t	Acceptable Commercial: Brown tiger prawn catches within acceptable ranges but western king prawns were below the acceptable range due to low recruitment levels.
Northern Invertebrates	Exmouth Gulf Prawn Managed Fishery (MSC)	Annual: Level 4	Sustainable: Adequate	Commercial: 471–1250t Recreational: NA	Commercial: 880t	Acceptable Commercial: Brown tiger catches within acceptable range and endeavour prawns just above their acceptable range. Western king prawn acceptable range reduced due to negative impact on recruitment of higher water temperatures and catches within revised range.
Shark Bay Invertebrate	Shark Bay Scallop Managed Fishery	Annual: Level 4	Sustainable: adequate	Commercial: Trial quota 1354t Recreational: NA	Commercial: 1197t	Acceptable Commercial: Catch achieved 88% of revised trial quota however most catch from Denham Sound and not northern Shark Bay. Recent surveys identified good recruitment in Denham Sound but below limit reference level for northern Shark Bay and the reasons for this require investigation.

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
Shark Bay Invertebrate	Shark Bay Crab Managed Fishery	Annual: Level 4	Sustainable: Adequate	Commercial: 550t (Q) Recreational: Not developed	Commercial: 518t	Acceptable Commercial: Catch achieved was below quota due to late season increase in TACC and operational factors rather than insufficient biomass. Spawning and recruitment levels have stablished under the current environmental conditions and harvest levels. Recreational: Catch levels are not considered a risk to stocks.
Gascoyne Nearshore Scalefish	Shark Bay Beach Seine and Mesh Net Managed Fishery	Annual: Level 2 Periodic: Level 3 Yellowfin whiting – 2014 Sea mullet – Underway	Sustainable: Adequate	Commercial: 235–335t Recreational: NA	Commercial: 176t	Acceptable Commercial: Catch below the acceptable range due to ongoing low levels of effort. Catch rates for Whiting, Sea mullet, Tailor and Yellowfin bream above the 10-year averages.
South Coast and West Coast Crustacean	West Coast Deep Sea Crustacean Managed Fishery (MSC)	Annual: Level 2	Sustainable: Adequate	Commercial: 154t (Q); 60,000–105,000 pot lifts Recreational: NA	Commercial: 152.8t (81,000 pot lifts)	Acceptable Commercial: TAC achieved with effort within acceptable range. The standardised catch rate of retained legal crabs is within the acceptable range.
Gascoyne Demersal Scalefish	Gascoyne Demersal Scalefish Managed Fishery	Annual: Level 2 Periodic: Level 5 Snapper – 2017	Inadequate	Commercial: Snapper 51.4t (Q) Other demersals 227t (Q) Recreational: Not formal	Commercial: Snapper 45.1t Other demersals 164t Recreational: 87–118t (95% CI, boat only, top 10 species in 2015/16)	Snapper: Acceptable Other demersals: Acceptable Snapper spawning biomass is around the limit level. Additional management action undertaken in 2018 including TACC reduction. Management for other demersals adequate.
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: 2t Charter: 1.5t EG, 1.7t DS, 1.2t 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)	Not Acceptable (recreational) Commercial: Incidental catch. Not considered a risk to stocks Recreational: Catch Not Acceptable in Freycinet.
North Coast Bioregion						
Northern Invertebrates	Onslow Prawn Managed Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 60–180t Recreational: NA	Negligible	Acceptable Commercial: Low effort by one boat in 2018.

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 Invertebrates	Nickol Bay Prawn Managed Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 90–300t Recreational: NA	Commercial: 81t	Acceptable Commercial: Catch just below acceptable range. Low catches expected due to low rainfall.
Northern Invertebrates	Broome Prawn Managed Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 55–260t Recreational: NA	Negligible	NA Commercial: Minimal fishing occurred in 2018.
Northern Invertebrates	Kimberley Prawn Managed Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 240–500t Recreational: NA	Commercial: 332t	Acceptable Commercial: Banana prawn catch within acceptable range.
Northern Estuarine, Nearshore and Embayment Scalefish and Invertebrates	Kimberley Gillnet and Barramundi Managed Fishery	Annual: Level 2	Sustainable: Adequate	Commercial: 33–45t (barramundi) Recreational: Not formal	Commercial: 60t (barramundi) 92t (total) Recreational: 20–35t (95% CI, boat only, top 10 species)	Acceptable Commercial: Catch is above the acceptable range. The level of catch is higher than previous years, but is not considered a risk to stocks as the catch rate remains high. Recreational: Catch levels are not considered a risk to stocks.
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: 1297t (total) 488t (goldband snapper – not including other jobfish) 147t (red emperor) Recreational: 34–47t (95% CI, boat only, top 10 species)	Acceptable Commercial: Goldband snapper and red emperor catches are within their catch ranges. See below for Pilbara Fish Trawl, and Pilbara Demersal Trap and Line catches. Recreational: Catch levels are not considered a risk to stocks. Recreational catches 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: Sustainable (catch range review is in progress following recent stock recovery) Recreational: NA	Commercial: 1,977t	Acceptable Commercial: Catches are increasing as the demersal scalefish assemblage in the Pilbara region recovers following effort reductions.
Northern Demersal Scalefish	Pilbara Demersal Trap Managed Fishery and Pilbara Line Fishery	Annual: Level 2, 3 Periodic: Level 5 – Underway	Sustainable: Adequate	Commercial: 400–600t (trap) 50–115t (line) Sustainable Catch range review is in progress following recent stock recovery Recreational: NA	Commercial: 563t (trap) 93t (line)	Acceptable Commercial: Trap and line fishery catch within acceptable range.

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 Large Pelagic Scalefish	Mackerel Managed Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 246–410t (Q, Spanish Mackerel) Recreational: Not formal	Commercial: 214t Recreational: 21–31t (95% CI, boat only, top 10 species)	Acceptable Commercial: The Spanish mackerel catch is below the tolerance range for the first time. A change in operators and environmental conditions may be influencing catch levels. Recreational: Catch levels are not considered a risk to stocks.
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	Annual: Level 4	Sustainable: Adequate	Commercial 646,000 oysters (Q) (14,071–20,551 dive hours) Recreational: NA	Commercial: 614,002 oysters (15,637 dive hours)	Acceptable Commercial: Catch below quota as MOP component was not fully utilised. Catch rates increased from 2017 to 2018. Abundance predicted to increase slightly in 2019.
Statewide Hand Collection	Western Australian Sea Cucumber Fishery	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): 36t Redfish: 25t	Acceptable Commercial: Catches within acceptable ranges. Catch rates for sandfish and redfish above the target reference levels. New stock of sandfish accessed in Pilbara. Main redfish stocks targeted this year 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: 31t (southern rock lobster)	Acceptable Commercial: Catch below acceptable range. Southern rock lobster stock indicator is above the threshold reference level for Zone 3 (Esperance) and Zone 4 (Bight). Recreational: 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
Statewide Abalone	Abalone (Greenlip/ Brownlip) Managed Fishery (MSC)	Annual: Level 3	Inadequate	Commercial: 74t (Q) (3440–5270 hours) Recreational: Not formal	Commercial: 61t (2624 hours) Recreational: 8t	Not Acceptable Commercial: Catch below TACC due to commercial industry decisions. Greenlip abalone stock indicator below threshold reference level for Area 2 and below limit reference level for Area 3. TACC reduced to 62t for the 2019 season with Greenlip abalone TACC at 21% of long-term levels. Spatial closures in Area 3 being considered for 2019 season. Recreational: Catch levels are not considered a risk to stocks.
South Coast Estuarine, Nearshore and Embayment Scalefish and Invertebrates	South Coast Estuarine Managed Fishery South Coast Salmon Managed Fishery South Coast Nearshore Open Access Net Fishery	Annual: Levels 1 and 2. Periodic: Levels 3 and 4 Salmon – 2017 Cobbler – 2018	Inadequate – Cobbler in Wilson Inlet Sustainable: Adequate – Salmon/ Mullet/ Bream	Commercial: Under revision Recreational: Not developed	Commercial: 182t (South Coast estuaries, total fish and crabs) 68t (South Coast nearshore, total fish and crabs) Recreational: 13–21t (95% CI, boat only, top 10 species)	NA Commercial: Wilson Inlet Cobbler catch under review. Decline is consistent with an environmentally limited stock. Low Salmon catch due to low effort from limited market demand. Recreational: Catch levels are not considered a risk to stocks.
Statewide Small Pelagic Scalefish (Purse Seine)	Albany/King George Sound Purse Seine	Annual: Level 1	Sustainable: Adequate	Commercial: 2683t (Q) Recreational: NA	Commercial: 1242t	Acceptable Commercial: Catch below conservatively set quota.
Statewide Small Pelagic Scalefish (Purse Seine)	Bremer Bay and Esperance Purse Seine	Annual: Level 1	Sustainable: Adequate	Commercial: 3000t (Q) Combined Recreational: NA	Commercial: 926t	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: 716t (key species only) 820t (total sharks and rays)	Acceptable Commercial: Catch of the key shark species and the catch of the total shark and ray species is within acceptable catch ranges.
South Coast and West Coast Demersal Finfish	South Coast Demersal Scalefish	Annual: Level 1 Periodic: Level 3 – 2014	Sustainable: Adequate	Commercial: Under development Recreational: Not formal	Commercial: 194t Recreational: 38–51t (95% CI, boat only, top 10 species) Charter: 5t	Acceptable Current commercial and recreational catch levels are at acceptable levels.

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 Inland Bioregion						
Northern Inland Freshwater Scalefish and Invertebrates	Lake Argyle Silver Cobbler Fishery	Annual: Level 1	Sustainable: Adequate	Commercial: 93–180t Recreational: NA	Commercial: 72t	Acceptable Commercial: Catch is below acceptable level due to reduced effort.
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)	59,890 marron (± 4516se) 69,231 fish (±9447se)	Acceptable Catch within acceptable range since 2003.

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.

The proportion of fish stocks identified as not being at risk or vulnerable through exploitation.

The Department undertakes annual stock assessments of fisheries that are subject to management. These assessments, together with trends in catch and fishing activity, have been used to determine the sustainability status of the State's most significant commercial and recreational fisheries

Performance is measured as the proportion of fisheries (that have sufficient data) for which the breeding stocks of each of the major target or indicator species are:

- being maintained at levels that ensure catches can be sustained at desirable levels given effort levels and normal environmental conditions; or
- recovering from a depleted state at an appropriate rate following management intervention.

The department's 2018/19 target for the proportion of fish stocks not at risk from fishing is 95%.

For the 2018/19 performance review, 47 resource and fishery combinations were reviewed. For the 47 reviewed, breeding stock assessments are available for 46 (98%) of these fisheries. For one fishery, northern shark, there is insufficient data to make an assessment on the resource due to the fishery having not operated since 2009.

Within the group of 46 assessed, 38 were considered to have adequate breeding stock levels and a further three fisheries (West Coast Demersal Scalefish Fishery [WCDSF], the Temperate Demersal Gillnet Demersal Longline Fishery [TDGDLF], and the Herring Management Fishery) had breeding stocks considered to be recovering at acceptable rates. The WCDSF and TDGDLF target relatively long-lived species so recovery is expected to take decades to complete.

Of the five remaining fisheries, the Cockburn Sound Crab Managed Fishery, the West Coast Beach Bait Fishery, the Greenlip Abalone Managed Fishery and South Coast Estuarine Managed Fishery continue to be environmentally limited with stocks recovering from the 2010/11 marine heat wave. Therefore, only one fishery has a single stock that is considered inadequate as a result of exploitation (pink snapper in Gascoyne Demersal Scalefish Fishery) with management actions implemented (2018) to assist stock recovery.

Consequently, for the 2018/19 reporting period, the proportion of the 46 assessed groups identified as not being at risk or vulnerable through exploitation is 98%, which is above the target level (Overview tables 2 and 3). The Department considers it has met this performance indicator.

OVERVIEW TABLE 2:
Proportion of fish stocks identified as not being at risk or vulnerable through exploitation

	2018/19 Target (%)	2018/19 Actual(%)
Proportion of fish stocks identified as not being at risk or vulnerable through exploitation	95	98

OVERVIEW TABLE 3:
Historic data on the proportion of fish stocks identified as not being at risk or vulnerable through exploitation

Year	Target (%)	Actual (%)
2008/09	82	86
2009/10	85	89
2010/11	83	94
2011/12	86	94
2012/13	91	97
2013/14	94	97
2014/15	94	97
2015/16	97	95
2016/17	97	95
2017/18	97	97
2018/19	95	98

The proportion of commercial and recreational fisheries where acceptable catches (or effort levels) are achieved.

The Department is continuing to implement an Ecosystem Based Fisheries Management (EBFM) approach where the aggregate effects of all fishing sectors are taken into account. This involves the use of a framework in which decisions on optimum resource use (i.e. allocation and reallocation of fish resources) are determined and implemented within a total sustainable catch for each fishery or fished stock.

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). Recreational and commercial catch values are for the latest year/season available.

An acceptable catch or effort range is being determined for each of the major recreational fisheries by the department since 2013/14. For most of the commercial fisheries in WA, each management plan seeks to directly control the amount of fishing effort applied to stocks, with the level of catch taken providing an indication of the effectiveness of the plan.

For quota-managed fisheries, the measure of success of management arrangements is that the majority of the Total Allowable Catch (TAC) is achieved and that it has been possible to take this catch using an acceptable amount of fishing effort. If an unusually large expenditure of effort is needed to take the TAC, or fails to achieve the TAC by a significant margin, this may indicate that the abundance of the stock is significantly lower than anticipated.

For these reasons, an appropriate range of fishing effort to take a TAC has also been incorporated for assessing the performance of quota-managed fisheries.

Where management is operating effectively, annual catches by each fishery should vary within a projected range. The extent of this range reflects the degree to which normal environmental variations affect the recruitment of juveniles to the stock that cannot be 'controlled' by fishery management. Additional factors may result in ongoing changes to the amount of effort expended in a fishery, which will in turn influence the appropriateness of acceptable catch ranges for individual fisheries.

An acceptable catch or effort range has been determined for each of the major recreational and commercial fisheries. The department's 2018/19 target is 90%.

For the purpose of this indicator, of the 47 resource and fishery combinations, comparisons between actual catches (or effort) with acceptable ranges have been undertaken for 31 commercial fisheries and an additional 16 have been identified as having a 'material' recreational catch share. There is still a relatively high number of fisheries not assessed due to a combination of ongoing environmentally induced stock issues in some regions (see above) or poor economic conditions with fisheries either closed or not having material levels of catches during this reporting period. Over time, the indicator may need to expand to include reference to fisheries or stocks for which there are other 'material' sectoral shares (e.g. customary fishing).

Of the 16 recreational fisheries, only six currently have formal acceptable catch ranges developed

and another 10 were assessed based on currently resource sustainability. Of these fisheries, the data from the 2015/16 statewide survey of boat-based recreational fishing had catch estimate levels for 14 that were within acceptable catch ranges and two that exceeded the acceptable catch range. These were baldchin groper and pink snapper which exceeded the acceptable catch range of the recreational sector within the West Coast Demersal Scalefish Fishery and pink snapper which exceeded the recreational catch range in Freycinet Estuary within Inner Shark Bay.

Of the 31 commercial fisheries, 12 were primarily catch-quota managed with 19 subject to effort-control management. Of the 12 individually transferable catch-quota managed fisheries, four operated within their acceptable effort/catch ranges and eight were acceptably below the range. In the 19 effort-controlled fisheries, 12 were within, one acceptably above and six acceptably below their acceptable catch ranges. Catch/effort above or below their acceptable ranges were determined acceptable due to adequate resource sustainability.

In summary, 14 of the 16 recreational fisheries and 31 of the 31 commercial fisheries or overall 45 of the 47 fisheries assessed were considered to have met their performance criteria. Consequently, for the 2018/19 reporting period, the percentage of fisheries where acceptable catches are achieved is 96%, which exceeds the target level (Overview tables 4 and 5). The department considers it has met this performance indicator.

OVERVIEW TABLE 4:
The proportion of commercial and recreational fisheries where catches or effort levels are achieved.

	2018/19 Target (%)	2018/19 Actual (%)
The proportion of commercial and recreational fisheries where catches (or effort levels) are acceptable	90	96

OVERVIEW TABLE 5
Historic data on the proportion of commercial and recreational fisheries where catches (or effort levels) are achieved

Year	Commercial		Recreational		Overall	
	Target (%)	Actual (%)	Target (%)	Actual (%)	Target (%)	Actual (%)
2008/09	85	96				
2009/10	90	93				
2010/11	90	94				
2011/12	94	100				
2012/13	88	97				
2013/14	92	89	80	77		
2014/15	95	89	80	85		
2015/16	95	90	80	100		
2016/17	95	93	85	100		
2017/18	95	93	85	92		
2018/19		100		88	90	96

Listed species

In accordance with EBFM principles, risk-based assessment of the impact of commercial and recreational fishing activities on listed fish and non-fish species is undertaken. Specific detail may again be found within each bioregional risk assessment of ecological assets. Risks associated with interactions with listed species were generally assessed as being negligible to low with the exception of risks to mammals (dolphins) resulting from the Pilbara trawl fishery. Dolphin exclusion devices have subsequently reduced the incidence to acceptable levels. Risks associated with birds and mammals (sea lions) in the South Coast Bioregion were also assessed as moderate and appropriate management measures continue to be undertaken to mitigate these risks. The level of entanglements of whales in pot ropes has successfully been reduced following

completion of research that, in collaboration with industry, identified appropriate and practical mitigation techniques[1].

Ecosystems and Habitats

A range of monitoring tools is used to assess the condition of ecosystems and associated biodiversity within the context of Ecosystem Based Fisheries Management. Detailed assessments of risk to the structure and benthic habitat of specific ecosystems can be found within each bioregional chapter. Across the marine bioregions, risks to benthic habitat and ecosystem structure and biodiversity have been generally assessed as ranging from negligible to at most only moderate. The exceptions to this are the estuarine ecosystems of the West Coast Bioregion which are identified as being at significant risk due to pressures from external (non-fishing) pressures largely associated with deteriorating water quality.

EXTERNAL IMPACTS

Environmental fluctuations and perturbations can influence aquatic resource status. While beyond the control of fishery management, monitoring and analysing trends in environmental variables (e.g. temperature) and correlations with fish stock dynamics (e.g. recruitment) are important to the ongoing monitoring and assessment of fishery resources and advice to managers. Similarly, the effects of climate change on fishery resources are being investigated and monitored as part of the inputs to fishery management advice.

Monitoring and analysing environmental data is undertaken by DPIRD staff in collaborations with a range of other research groups (e.g. Universities, CSIRO, etc.).

DPIRD is the lead State government agency responsible for the management of aquatic and terrestrial biosecurity in Western Australia. Aquatic biosecurity threats include disease outbreaks in wild and farmed fish and the introduction of marine and freshwater pest species that are not native to WA. Statewide Biosecurity in marine and terrestrial systems is now managed under the Sustainability and Biosecurity Pillar in DPIRD. This Pillar is also responsible for coordinating the fish kill response program within the State.

1 How *et al*., (2015) Effectiveness of mitigation measures to reduce interactions between commercial fishing gear and whales. FRDC Project 2013/037 Fisheries Research Report, WA. 267.

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 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.

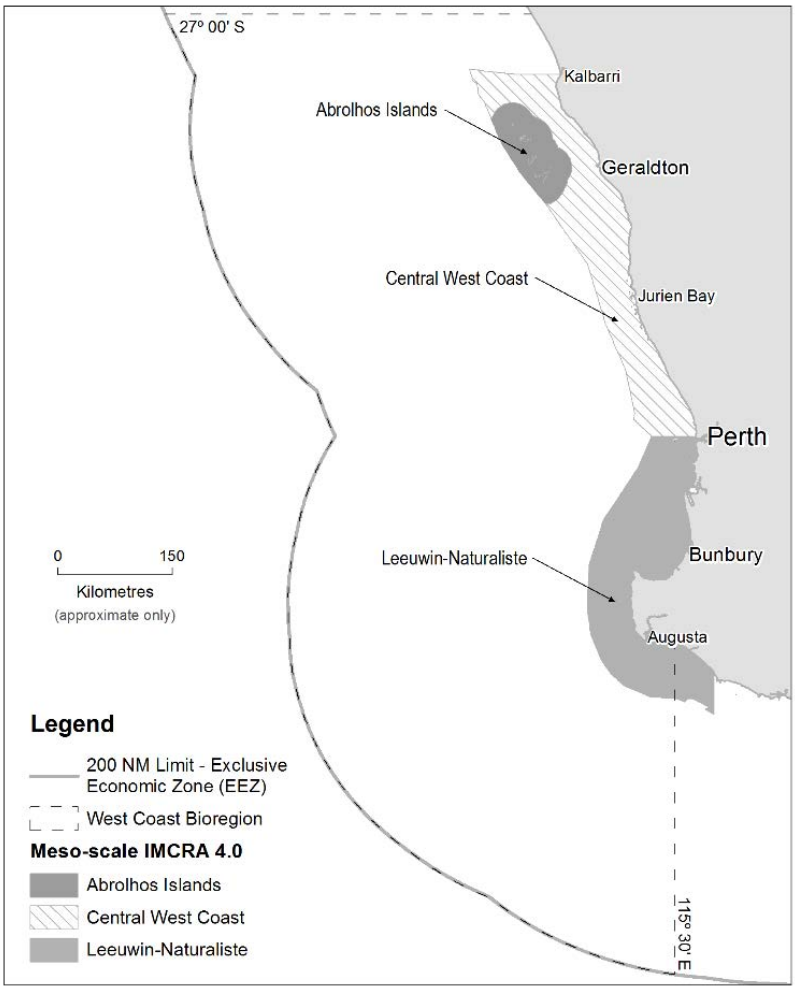
The most significant impact of the clear, warm, low-nutrient waters of the Leeuwin Current is on the growth and distribution of the temperate seagrasses. These form extensive meadows in protected coastal waters of the West Coast Bioregion, generally in depths of less than 20 m (but up to 30 m), and act 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 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 Is.; 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:

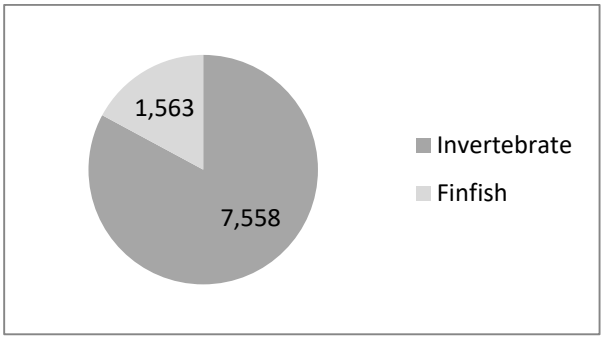
- Increasing frequency of El Niño/Southern Oscillation (ENSO) events;
- More years with a weaker Leeuwin Current;
- Increases in water temperature off the west coast of WA, particularly the lower west coast;
- Increase in salinity, which includes some large annual fluctuations;
- Change in the frequency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

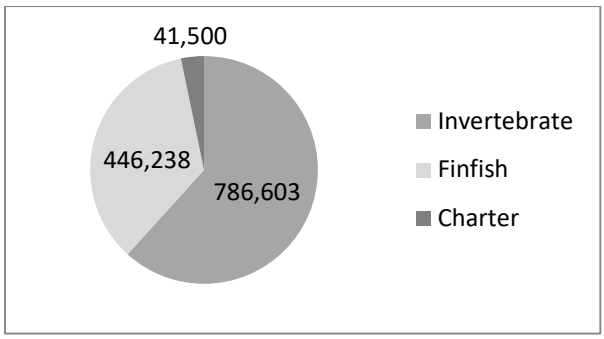
The principal commercial fishery in this region is the western rock lobster fishery, which is Australia's most valuable single-species wild capture fishery. There are also significant commercial fisheries for other invertebrates including scallops, abalone, blue swimmer crabs and octopus that use trawl, 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.



WEST COAST OVERVIEW FIGURE 3
Recreational catches (by number) in the West 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 principal aquaculture development activities in the West Coast Bioregion are the production of blue mussels (*Mytilus galloprovincialis*), marine algae (*Dunaliella salina*) for beta-carotene production and the emerging black pearl industry based on the production of *Pinctada margaritifera* at the Abrolhos Islands. The main mussel farming area is in southern Cockburn Sound, where conditions are sheltered and the nutrient and planktonic food levels are sufficient to promote good growth rates. Owing to the generally low productivity of the Western Australian coastline under the influence of the Leeuwin Current, areas outside embayments (where nutrient levels are enhanced) are unsuitable for bivalve aquaculture. Initiatives to expand the number of aquaculture sectors in this bioregion currently include those for octopus, live rock/coral 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.

Tourism

The State capital, Perth, is the principal gateway for more than two million visitors to Western Australia each year 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. 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.

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.

Shipping and Maritime Activity

The West Coast Bioregion contains several major port facilities, including the State's busiest general cargo port (Fremantle), 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. In addition to commercial and naval shipping, international cruise ship visitations have increased to record levels in recent years and some cruise liners are now 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.

Other Activities

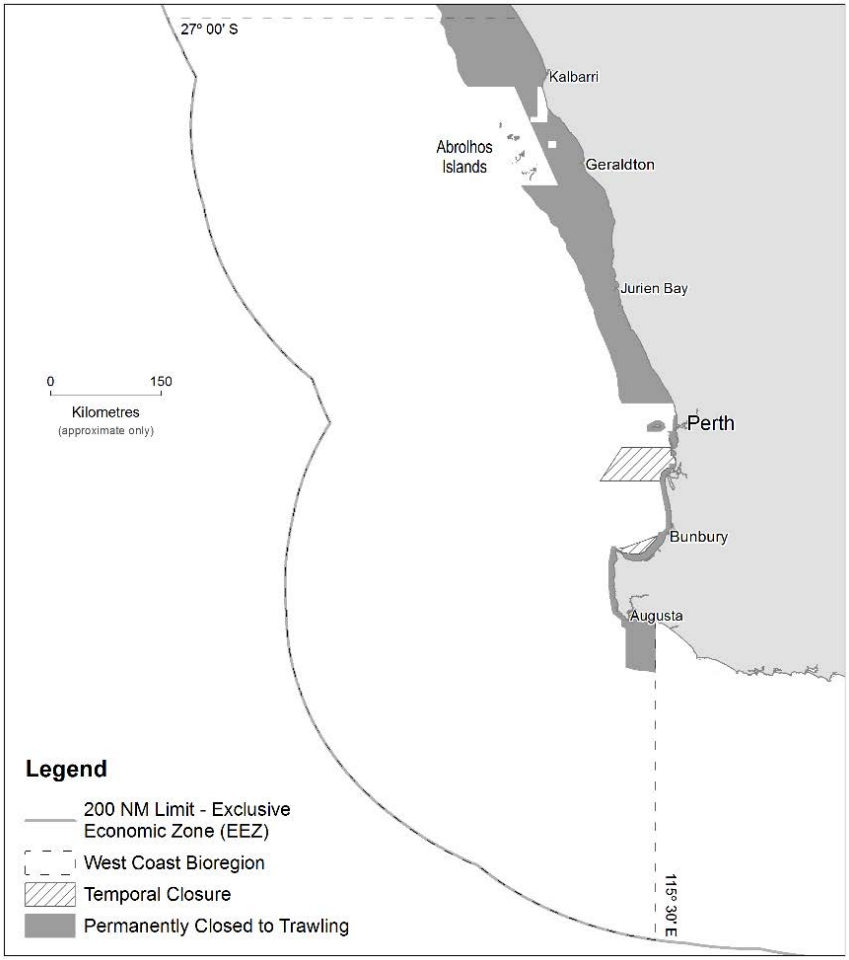
High rates of population growth and boat ownership in Western Australia have strained recreational boating facilities around major population centres, particularly in the Perth metropolitan region. New and upgraded marinas and boat launching facilities have been completed or are planned to accommodate this demand. In addition, major coastal infrastructure developments have been planned for an outer deep-water harbour at Fremantle and for a deep-water iron-ore 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. Plans have commenced to develop two additional delamination plants in the metropolitan region, which may develop if 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 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.

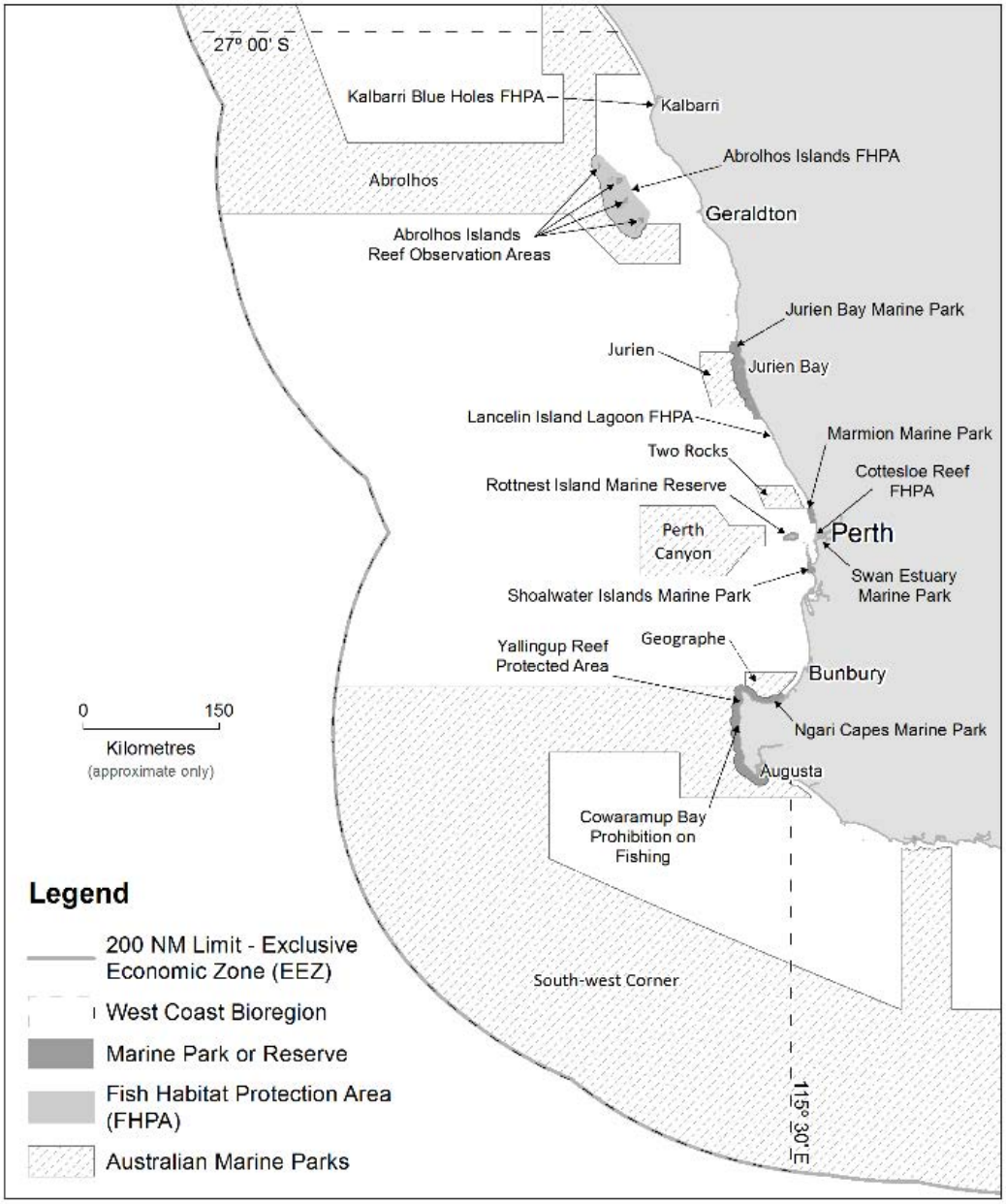
WEST COAST OVERVIEW TABLE 1
The areas and proportions of the West Coast Bioregion making up State Waters and all continental shelf waters, out to 200 m depth, which meet the IUCN criteria for classification as marine protected areas. This table does not yet include the closures that may be implemented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

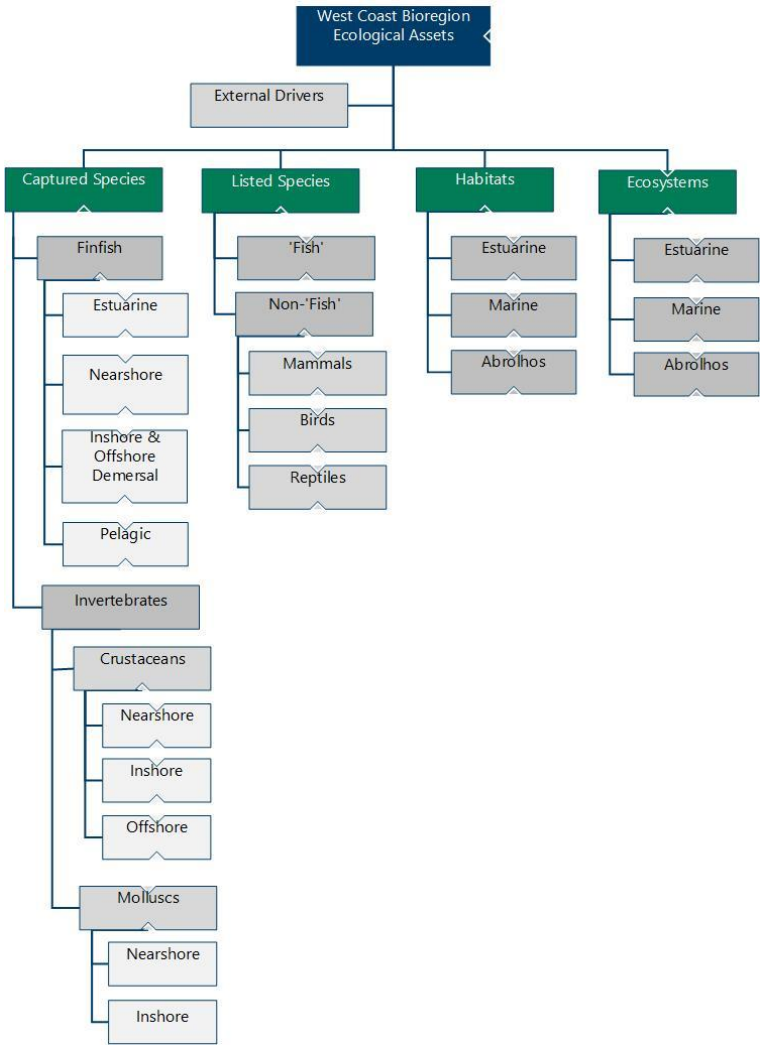
The Commonwealth Government has also implemented its Marine Bioregional Plans for Commonwealth waters between Kangaroo Island (South Australia) and Shark Bay, which includes a number of marine Protected Areas (West Coast Overview Figure 5).



WEST COAST OVERVIEW FIGURE 5
Map showing current and proposed formal 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 (Fletcher *et al.,* 2010 – 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 Ecosystem Management Figure 6 and their current risk status reported on in the following sections.



WEST COAST ECOSYSTEM MANAGEMENT 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] 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 some fish stocks within estuaries 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 achieved 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 activities being undertaken to further monitor and assess stock status and estimate recreational shore-based fishing catch and effort.

Inshore and Offshore Demersal

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

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 and the resultant fishing pressure applied to them.

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	MODERATE
Crustaceans (Lobsters)	Inshore	LOW

The stocks of crabs in Cockburn Sound are recovering and breeding stock levels are improving. However, the fishery remains closed to fishing in 2016/17 with a review of the stock status being conducted in 2018. It is unlikely that the stock will return to high levels of the past, mainly as a result of changing environmental conditions (e.g. improvement in water quality and resulting decline in nutrients).

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. The Peel-Harvey crab fishery achieved MSC certification for the commercial and recreational sectors.

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 record high levels. The Western Rock Lobster fishery has maintained MSC certification since 2000.

Molluscs

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

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 environmentally limited with the Abrolhos Island

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.

fishery closed and no fishing occurring in the Mid-West Trawl Fishery for 5 years before re-opening in 2017.

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	MODERATE

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	LOW

The only identified risk to bird species was to little penguins from boat strikes and non-fishing activities such as a reduction in their main food source i.e. whitebait.

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 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 more than 65% in recent years. Thus, risks to mammals 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.

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

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

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, which includes 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	MODERATE

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. A benthic habitat monitoring program is underway to quantify impacts of recreational crabbing as a part of the MSC assessment process. 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	MODERATE
Abrolhos Islands	Marine	MODERATE

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)[1]. Continued monitoring of a deep water closed area will allow evaluation of potential 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)[2]. 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.

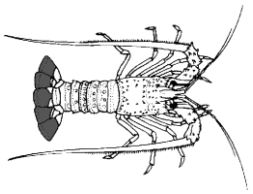
1 Hall NG, and Wise BS. 2011. Development of an ecosystem approach to the monitoring and management of Western Australian fisheries. FRDC Report – Project 2005/063. Fisheries Research Report, No. 215. Department of Fisheries, Western Australia. 112 pp.

2 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 2019

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



OVERVIEW

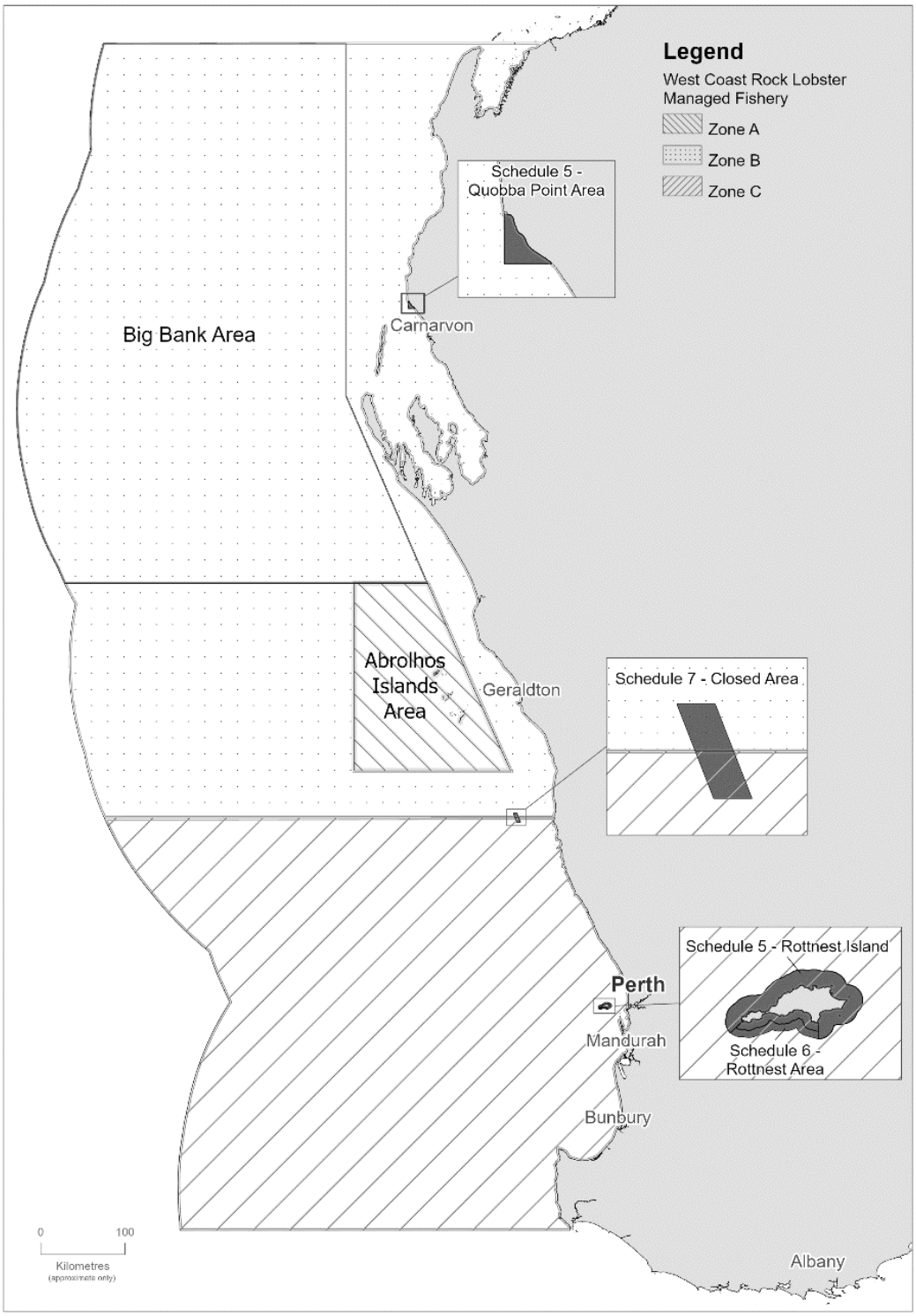
The West Coast Rock Lobster Managed Fishery (WCRLMF) targets the western rock lobster (*Panulirus cygnus*), on the west coast of Western Australia between Shark Bay and Cape Leeuwin. Lobsters are taken throughout their range by both the commercial and recreational sector and each sector operates to formal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

The WCRLMF was one of the first limited entry fisheries in the world and for over 20 years utilised an Individual Transferrable 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 12 months. The recreational fishery also now runs 12 months state-wide, whereas the season previously extended from 15 October each year until 30 June the following year. 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 bag and/or boat limits.

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (6,300 + 1.5% t)	Total Catch 2018: 6,400 t	Acceptable
Recreational fishery (506 t)	Total Catch 2018: 387–557 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 (GVP $424 m)	Moderate Risk	Acceptable
Social (high amenity)	Moderate Risk	Acceptable
Governance	Low Risk	Acceptable
External Drivers	High Risk (climate)	Acceptable

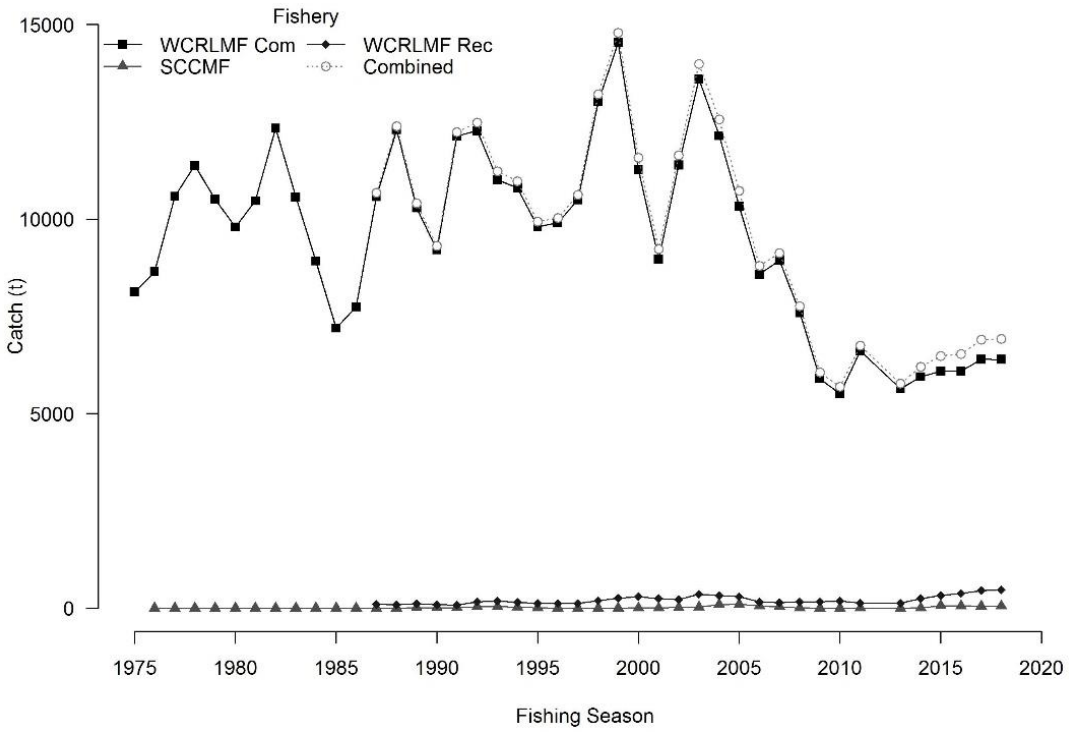


WESTERN ROCK LOBSTER FIGURE 1.
Map showing boundaries of the West Coast Rock Lobster Managed Fishery.

CATCH AND LANDINGS

The total commercial landings of western rock lobster in 2018 from the WCRLMF were 6,400 t plus 9.5 t of “additional” domestic quota from the Local Lobster Program. The total allowable commercial catch (TACC) was 6,395 t (6,300 t plus a 1.5% drip loss factor). The median estimate of the recreational catch was 472 t (range: 387 - 557 t)1 compared to the Total Allowable Recreational Catch (TARC) of 506 t (Western Rock Lobster Figure 2).

1 Note: This figure varies from Overview Table 7 and the Department’s Annual Report because this information was not available at the time of production



WESTERN ROCK LOBSTER FIGURE 2.
Total landings by fishery including the South Coast Crustacean fishery (SCCMF) (and combined) for western rock lobster.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

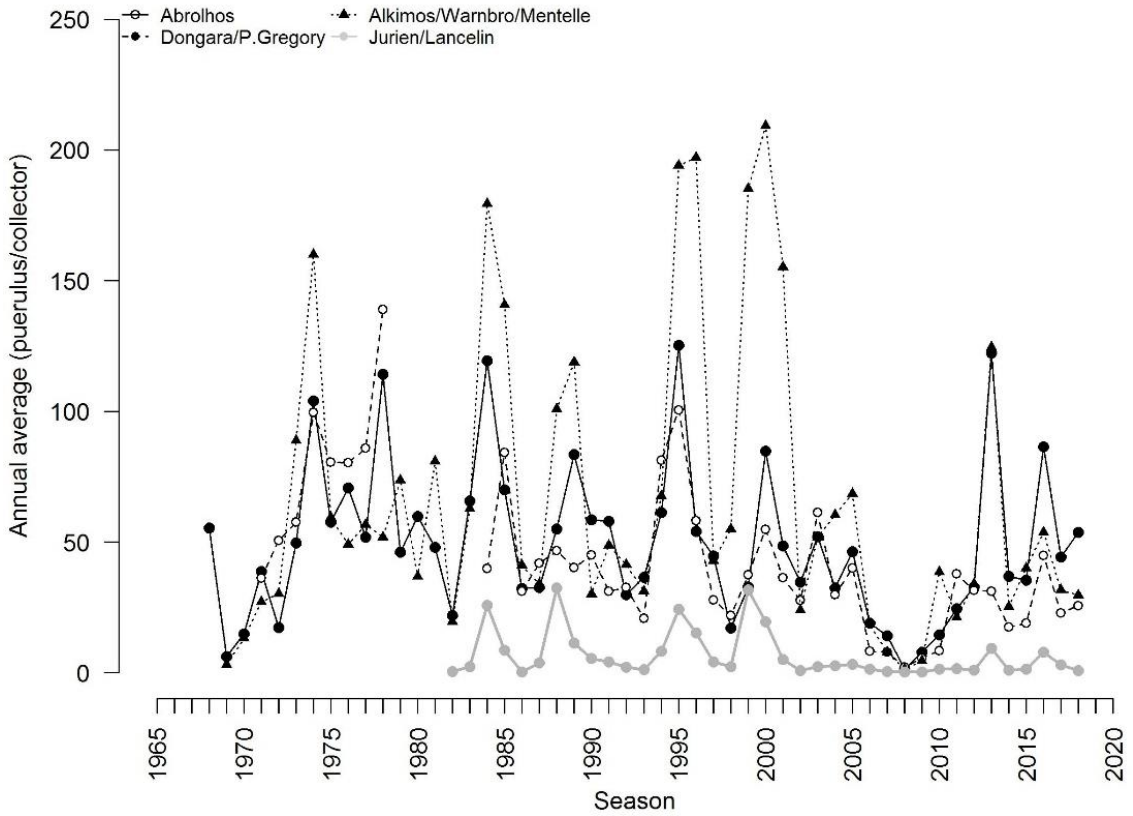
Western rock lobster - (Sustainable-Adequate)

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**.

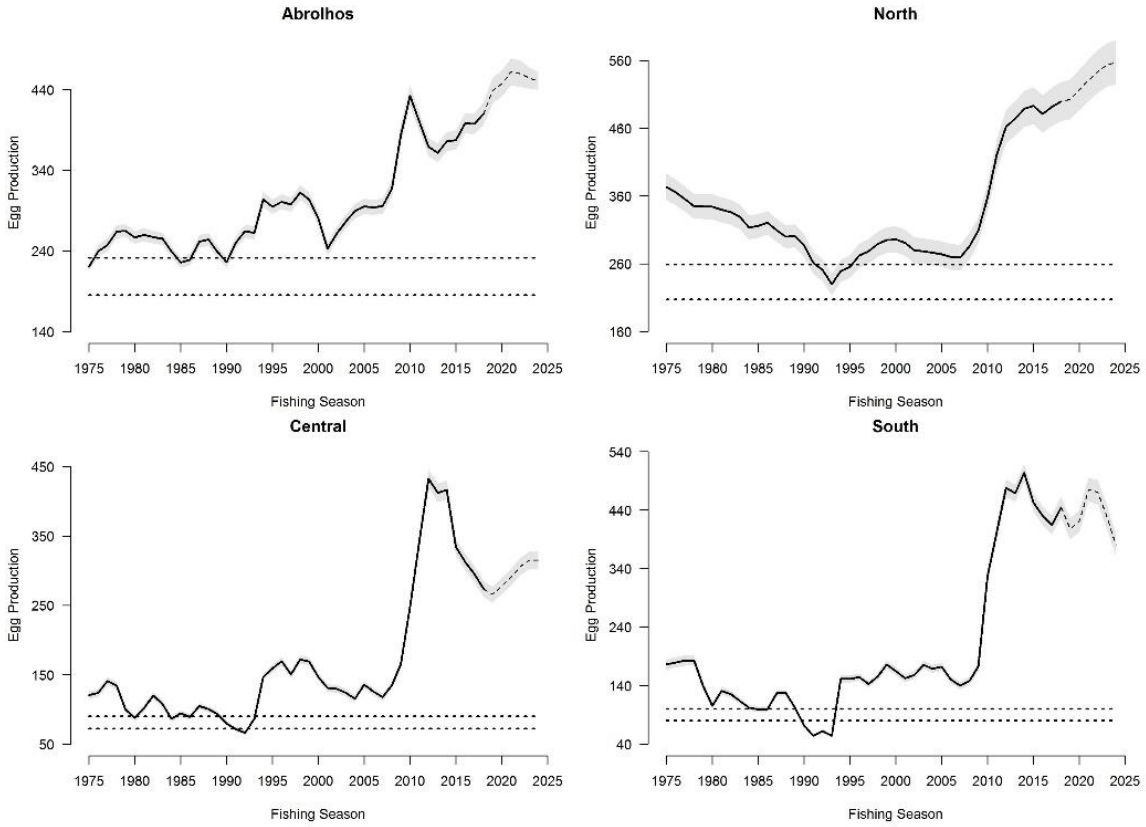
Fishery-independent recruitment (puerulus) monitoring indicates that the puerulus settlement was average in all areas during 2018/19 and similar to that in 2017/18 (Western Rock Lobster Figure 3).

A review of the WCRLMF stock assessment was conducted by a team of international scientists in June 2018. Outcomes included that the science process was considered appropriate to be used with confidence to assess the stock and produce reliable advice for setting the annual TAC.

The integrated population model indicates that a continuation of fishing at similar or slightly higher TACCs (e.g. 6,500 t) over the coming five-year period will continue to result in increasing legal and spawning biomass and catch rates and reduced 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. 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

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 12.4 t in 2018 and only incidental landings of the other species being recorded (1.2 t and 2.4 t for CC and BG, respectively). See Octopus, Deep Sea Crab and West Coast Demersal Scalefish reports for further information.

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 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 2018.

Turtles can also get caught in the float rigs of lobster pots. In 2018 no turtles were reported to have been entangled in lobster fishing gear.

HABITAT AND ECOSYSTEM INTERACTIONS

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.

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 233 commercial vessels operating in 2018 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 60,000 recreational fishers holding rock lobster licences in 2018. At current high stock levels there is a **moderate risk** to this valuable social amenity.

Economic

The estimated average price across all processors and all zones of the WCRLMF received by commercial fishers for the western rock lobster in 2018 was $66.41/kg. This was up slightly from that paid in 2017 ($60.39/kg). The higher beach price with a slightly increased TACC resulted in the overall value of the WCRLMF increasing to $424 million. As the majority of landed lobsters are exported to a single market (China) this represents a **moderate risk**.

GOVERNANCE SYSTEM

Harvest Strategy

The Harvest Strategy and Control Rules 2014-2019 (HSCR) (DoF, 2014) was used to set catch limits for both 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 target maximising the profitability of the WCRLMF i.e. at 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 6,400 t was close to the TACC of 6,395 t (including 1.5% for water loss) and therefore the catch level was **acceptable**. The average of the estimate of recreational catch (472 t) was close to the TARC of 506 t for the 2017/18 season and was therefore also considered **acceptable**. The harvest control rules surrounding recreational catch are based on a five-year moving average (FYMA).

Compliance

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

The recreational fishery now runs 12 months state-wide, whereas the season previously extended from 15 October each year until 30 June the following year. Consultation with the commercial industry and Recfishwest on the review of the HSCR has begun. This process will aim to incorporate some of the outcomes from a recent FRDC project (Rogers *et al*. 2017) which examined the current TACC setting methodology. A TACC sub-committee of the Western Rock Lobster will have direct input into the development of the new HSCR.

EXTERNAL DRIVERS

The variations in WRL recruitment to the fishery are largely a result of variable levels of puerulus settlement 3-4 year previously. Catches are also dependent upon the environmental conditions at the time of fishing. Investigation into the puerulus downturn in 2007-2009 have identified that when the spawning started early (water temperature driven) and was coupled with low numbers of winter storms during the larval phase, the puerulus settlement was significantly lower.

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). As of mid-2019 there are signs that this area may be recovering and returned to a historical pattern.

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 status of the Chinese economy as China imports nearly all of the WRL.

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WEST COAST ROE'S ABALONE RESOURCE STATUS REPORT 2019

L. Strain, J. Brown and R. Jones

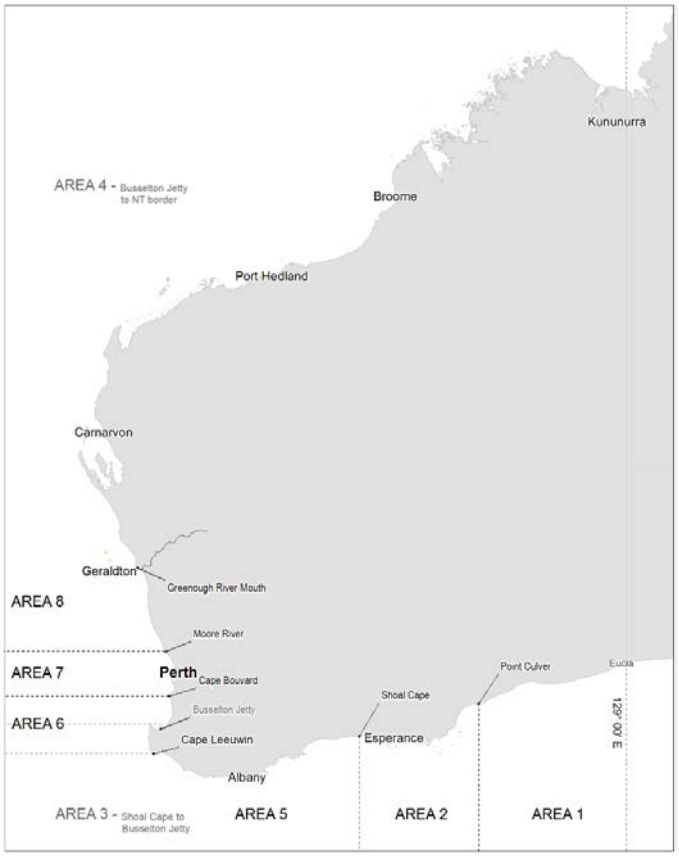
OVERVIEW

The Roe's abalone (*Haliotis roei*) resource is accessed by both 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 and allocated as Individually Transferable Quotas (ITQs).

The recreational fishery is divided into three zones: 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.* (2019b) 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_2.pdf.

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (68 t)	Total Catch 2018: 48 t	Acceptable
Recreational fishery (18-22 t Perth Metro Fishery)	Total Catch 2018: 21–25 t Perth Metro Fishery; 14 t Other	Acceptable
EBFM		
Indicator species		
Roe's abalone (*Haliotis roei*)	Performance Indicator above Target for open areas	Adequate
Ecological		
Bycatch	Negligible risk	Adequate
Listed Species	Negligible risk	Adequate
Habitat	Negligible risk	Adequate
Ecosystem	Negligible risk	Adequate
Economic (GVP $1.22 m)	High risk	Management Action
Social (Amenity - Significant)	High risk	Management Action
Governance	Significant risk	Management Action
External Drivers	Significant risk	Management Action



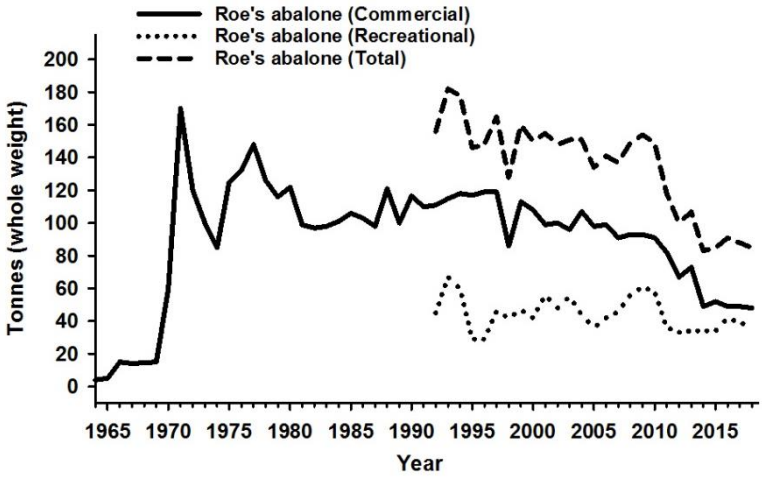
ROE'S ABALONE FIGURE 1.
Map showing the boundaries of the management areas in the commercial Abalone Managed Fishery in Western Australia. The Roe's Abalone fishery operates in Areas 1, 2, 5, 6, 7 and 8, other areas are associated with the Greenlip/Brownlip Abalone fishery

ROE'S ABALONE FIGURE 2.
Map 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 2018 the total commercial catch was 48 t whole weight, 1 t less than the catch in each of the last 2 seasons and only 71% of the 68 t whole weight TACC (Roe's Abalone Figure 3). The commercial catch was less than the TACC in Area 1 (23% caught), Area 5 (43% caught) and Area 6 (47% caught), which was primarily driven by economic reasons (low value of catch and few viable markets), high cost of accessing these areas and prevailing weather conditions (Area 6). In 2018 the TACC was reduced in Area 2 (by 6 t) and Area 5 (by 5 t) due to lower catches over the last 5 seasons and concern about the decline in the standardised catch per unit effort (SCPUE) post marine heatwave (still above target reference level). In Area 7, 23.4 t of the 24 t TACC was caught, which was in line with the stock prediction and allocation models for the Perth Metropolitan Roe's Abalone Fishery (DoF 2017).

The recreational catch of Roe's abalone in 2018 was 37 t whole weight, which represents about 44% of the total Roe's abalone catch (Roe's Abalone Figure 1). The recreational catch includes 21–25 t (23 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.



ROE'S ABALONE FIGURE 3.
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 2018 TACC for each management area, and the TARC for Zone 1 of the recreational fishery.

Area 1 (near WA/SA border): The catch in 2018 was 1.1 t whole weight 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 2018 was 11.5 t whole weight of the 12 t TACC. The SCPUE gradually declined between 2010 and 2015, increased in 2016 and has declined slightly but is still above the target reference level.

Area 5 (Albany): The catch in 2018 was 6.5 t whole weight of the 15 t TACC. The SCPUE has been slightly lower than the historical average in the last six years but has remained stable during this time and is still above the target reference level.

Area 6 (Capes): The catch in 2018 was 5.6 t whole weight of the 12 t TACC. The SCPUE in 2018 was above the target reference level and within the historical range, but due to the prevailing weather conditions resulting in low catch there is a degree of uncertainty around the SCPUE estimate.

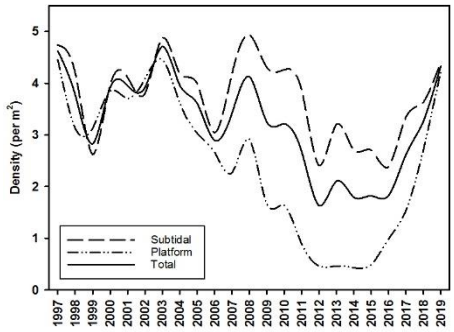
Area 8 (Kalbarri): Closed since the 2011/12 season due to catastrophic mortality following the 2011 marine heatwave. With no evidence of natural recovery, a restocking project has been successful on a trial-scale, but it has yet to be determined if restocking would recover the entire stock in the longer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

Perth Metropolitan Roe's Abalone Fishery (Area 7 / Zone 1): The commercial catch in 2018 was 23.4 t of the 24 t TACC. The SCPUE in Area 7 steadily declined between 2005 and 2014, but has

now increased in each of the last four years. The SCPUE is above the target reference level and the TACC was set using the stock prediction model. The recreational catch estimate was 21–25 t (23 t) whole weight and has been managed to the 20 t (± 2 t) TARC for the last 8 years. The Perth metropolitan catch range overlaps with the upper end of the acceptable range due to larger size of abalone taken.

Fishery-independent surveys indicate that the density of harvest-sized (commercial) Roe's abalone in both the subtidal and platform habitats, and across both fished and unfished areas experienced substantial declines between 2002 and 2012 (Roe's Abalone Figure 4a and b). The density of harvest-sized animals on the reef platform has increased in the last four years from the record-low levels during 2012-2015, while the density on the subtidal habitat is at the highest level since 2008 (Roe's Abalone Figure 4a). Importantly, this increase in density is present in both unfished and fished stocks, suggesting that favourable environmental conditions for growth have continued (Roe's Abalone Figure 4b). Age 1+ (17 – 32 mm) animals have also shown an increase in density over the last four 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 4c). Recovery of the Perth Metropolitan Roe's Abalone Fishery is continuing from historically low levels with the stock indicators either at (harvest-size animals) or nearing (recruitment in fished areas) pre-marine heatwave levels.

a)



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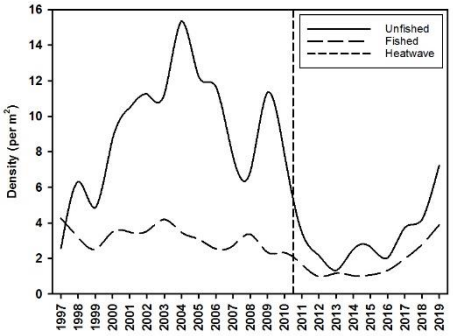

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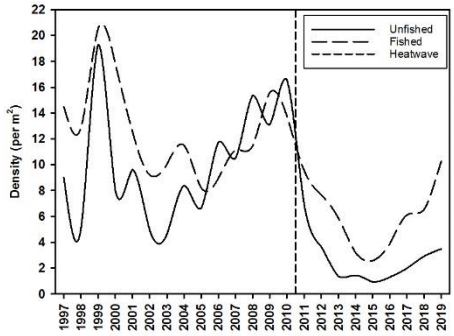

ROE'S ABALONE FIGURE 4.
Density of Roe's abalone in the Perth Metropolitan Fishery (Area 7/Zone 1) from fishery-independent surveys. a) Density of Roe's abalone (71 mm+) in the subtidal and platform fished areas, b) Density of Roe's abalone (71 mm+) in the fished and unfished areas, c) Density of Roe's Age 1+ 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 21 vessels commercially fishing for Roe's abalone, employing approximately 40 people across WA. 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 16,196 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 2018 was $1.22 million, based on the estimated average price for Roe's abalone of $25.41/kg whole weight. The price of Roe's abalone has dropped by over 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 average 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 a temperature factor (DoF 2017). The predicted recruitment (Age 1+) 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 2019/20 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, 24 t in Area 7 and 0 t in Area 8.

Annual Catch Tolerance Levels

Commercial – Acceptable: 68 t (TACC) (530 - 640 fishing days)

Recreational – Acceptable: 18–22 t (TARC) Perth metropolitan fishery only (Zone 1).

Commercial catch was below TACC due to low catches in regional areas resulting from economic and accessibility issues. The commercial fishing effort (469 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 overlaps with the upper end of the acceptable range due to larger size of abalone taken.

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 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 2018, 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.

The commercial Roe's abalone fishery has undergone full MSC assessment and achieved certification in 2017, with the 1st surveillance audit completed during 2018 (https://fisheries.msc.org/en/fisheries/western-australia-abalone-fishery/@@view).

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 on Roe's abalone were estimated at 99.9%. 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). Roe's abalone has been assessed as a significant risk to climate change effects.

Annual 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 beach price and overall economic value during the last decade.

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

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WEST COAST BLUE SWIMMER CRAB RESOURCE STATUS REPORT 2019

D. Johnston, R. Marks and G. Grounds

Overview

Blue swimmer crabs (*Portunus armatus*) are found in waters less than 50 m depth along the entire Western Australian coast. 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, 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 the Resource Assessment Reports (www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_3.pdf ; www.fish.wa.gov.au/Documents/research_reports/frr307.pdf)

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

SUMMARY FEATURES 2019

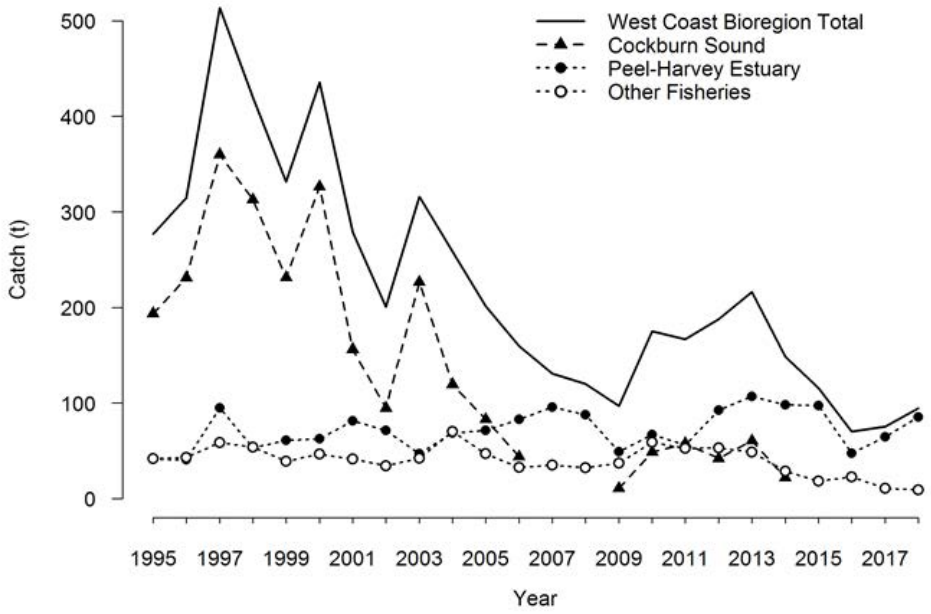
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2018: 94.7 t	Acceptable
Recreational fishery	Total Catch 2017/18: 61.1 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Cockburn Sound	Below limit	Environmentally limited
Peel-Harvey	Above threshold	Adequate
Other SW	Above threshold	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Negligible Risk	Adequate
Habitat	Low 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	Management Review Underway
External Drivers	High Risk	

CATCH AND LANDINGS

Commercial Sector

Total commercial catch of blue swimmer crabs in the West Coast Bioregion increased to 95 t in 2018, primarily due to increased catches in the Peel-Harvey Estuary (West Coast Blue Swimmer Crab Figure 1). This is still well still well below historical catches. The West Coast catch accounts for approximately 16% of the State total commercial blue swimmer crab catch of 606 t for 2018.

The State total catch of blue swimmer crabs in 2018 was similar to that landed in 2017.



WEST COAST BLUE SWIMMER CRAB FIGURE 1
West Coast bioregion commercial catch history for the blue swimmer crab in Western Australia since 1995. Other fisheries include Warnbro Sound, Mandurah to Bunbury (Area 1 and 2), Swan River and Hardy Inlet. The Cockburn Sound Crab Managed fishery was closed 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 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).

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)

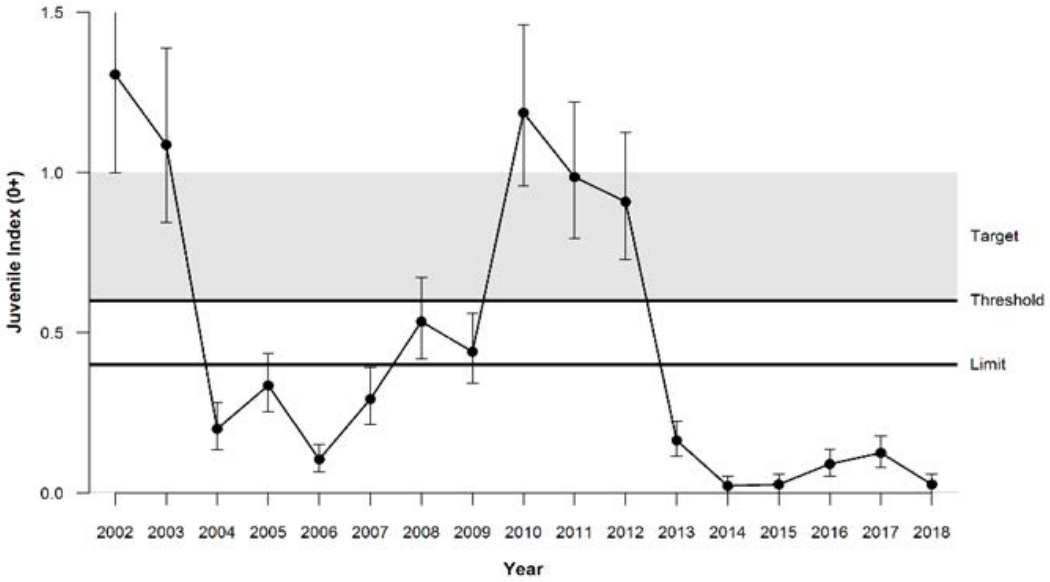
Since the fishery was closed in 2014, a preliminary harvest strategy has been determined for the Cockburn Sound Crab Fishery where the primary performance indicators are the juvenile abundance index and egg production index (Johnston *et al*., 2015a, b). A weight-of-evidence approach was used for the stock assessment where the 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: The juvenile index declined from 0.1 juveniles/100 m2 trawled in 2017 to 0.03 juveniles/100 m2 trawled in 2018, similar to levels in 2014 and 2015 and remains below the limit reference level of 0.4 juveniles/100 m2 trawled. (West Coast Blue Swimmer Crab Figure 2).

Egg Production index: The egg production index declined further from the 10.3 level observed in 2017 to 6.4 in 2018 and remains below the harvest strategy limit level of 12. The decline in egg production from 11.98 in 2016 to 10.3 in 2017 reflected the 2018 juvenile recruitment index, but the effects of the further decline in 2018 on the 2019 recruitment index is as yet unknown. As catch rates undertaken aboard a leased commercial vessel during the closure also declined in 2018, the status of the stock has been classified as environmentally limited.

As the 2018 egg production index and 2018 juvenile index were below their respective limit levels, the fishery remained closed for the 2018/19 season. The future of this fishery is in review.

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

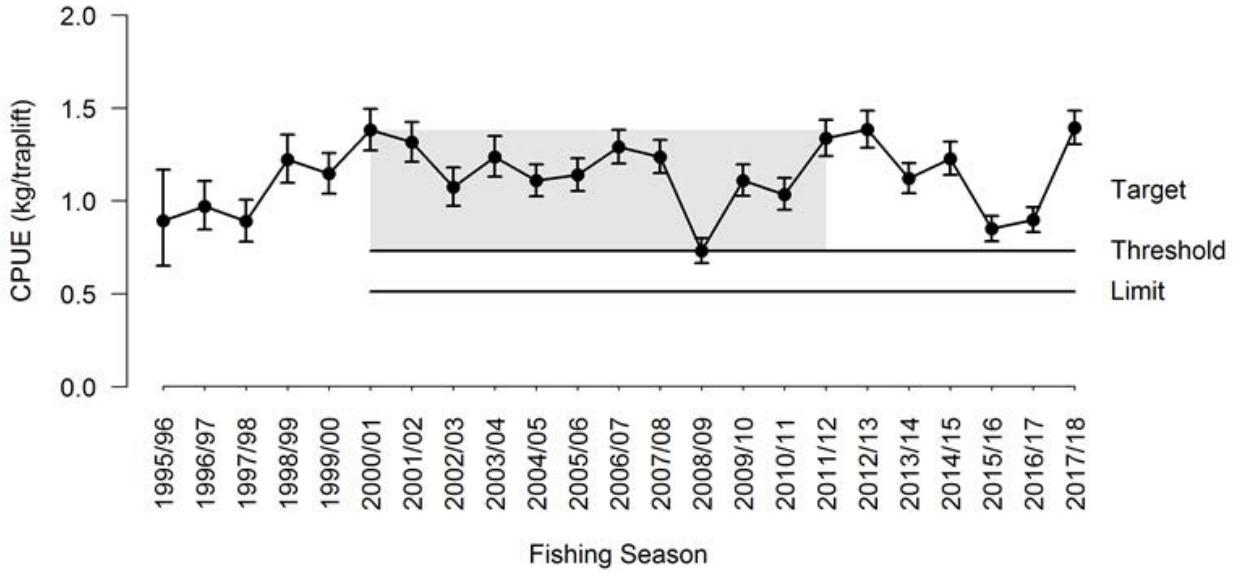


WEST COAST BLUE SWIMMER CRAB FIGURE 2
Annual standardised index of juvenile (0+) blue swimmer crabs in Cockburn Sound calculated using data from juvenile research trawls conducted in April, May and June of each year. The index units are numbers of juveniles/100m^2 trawled. The associated reference points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

Peel-Harvey Estuary (Sustainable-Adequate)

The commercial catch and effort from the Peel-Harvey Estuary for the 2017/18 fishing season (November-August) was 96.6 t from 62,434 trap lifts which is a 75% increase in catch and an 18% increase in effort compared to the 2016/17 season.

Since the conversion from nets to traps in 2000/01 annual 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 1.4 kg/traplift for the 2017/18 fishing season was above the harvest strategy threshold of 0.7 kg/traplift and was the highest standardised catch rate since 2000/01, indicating the stock is currently being fished at sustainable levels (West Coast Blue Swimmer Crab Figure 3). 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**.

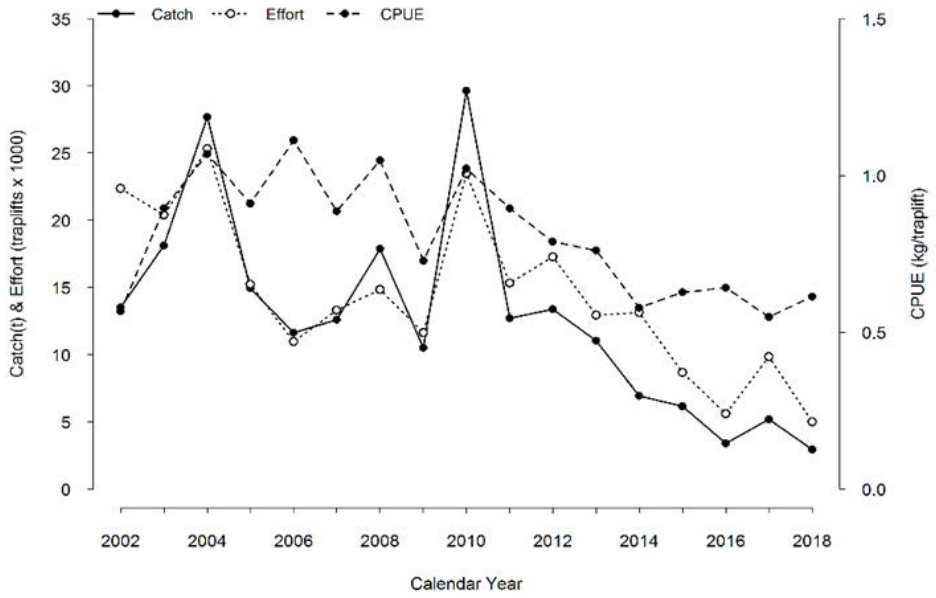


WEST COAST BLUE SWIMMER CRAB FIGURE 3.
Annual standardised commercial catch rate (kg/traplift) of blue swimmer crabs in the Peel-Harvey crab fishery relative to the associated reference points (target, threshold and limit) for the harvest strategy. The reference period is from 2000/01 to 2011/12; defined as the period where the fishery was operating with traps only and during which time the threshold (lowest historical catch rate), limit (30% below the lowest catch rate) and target (range between the threshold and highest historical catch rate) were set. Fishing season is defined as 1 November to 31 August.

Mandurah to Bunbury Developing Crab Fishery (Sustainable-Adequate)

The Mandurah to Bunbury Developing Crab Fishery (Area 1 and Area 2) reported a total annual catch and effort for 2018 of 2.9 t and 5,020 traplifts, respectively, representing a 43% and 49% decline compared to 2017, primarily a result of reduced fishing effort in Area 1 (West Coast Blue Swimmer Crab Figure 4).

The mean catch rate for 2018 of 0.59 kg/traplift was an 11% increase on the 2017 catch rate of 0.53 kg/traplift (West Coast Blue Swimmer Crab Figure 4). These catch rates are on the preliminary threshold levels that have been established (Area 1 Comet Bay 0.53 kg/traplift) and above the historical low of 0.46 kg/traplift in 2002. Catch rates will be monitored closely over the next year to ensure they do not fall below the threshold. On the basis of this evidence, the crab stock in this region is classified as **Sustainable**.



WEST COAST BLUE SWIMMER CRAB FIGURE 4.
Blue swimmer crab trap catch (t), effort (traplifts x 1000) and catch per unit effort (kg/traplift) in Area 1 and Area 2 of the Mandurah to Bunbury Developing Crab Fishery since 2002.

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. The potential impacts of wading on near shore habitats by the recreational fishers who scoop net in the Peel-Harvey Estuary is currently being assessed.

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 2017, approximately 20 people were employed as skippers and crew on vessels targeting blue swimmer crabs in the West Coast Bioregion. 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 2018 had an estimated gross value of production (GVP) of approximately $0.59 million, an increase on the $0.44 million in 2017 (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 2017/18 was $6.16 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 2018 egg production index and 2018 juvenile index were below their respective limit levels, the fishery remained closed for the 2018/19 season**.**

Peel Harvey:

The primary performance indicator is standardised annual commercial catch As the indicator was above the threshold for 2017/18, no management changes occurred for the 2018/19 season.

Other West Coast fisheries:

The primary performance indicator is nominal annual commercial catch rate

As the indicators were above the threshold in 2018 (Area 1 Comet Bay ≤0.53 kg/trap lift and Area 2 Mandurah-Bunbury ≤1.22 kg/traplift), no changes to the management occurred for the 2019 season.

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 will need 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 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 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 consulted with peak sector bodies, in August 2019 the Minister for Fisheries announced his decision to implement:

- an annual 3-month closure (1 September through 31 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 also working with Recfishwest, WAFIC and the Southern Seafood Producer's Association 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 is underway and scheduled to run until the end of June 2020.

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, increased predation 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.

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WEST COAST OCTOPUS RESOURCE STATUS REPORT 2019

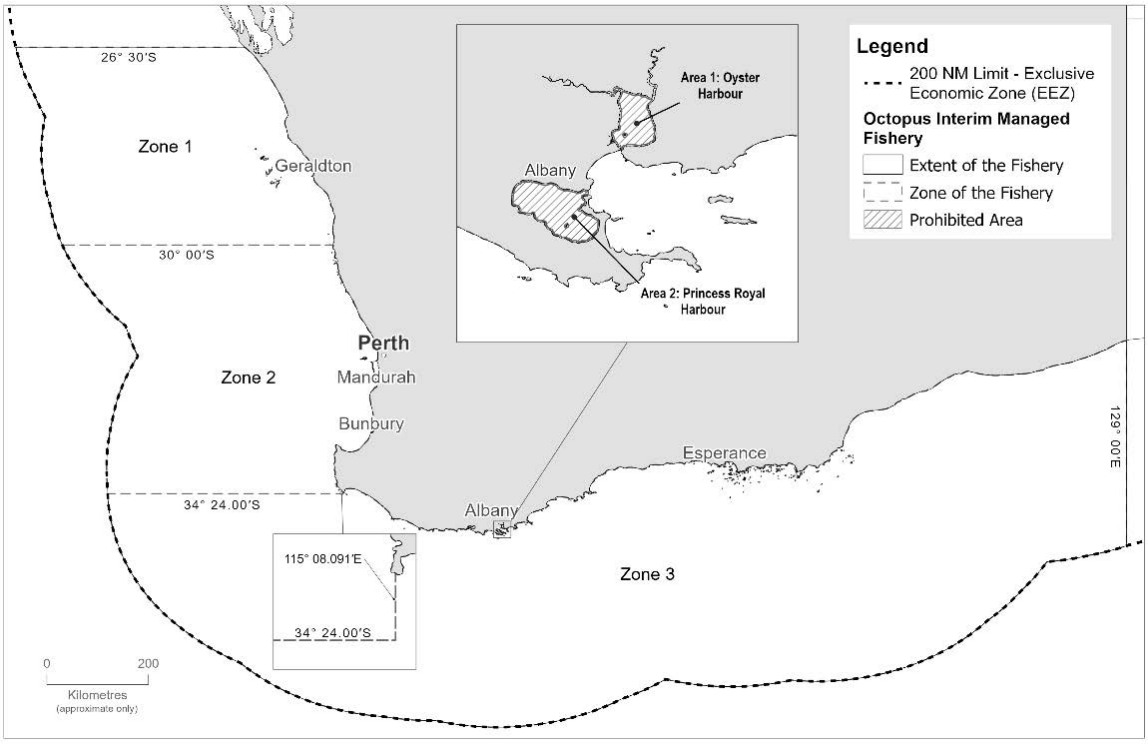
A. Hart, D. Murphy, P. Kalinowski and L. Wiberg

OVERVIEW

The octopus fishery in Western Australia targets the octopus (*Octopus* aff. *tetricus*), which is closely related to, but a separate species from, *Octopus tetricus*, which is found on the east coast of Australia and New Zealand (Amor et al. 2014). 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 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 2019

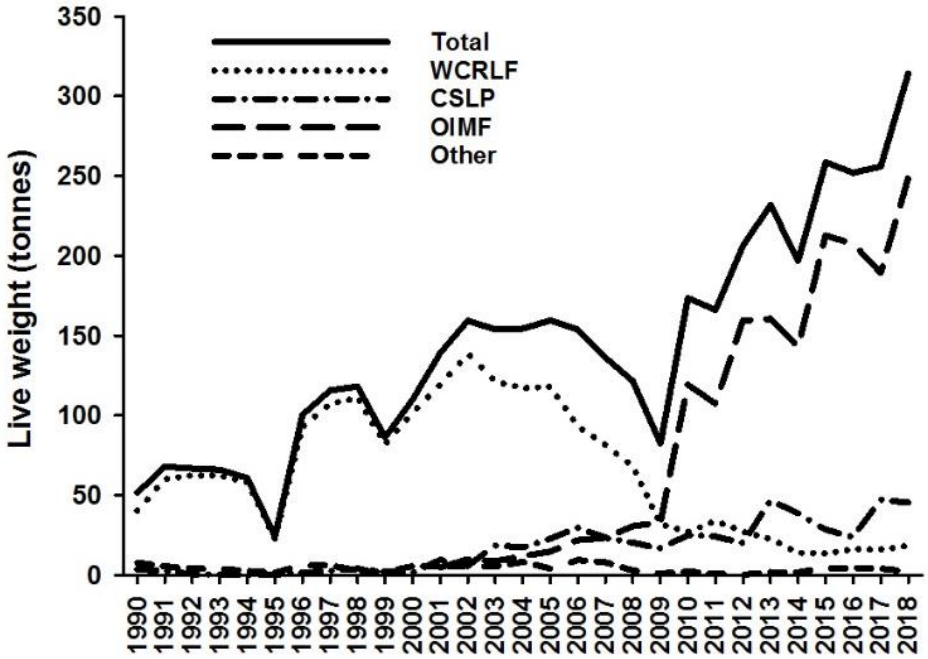
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2018: 314 t	Acceptable
Recreational fishery	Total Catch 2018: 1 t	Acceptable
EBFM		
Indicator species		
Common Octopus (Octopus aff. tetricus)	Performance indicator above target	Adequate
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Low Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (GVP $3.9 m)	Low Risk	Adequate
Social	Low Risk	Adequate
Governance	Low Risk	Acceptable
External Drivers	Low Risk	Adequate



OCTOPUS FIGURE 1.
Map showing boundaries of the Octopus fishery.

CATCH AND LANDINGS

In 2018 the total commercial octopus catch was 314 t live weight, which was 22% higher than the 2017 catch of 257 t and represents the highest catch recorded (Octopus Figure 2). The recreational catch by boat-based recreational fishers state-wide during 2017/18 was estimated at 1,752 octopus (SE=423), with most catches occurring in the West Coast Bioregion, which equates to an estimated total weight of approximately 1.0 tonne (Ryan *et al*. 2019).



OCTOPUS FIGURE 2.
Commercial catch (t) of Octopus aff. tetricus in Western Australia since 1990. WCRLF (West Coast Rock Lobster Managed Fishery), CSLP (Cockburn Sound Line and Pot Managed Fishery), OIMF (Octopus Interim Managed Fishery) and Other, which is bycatch from trawl and miscellaneous pot fisheries.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Octopus (Sustainable – Adequate)

Octopus aff. *tetricus* was subject to a recent comprehensive resource assessment which looked at 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 abundant and widely distributed along the West and South Coast of Western Australia. The estimated area of fished habitat in 2018 was 1200 km^2 (Hart et al. 2019) This area was only a minor percentage (6%) of the total estimated habitat area on the West Coast of 20,073 km^2 (Hart et al. 2019). The current catch of 314 t is likely to be less than 10% of the total biomass. 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 2018 there was two reported entanglements with a whale. 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

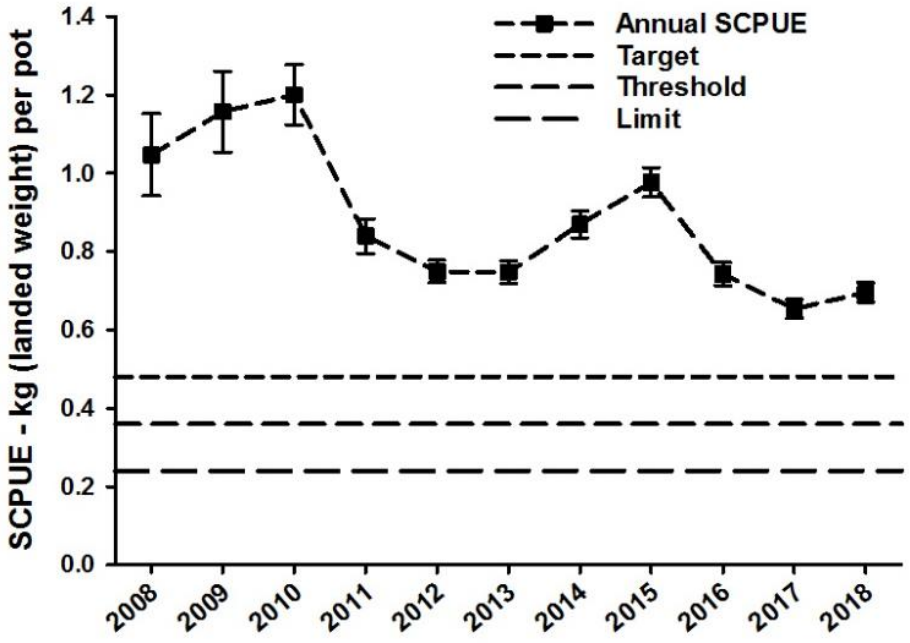
Habitat

In the CSLP 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 11 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 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 2.
Standardised catch per unit effort (SCPUE) (±95% CL) in kg / pot (kg in live weight) of *Octopus* aff. *tetricus*. 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 CSLPMF, and 21 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 2018 was $3.9 million based on the total catch of 314 t and an average product price of $12.33 /kg live weight. **Low** Risk.

GOVERNANCE SYSTEM

Annual Catch Tolerance Levels

Commercial – Acceptable

The target catch range for octopus is 200-500 t. The 2018 catch of 314 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 2).

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 February 2018 the Department commenced a 2-year baited trap trial in the OIMF and CSL&P to inform consideration of the use of baited traps in the future. Following the conclusion of the trial, the Department will consider the appropriateness of incorporating the use of baited traps formally into the fishery.

The Octopus Interim Managed Fishery commenced assessment to attain Marine Stewardship Council (MSC) certification in 2018. The Fishery successfully attained MSC certification in late 2019.

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.

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WEST COAST NEARSHORE AND ESTUARINE FINFISH RESOURCE STATUS REPORT 2019

K. Smith and G. Grounds

OVERVIEW

In the West Coast Bioregion (WCB) nearshore and estuarine finfish are targeted by beach-based fishers and boat-based recreational fishers operating in shallow water. The main recreational method is line fishing. The main commercial methods are haul, beach seine and gill netting. Fishery landings of nearshore species include western Australian salmon (*Arripis truttaceus*), Australian herring (*Arripis georgianus*), southern school whiting (*Sillago bassensis*), yellowfin whiting (*Sillago schombergkii*), yelloweye mullet (*Aldrichetta forsteri*), whitebait (*Hyperlophus vittatus*), tailor (*Pomatomus saltatrix*), southern garfish (*Hyporhamphus melanochir*), silver trevally (*Pseudocaranx georgianus*) and King George whiting (*Sillaginodes punctatus*). Landings of estuarine finfish are mainly sea mullet (*Mugil cephalus*) and black bream (*Acanthopagrus butcheri*).

Six commercial fisheries target nearshore and/or estuarine finfish in the WCB. Four estuaries are open to commercial fishing (Swan-Canning Estuary, Peel-Harvey Estuary, Vasse-Wonnerup Estuary, 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 key more detailed, online information are provided in the reference list.

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2018: 428 t	Acceptable
Recreational fishery	Total Catch 2017/18: 49–64 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Sea mullet (WCB)	Above threshold	Adequate
Australian herring	Above threshold	Recovering
Southern garfish (metro zone)	Below limit	Inadequate
Yellowfin whiting	Above threshold	Adequate
King George whiting	Undefined	Not assessed
Whitebait	Below limit	Inadequate
Tailor	Above threshold	Adequate
Estuarine cobbler (Peel-Harvey)	Above threshold	Adequate
Perth herring	Undefined	Environmentally limited
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Negligible risk	Adequate
Habitat	Negligible risk	Adequate
Ecosystem	Moderate risk	Adequate
Economic (GVP $1 to $5 m)	Medium risk	Acceptable
Social (high amenity)	Moderate risk	Acceptable
Governance	Moderate risk	Acceptable
External Drivers	High risk	

CATCH AND LANDINGS

In 2018, the total commercial catch of nearshore and estuarine finfish in the WCB was 428 t, comprising 272 t from ocean waters and 156 t from estuaries (Nearshore and Estuarine Finfish Table 1). The commercial catch was taken predominantly by six fisheries:

- West Coast Estuarine Managed Fishery,

- South West Coast Salmon Managed Fishery,

- South West Beach Seine Fishery,

- West Coast Demersal Scalefish Managed Fishery,

- West Coast Nearshore Net Fishery,

- Cockburn Sound (Fish Net) Managed Fishery and

- West Coast Beach Bait Managed Fishery.

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. 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 boat-based recreational harvest range for the top 10 nearshore and estuarine species in the West Coast were steady at 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). No recent estimates of shore-based recreational catches are available.

NEARSHORE AND ESTUARINE FINFISH TABLE 1.
Total catches (tonnes) of finfish in commercial fisheries in nearshore and estuarine waters in West Coast Bioregion in previous five years. (*whitebait catch also reported in financial years 2013/14 - 2017/18)

Common name	Scientific name	2014	2015	2016	2017	2018
Sea mullet	Mugil cephalus	123.4	143.4	138.4	127.1	140.9
Western Australian salmon	Arripis truttaceus	60.1	37.9	98.0	103.8	139.5
Australian herring	Arripis georgianus	46.6	49.0	61.7	48.3	42.8
Whitebait	Hyperlophus vittatus	63.5 (12)*	61.2 (97)*	16.3 (34)*	15.1 (19)*	40.2 (29)*
Yellowfin whiting	Sillago schombergkii	36.6	46.5	31.8	25.9	23.4
Yelloweye mullet	Aldrichetta forsteri	19.8	6.3	12.5	14.6	12.7
Tailor	Pomatomus saltatrix	10.5	9.8	3.0	2.0	4.9
Perth herring	Nematalosa vlaminghii	2.5	2.5	3.0	4.4	3.5
Blue sprat	Spratelloides robustus	1.7	0.7	1.5	0.8	7.7
Southern garfish	Hyporamphus melanochir	4.8	2.4	2.4	0.8	0.9
Black bream	Acanthopagrus butcheri	0.8	1.1	3.6	0.8	2.7
Trevallies	Pseudocaranx spp.	2.2	1.8	1.4	2.5	1.2
Other finfish		5.8	8.0	7.8	6.9	7.8
Total		378.4	370.8	381.5	353.0	428.1

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. For level 3 assessments, performance indicators include both spawning potential ratio (SPR) and fishing mortality (F).

Sea mullet (Sustainable-Adequate)

The population structure of sea mullet in WA is unclear, due to uncertainty about the level of connectivity between Bioregions. Given this uncertainty, sea mullet within each Bioregion are currently managed as separate units. A level 3 assessment of stock status is underway which

may also provide more information about stock structure.

Refer to the Inner Shark Bay Scalefish and South Coast Nearshore and Estuarine Finfish status reports for information about sea mullet in other Bioregions.

Recent commercial landings in the WCB are low compared to historical levels due to effort reductions (Nearshore and Estuarine Finfish Figure 1). Since 2000, landings have been relatively stable and ranged from 77 t (in 2011) to 143 t (in 2015). The 2018 WCB catch was 141 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, the majority (~80% p.a.) of commercial landings are currently taken in the Peel-Harvey Estuary. The Peel-Harvey standardised commercial catch rate has been stable since 1980, suggesting stable stock availability over a long period. On the basis of this evidence, the sea mullet stock in this region is classified as **sustainable-adequate.**

Yellowfin whiting (Southern stock) (Sustainable-Adequate)

In WA yellowfin whiting occurs from Exmouth southwards, including relatively low densities of fish along the south coast. The population structure over this range is unclear. Yellowfin whiting are currently managed as two separate stocks. The southern stock includes the WCB and 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 trend is expected to continue.

In 2018, the total commercial catch of the southern stock was 23 t. The majority (>95%) of commercial landings of the southern stock occur in the WCB, with the remainder in the SCB. The West Coast Estuarine Managed Fishery (WCEMF) takes about 70% of these landings each year, with the South West Beach Seine Fishery contributing significant amounts in some years. The commercial catch in the Peel-Harvey Estuary (i.e. Area 2 of the WCEMF) rapidly increased from 10 t in 2012 to 30 t in 2015 in response to a strong recruitment event (Nearshore and Estuarine Finfish Figure 2) (Department of Fisheries 2017). Catches have now returned to more typical levels. The Peel-Harvey catch was 12 t in 2018.

The total recreational catch is unknown due to 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 spawning biomass was above the threshold level (30%). On the basis of this evidence, the yellowfin whiting stock in this Bioregion is classified as **sustainable-adequate.** For information about the northern stock of yellowfin whiting see Inner Shark Bay Scalefish Status Report.

King George whiting (Not assessed)

In WA, King George whiting occurs in the WCB and SCB. Juveniles occur in both Bioregions but adults appear to be restricted to offshore waters of the WCB. In WA, the majority of landings are taken recreationally. The current shore-based recreational catch is unknown, but likely to be smaller than the boat-based recreational catch (Brown *et al.* 2013). The estimated boat-based recreational harvest range for King George whiting in the West Coast was steady at 8 t (95% CI 6–11) in 2017/18 compared with 12 t (95% CI 8–15) in 2015/16 (Ryan *et al.* 2019).

The catch levels in each sector fluctuate markedly in response to recruitment variations, e.g. recruitment driven peaks in south coast catches in 1998 and 2015 (Nearshore and Estuarine Finfish Figure 3). Recreational catches are taken in both the WCB and SCB, whereas the majority (>90%) of commercial catches are taken in the SCB.

A level 3 assessment was conducted in 2010-2012, which suggested that spawning biomass was around the target level of 40% (Fisher *et al.* 2014). No further assessment has been conducted. On the basis of this evidence, the King George whiting breeding stock is classified as **not assessed.**

Australian herring (Sustainable-Recovering)

The 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 2018, the total WA commercial catch was 63 t (Nearshore and Estuarine Finfish Figure 4). The South Coast Open Access net fishery, Cockburn Sound (Fish Net) Managed Fishery, South West Beach Seine Fishery and South Coast Estuarine Managed Fishery, reported most of the commercial catches in 2018. The south coast trap net fishery, which historically took most of the commercial catch, was closed in 2015. 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 compared with 11 t (95% CI 8-14) in 2015/16 (Ryan *et al.* 2019). The current shore-based recreational catch is unknown. Partial estimates of shore-based catch are available for the Perth area, February-June only (Smallwood *et al.* 2012). Since 2010,

when the Perth shore-based survey commenced, herring catches have been variable with no clear trend. The catch was estimated to be 12-37 tonnes in 2017 and 3-11 tonnes in 2018 (95% CI).

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 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**.

Southern garfish (Perth metropolitan zone) (Inadequate)

Southern garfish ranges across southern Australia from WA (Lancelin) to New South Wales (Eden). 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.* 2016). 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).

The most recent level 3 assessment in 2016 indicated that spawning biomass in the Perth metropolitan zone was below the limit reference level (i.e. 20% of unfished level) (Smith *et al*. 2016, Smith *et al.* 2018). In June 2017, this zone was closed to commercial and recreational fishing for southern garfish to aid stock recovery. Monitoring is being undertaken to assess signs of recovery.

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

Whitebait (Unsustainable-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 followed a relatively stable trend (i.e. non-directional) from the late 1980s until 2009/10. Since then, relatively low catches have been reported that are likely due to low stock abundance (Nearshore and Estuarine Finfish Figure 5). Whitebait has a lifespan of only 3-4 years, and so catches are likely to be strongly driven by recruitment variability. The 2011 heatwave event along the west coast appears to have resulted in reduced spawning success in winter 2011, followed by exceptionally low catches and catch rates in 2012/13 and 2013/14 (Nearshore and Estuarine Finfish Table 1). The total catch was 29 t in 2017/18. Standardised catch rates have followed a declining trend since the late 1980s. The evidence suggests that the stock is **unsustainable-inadequate**. The contracted distribution and apparent heatwave impacts also suggest environmental limitations.

Tailor (Adequate)

In WA, tailor occurs from Onslow to Esperance and is believed to constitute a single stock over this range (Smith *et al.* 2013b).

The commercial catch reached an historic low of 8 t in 2017, then increased slightly to 16 t in 2018. The commercial catch has followed a declining trend since 2001 when 42 t was reported. In 2018 most of the commercial catch was taken in the Gascoyne Coast Bioregion (11 t, see Inner Shark Bay Scalefish Status Report), with the remainder in the WCB (5 t) and the South Coast Bioregion (<1 t). The majority of the WCB commercial catch is taken in the Peel-Harvey Estuary.

The current recreational catch is uncertain due to lack of information about shore-based fishers, who previously were believed to take more tailor than boat-based recreational fishers (Smith *et al.* 2013b). However, the shore-based recreational catch appears to have declined and may now be lower than the boat-based recreational catch. 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 compared with 5 t (95% CI 3-7) in 2015/16 (Ryan *et al.* 2019).

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). Juvenile recruitment is monitored annually in the Perth area. A strong recruitment pulse led to higher catch rates in the Perth area in 2011-2014. Recruitment levels have been stable (non-directional) over the past 20 years (Nearshore and Estuarine Finfish Figure 6).

In the WCB, the majority of recent and historical catches of tailor have been taken by shore-based recreational fishers. Anecdotal reports suggest historical (pre-1970) abundance of tailor in the WCB was much higher than current levels. The dearth of information about shore-based recreational fishing in the WCB makes this decline difficult to quantify.

The current risk level for tailor is MEDIUM, based on all lines of evidence including recent trends in catch, effort and catch rates, and a vulnerability assessment. On this basis, the stock is classified as **sustainable-adequate**.

Estuarine cobbler (Peel-Harvey-Adequate)

In WA, cobbler occurs in ocean and estuarine waters but is 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.

Since 1996, annual landings of cobbler in the WCB have ranged from <1 t to 10 t, most of which occurred in the Peel-Harvey Estuary. In 2018, approximately 2 t of cobbler was reported from this estuary. Commercial landings of cobbler in the Peel-Harvey Estuary are currently managed under a Harvest Strategy, which uses catch and catch rate as indicators of fishery performance (Department of Fisheries 2015). Both catch and catch rate were in the target range in 2018, suggesting a low fishing impact on this stock.

The current risk level for the Peel-Harvey stock is MEDIUM, based on all lines of evidence including trends in catch, effort and catch rates, and a vulnerability assessment (PSA). 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 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. Landings by recreational fishers are negligible.

Perth herring is anadromous (i.e. spawns in rivers then migrates back to ocean waters after spawning). Low spawning success due to environmental degradation in the upper reaches of WCB estuaries and low rainfall is believed to be the main cause of ongoing low stock abundance. Commercial landings within the Peel-Harvey Estuary are managed under a Harvest Strategy, which specifies a maximum annual catch (target reference level <2.7 t) for this species (Department of Fisheries 2015). The catch was 4.4 t in 2017, which was above the threshold reference level of 3.5 t. An assessment to determine the sustainability risk commenced in response to the threshold breach and is still underway. The catch was 3.5 t in 2018. The stock is classified as **environmentally limited.**

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.

In the WCB, there were 59 commercial fishers employed (either part or full time) in nearshore and estuarine fisheries in 2018, largely supplying fresh fish to meet demand for locally-caught product.

Economic

Estimated annual value (Gross Value of Production) to commercial fishers for 2018:

Level 2: $1 to 5 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.

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 areas 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 **Medium.**

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. A formal harvest strategy exists for finfish captured commercially within the Peel-Harvey Estuary (Department of Fisheries 2015). A formal harvest strategy is not currently in place for the remainder of this resource.

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 2018, the catch of sea mullet exceeded the threshold reference level (70 t). The Department reviewed the current risk posed by this catch level and determined that it was **acceptable**. Risk will be reassessed after the completion of a stock assessment that is underway.

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 2000-2014. The 2018 catch was 63 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 licensees on operational issues. Industry Management Meetings are convened by the Department through the Western Australian Fishing Industry Council (WAFIC), who are 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 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).

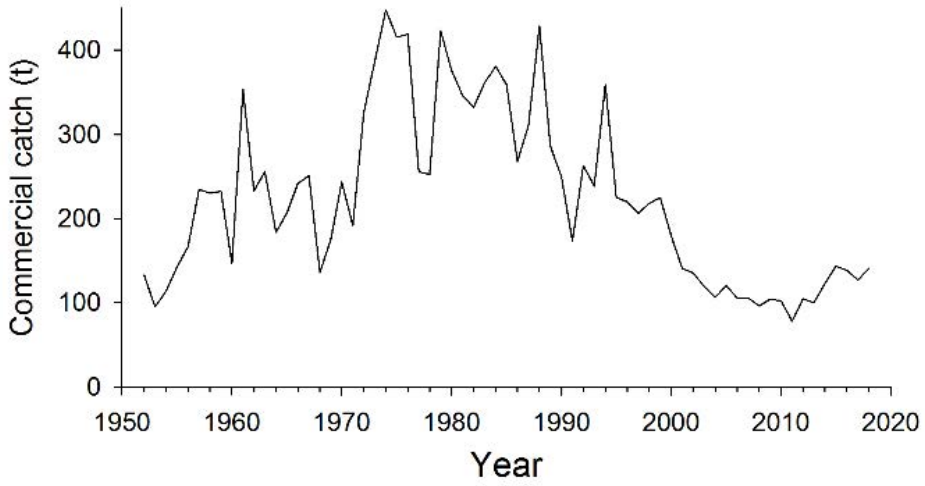
Changes in environmental variables due to climate change (such as ocean temperature, currents, winds, nutrient supply, rainfall, ocean chemistry and extreme weather conditions) are expected to have major impacts on marine ecosystems. These impacts are expected to create both difficulties and opportunities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

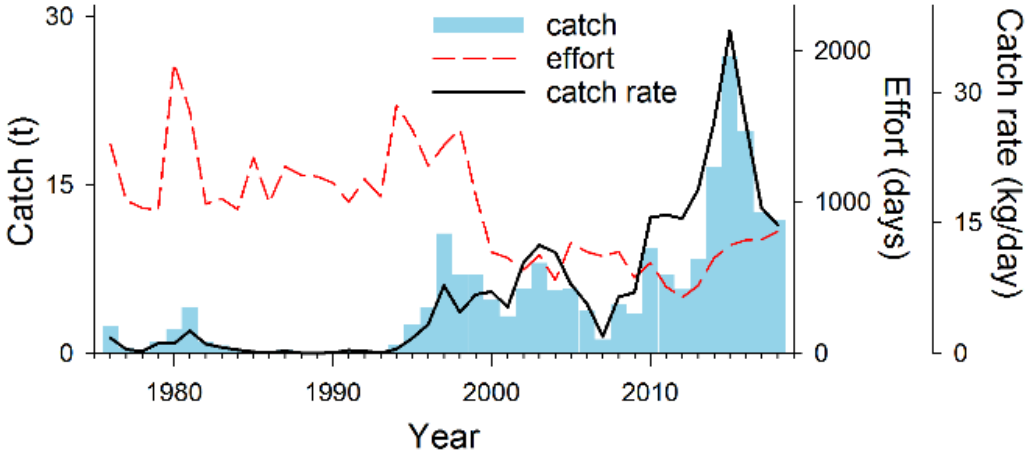
WCB estuaries are highly modified and often degraded environments and the impacts of environmental factors on estuarine fish are likely to be more important than fishing pressure. Impacts in estuaries are most pronounced among 'estuarine-dependent' species, i.e. those that rely on estuarine habitats 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.

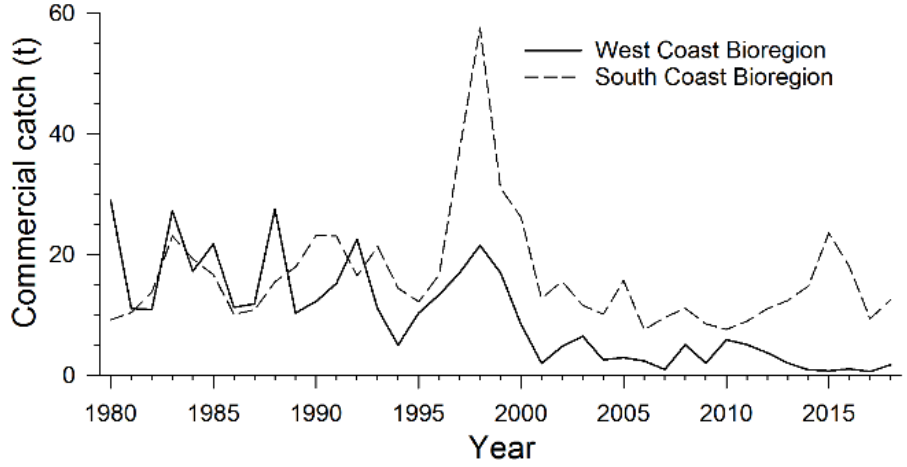
High risk.



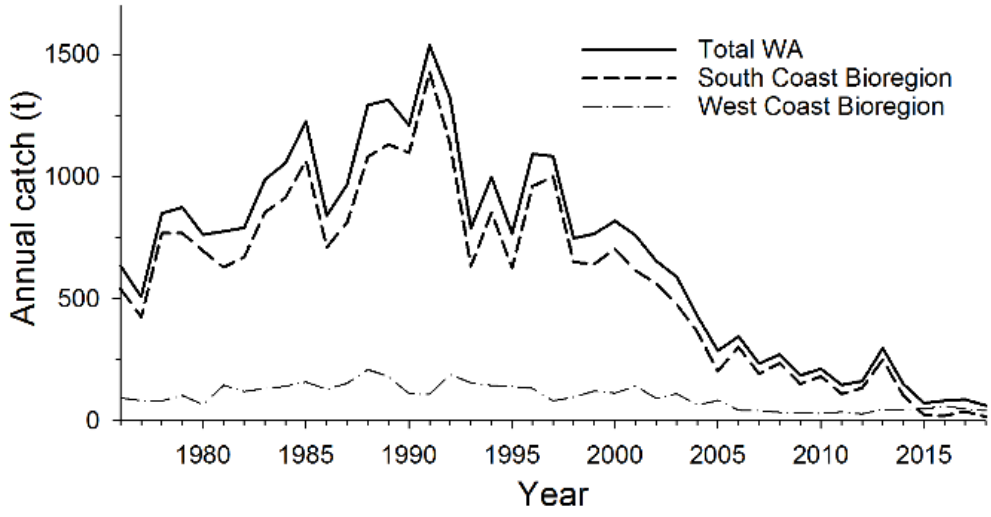
NEARSHORE AND ESTUARINE FINFISH FIGURE 1.
Annual commercial catch of sea mullet in the West Coast Bioregion, 1952 to 2018.



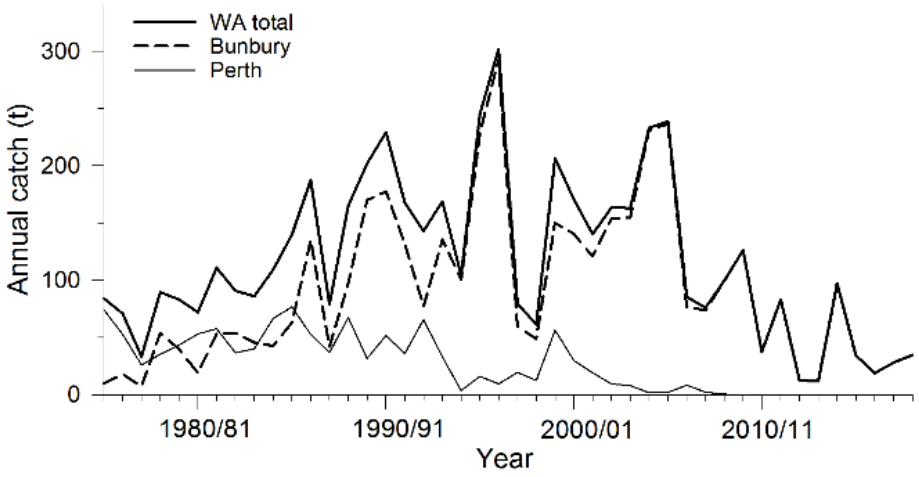
NEARSHORE AND ESTUARINE FINFISH FIGURE 2.
Annual commercial haul net catch, effort and nominal catch rate of yellowfin whiting in the Peel Harvey Estuary, 1976 to 2018. Catch and effort by other methods not shown.



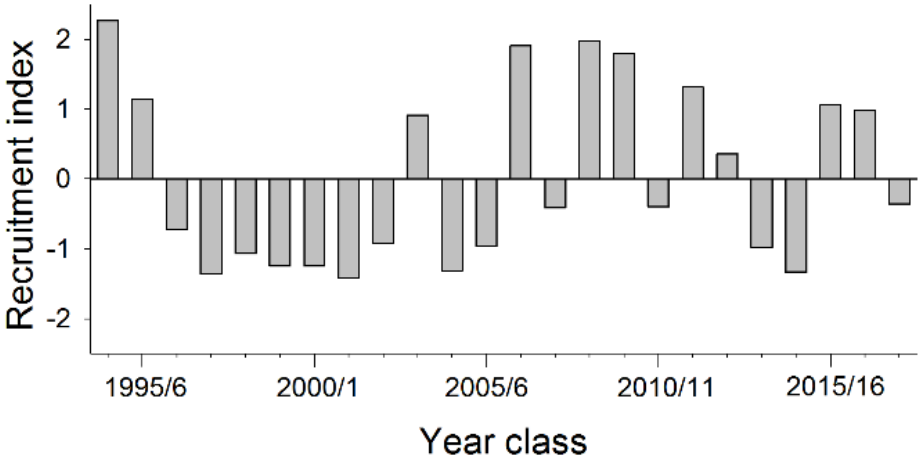
NEARSHORE AND ESTUARINE FINFISH FIGURE 3.
Annual commercial catches of King George whiting in the West Coast Bioregion and South Coast Bioregion, 1976 to 2018.



NEARSHORE AND ESTUARINE FINFISH FIGURE 4.
Annual commercial catches of Australian herring in the West Coast Bioregion and South Coast Bioregion, 1976 to 2018.



NEARSHORE AND ESTUARINE FINFISH FIGURE 5.
Annual commercial catches of whitebait in the Bunbury and Perth areas, 1975/76 to 2018/19.



NEARSHORE AND ESTUARINE FINFISH FIGURE 6.
Index of annual recruitment of juvenile tailor in Perth area, 1994/95 to 2017/18.

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WEST COAST SMALL PELAGIC SCALEFISH RESOURCE STATUS REPORT 2019

J. Norriss and G. Grounds

OVERVIEW

The five species comprising the west coast small pelagic scalefish resource are tropical sardine ('scaly mackerel', *Sardinella lemuru*, pictured above), pilchard (*Sardinops sagax*), Australian anchovy (*Engraulis australis*), yellowtail scad (*Trachurus novaezelandiae*) and maray (*Etrumeus teres*). They are taken predominantly by the West Coast Purse Seine Fishery (WCPSF) together with fishery developmental zone license 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), Perth Metropolitan (31° 00'S to 33° 00'S) and Southern Development Zone (33° 00'S to Cape Leeuwin). Licensees are also entitled to take Perth herring (*Nematalosa vlaminghi*), which forms part of the West Coast Nearshore and Estuarine Finfish Resource, but have not done so since 1997.

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery Commercial TAC, Perth metro and Southern development combined: 3,000 t (Pilchards 2,328 t, Other small pelagic sp. 672 t)	Total Catch 2018: 340 t (all small pelagic species & zones combined)	Acceptable
Recreational fishery (not defined)	Total Catch 2017/18: <1 t	Acceptable
EBFM		
Indicator species		
Tropical sardine	Above threshold	Adequate
Pilchard	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 boundaries of the West Coast small pelagics scalefish resource.

CATCH AND LANDINGS

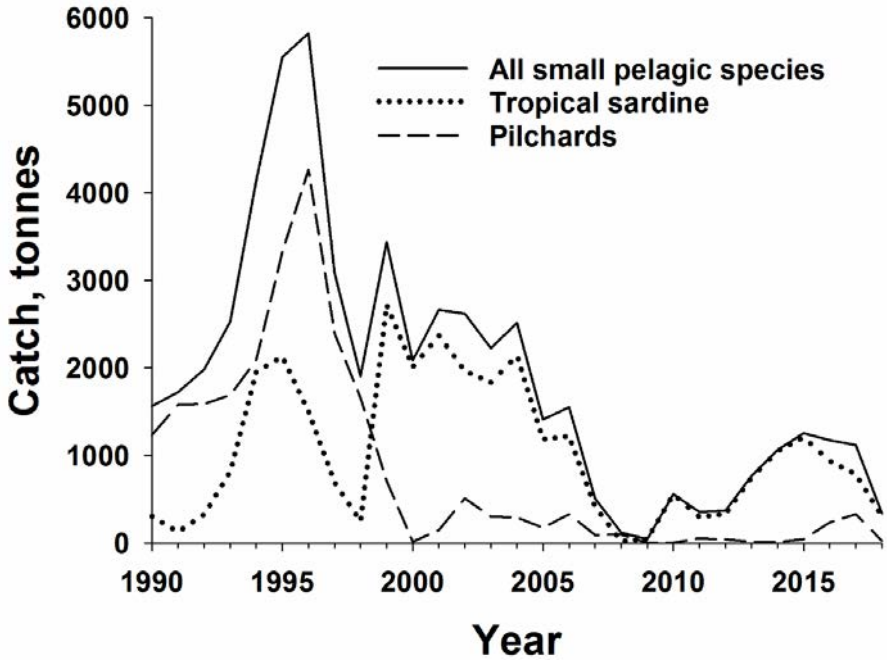
The total combined catch of the five west coast small pelagic scalefish species taken by the WCPSF and developmental licensees in 2018 was 340 t, of which 91% was tropical sardine and 8% pilchards (West Coast Small Pelagic Scalefish Figure 2). Tropical sardines have dominated the catch since pilchards suffered mass mortality events in 1995 and 1998/99 caused by a herpesvirus.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Tropical sardine (Sustainable-Adequate)

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

The WCPSF and developmental licensee catch of tropical sardines in 2018 was 308 t, a 61% decrease from 2017 and the lowest catch since 2011 (West Coast Small Pelagic Scalefish Figure 2). Much of this reduction can be attributed to a fire at a key fish processing facility. Confidentiality requirements preclude disclosure of the spatial distribution of the catch. The limited spatial distribution of fishing effort for what appears to be a highly mobile species 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 total annual catch of all five west coast small pelagic scalefish species, tropical sardines and pilchards by the WCPSF and developmental licensees from 1990 to 2018.

Pilchard (Sustainable-Adequate)

The pilchard is a small, low trophic level pelagic species that feeds by filtering plankton. Longevity is up to 9 years and maximum size 200-250 mm SL.

The WCPSF and developmental licensee catch of pilchards in 2018 was 28 t. This was the lowest annual catch since 2014 (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 since then as the fishery transitioned to take mostly tropical sardine.

Population modelling, based on spawning biomass estimates (from egg surveys), catch-at-age and catch data, suggested the stock had recovered from the 1998/99 mass mortality event 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 WCPSF are restricted by the West Coast Purse Seine Limited Entry Fishery Notice 1989. Small quantities of finfish species are sometimes taken as bycatch, but this occurs infrequently and the majority are released from the net unharmed. **Negligible** risk.

Interactions with endangered, threatened and protected species (ETPs) must be reported to the Department on monthly statutory CAES returns. WCPSF interactions are rare and usually result in the animal released unharmed, indicating the fishery poses a **negligible** risk to ETPs.

HABITAT AND ECOSYSTEM INTERACTIONS

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 habits when this occurs, and would be kept to a small, localised area. The WCPSF is therefore considered to be a **negligible** risk to these habitats.

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 eight 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. The estimated gross value of production (GVP) for the WCPSF in 2018 had dropped to <$1 million (Level 1) in 2018 due to a fire at a key fish processing facility. As such the economic risk has increased and is considered **Moderate**.

GOVERNANCE SYSTEM

Harvest Strategy

The WCPSF is currently managed under a constant catch harvest strategy, with catches limited to notional TACs.

Allowable Catch Tolerance Levels

Currently, a notional combined Total Allowable Catch (TAC), covering both the Perth metropolitan fishery and the Southern Development Zone, is set for pilchards and another for other small pelagic species. For the 2017/18 licensing period (1 April 2017 – 31 March 2018) the notional TAC was 2,328 t for pilchards and 672 t for other small pelagic species (including tropical sardines). Reaching or exceeding the notional TACs will trigger a management response.

Compliance

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

Consultation

Consultation with licensees occurs directly on operational issues and through industry Management Meetings convened by the West Australian Fishing Industry Council (WAFIC), who are responsible for statutory management plan consultation under a Service Level Agreement with the Department.

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

Management Initiatives

There are no broader management reviews planned for the WCPSF in 2019. Stocks will continue to be monitored principally through Level 1 (catch based) assessments.

At the request of industry in October 2019 the Department applied to the Commonwealth Department of Environment and Energy for approval of West Coast Purse Seine Fishery and Development Zones under the *Environment Protection and Biodiversity Conservation Act 1999* to allow the export of product from these Fisheries.

EXTERNAL DRIVERS

Climate change is likely to be causing a southward contraction in the natural distribution of pilchards (**moderate** risk) and facilitating a southward extension for tropical sardine (**negligible** risk).

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WEST COAST DEMERSAL SCALEFISH RESOURCE STATUS REPORT 2019

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).

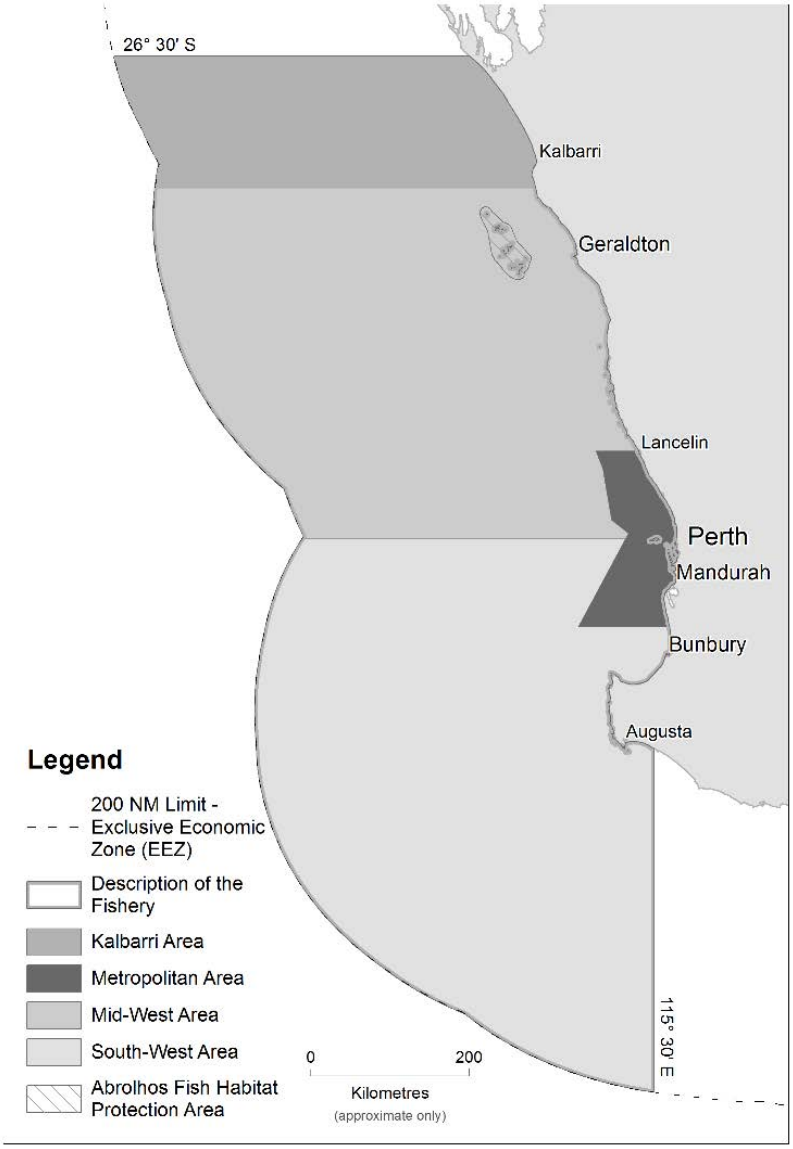
Following an assessment in 2007 demonstrating overfishing of the inshore demersal resource, management arrangements designed to recover the resource were progressively introduced between late 2007 and early 2010. The objective of these was to maintain the retained catches of demersal species by all sectors to below 50% of their 2005/06 levels 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 2019

Asset (Allowable catch)	Outcome	Status
[a]Commercial fisheries (450 t)	Total Catch 2018: 244 t	Acceptable
[b]Recreational fishery (250 t)	Total Catch 2017/18: 293 t	Not acceptable
EBFM		
Indicator species		
WCDSR	High Risk	
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



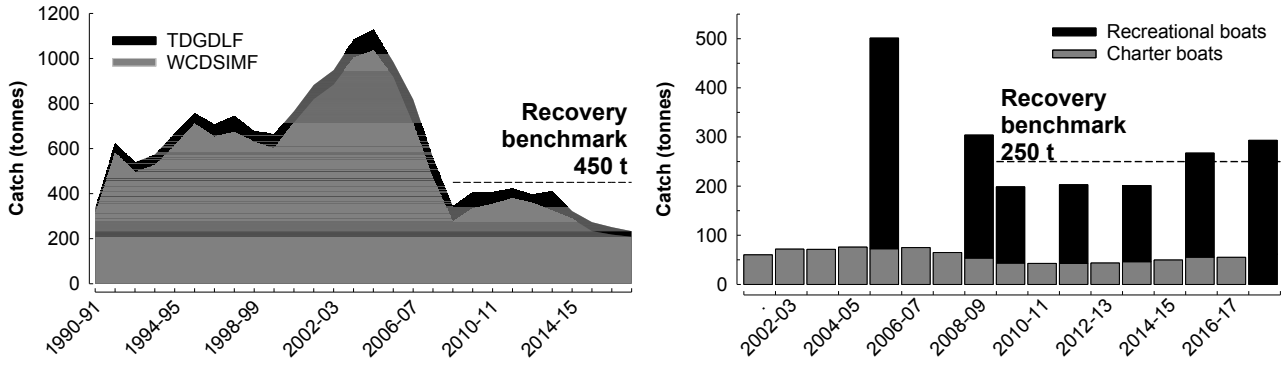
WEST COAST DEMERSAL SCALEFISH RESOURCE FIGURE 1.
Map showing boundaries of the West Coast Demersal Scalefish Interim Managed Fishery

CATCH AND LANDINGS

The total retained catch of demersal species by commercial fisheries in the WCB in 2017/18 was 244 t. The West Coast Demersal Scalefish Interim Managed Fishery (WCDSIMF) retained 213 t of demersal species (230 t of all fishes) in 2018, while 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 25 t, 2 t, 0 t and 3.5 t, respectively.

In 2017/18, catches of demersal species by all commercial fisheries in the WCB and by the WCDSIMF were below stock recovery benchmarks (50% of 2005/06 catches) of 450 t and 410 t, respectively (West Coast Demersal Scalefish Resource Figure 2), as they have been since 2008, when management commenced to recover stocks. Catches by the WCDSIMF of demersal species in 2018 in the Kalbarri Area (84 t) have declined since 2016 (92 t), while in the Mid-west Area, they have been steady (78 t in 2018) and in the South-west Area, they have increased from 45 t to 50 t.

The retained catch of the top 15 demersal species in 2017/18 by the recreational sector (private boat-based fishers and charter fishers) of 293 t (was above the stock recovery benchmark of 250 t (West Coast Demersal Scalefish Resource Figure 2). The estimated recreational harvest for the top 15 demersal species (or groupings) in the West Coast were steady at 231 t (95% CI 210–253) in 2017/18 compared with 213 t (95% CI 194–231) in 2015/16. The annual estimated private boat-based recreational fishing effort in the West Coast Bioregion was steady in 2017/18 (311,495, SE=12,127) compared with 2015/16 (271,311. SE=11,032) (Ryan *et al*. 2019). Charter fishers retained 62 t of the top 15 demersal species in 2017/18, which has gradually increased from 41 t in 2010/11, just after management changes were made.



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 Level 3 assessments of stock status of indicator species evaluate additional key performance indicators, including fishing mortality (*F*) and spawning potential ratio (SPR), using a weight-of-evidence approach that considers all available information (Wise *et al*., 2007; Fairclough *et al*., 2014) and determines 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. Forty three tonnes of WA dhufish were landed by all commercial fisheries in 2017/18 and, of that, 37 t were landed by the WCDSIMF in 2018. (West Coast Demersal Scalefish Resource Figure 3).

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. Twenty five tonnes and 10 t were landed in those areas in 2018, which had increased slightly from 2017.

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 most recent two estimates were above the recovery benchmark of 126 t (West Coast Demersal Scalefish Resource Figure 2). In 2017/18, the retained catch of WA dhufish comprised 12 t by charter fishers and 123 t (95% CL: 105-141 t) by boat-based recreational fishers.

The numbers of WA dhufish released by the recreational sector in 2017/18 represented 59% of the 63,068 (SE=5,842) caught (retained and released) by boat-based recreational fishers (Ryan *et al.* 2019) and 40% of the ~3,500 caught by charter fishers.

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 3). 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 catches below those benchmarks (65 t total in 2017/18 (West Coast Demersal Scalefish Resource Figure 3). In 2018, catches of snapper in the Kalbarri (30 t) and Mid-west (24 t) areas were below their respective benchmarks of 65 t and 43 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, 60 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).

The numbers of Snapper released by the recreational sector in 2017/18 represented 71% of 61,446 (SE=4,922) caught (retained and released) by boat-based recreational fishers (Ryan *et al.* 2019) and 45% of the ~12,600 caught by charter fishers.

A weight of evidence assessment of Snapper at the biological stock (bioregion) level, including age composition data collected from 2012/13-2014/15 (post management changes), 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 3). 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)

Retained catches of Baldchin groper in the WCB by all commercial fisheries (9 t, 2017/18) and the WCDSIMF (6 t, 2018) have been around or below respective stock recovery benchmarks of 22 t and 17 t since commencement of the current management regime (West Coast Demersal Scalefish Resource Figure 2). 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) (West Coast Demersal Scalefish Resource Figure 2).

The numbers of Baldchin groper released by the recreational sector in 2017/18 represented 33% of 22,971 (SE=2,184) caught (retained and released) by boat-based recreational fishers (Ryan *et al.* 2020) and 38% of the ~6,000 caught by charter fishers.

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 1.5*M* (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.

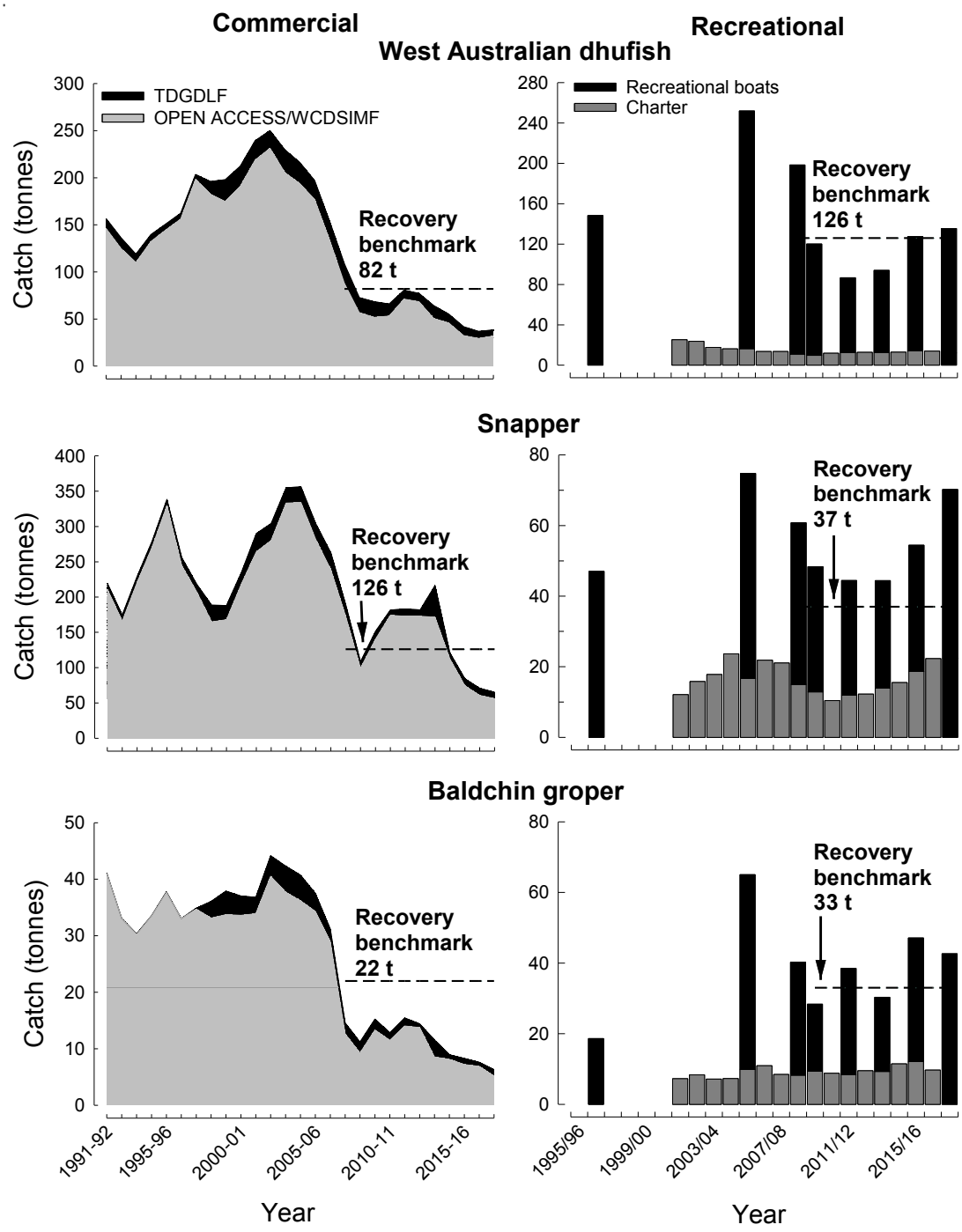
The above evidence indicates that estimated levels of fishing pressure should allow the stock to recover from overfishing, if retained catches are maintained below the stock recovery benchmark and levels of post-release mortality are not significant. The biological stock is classified as **recovering**.

Offshore Demersal

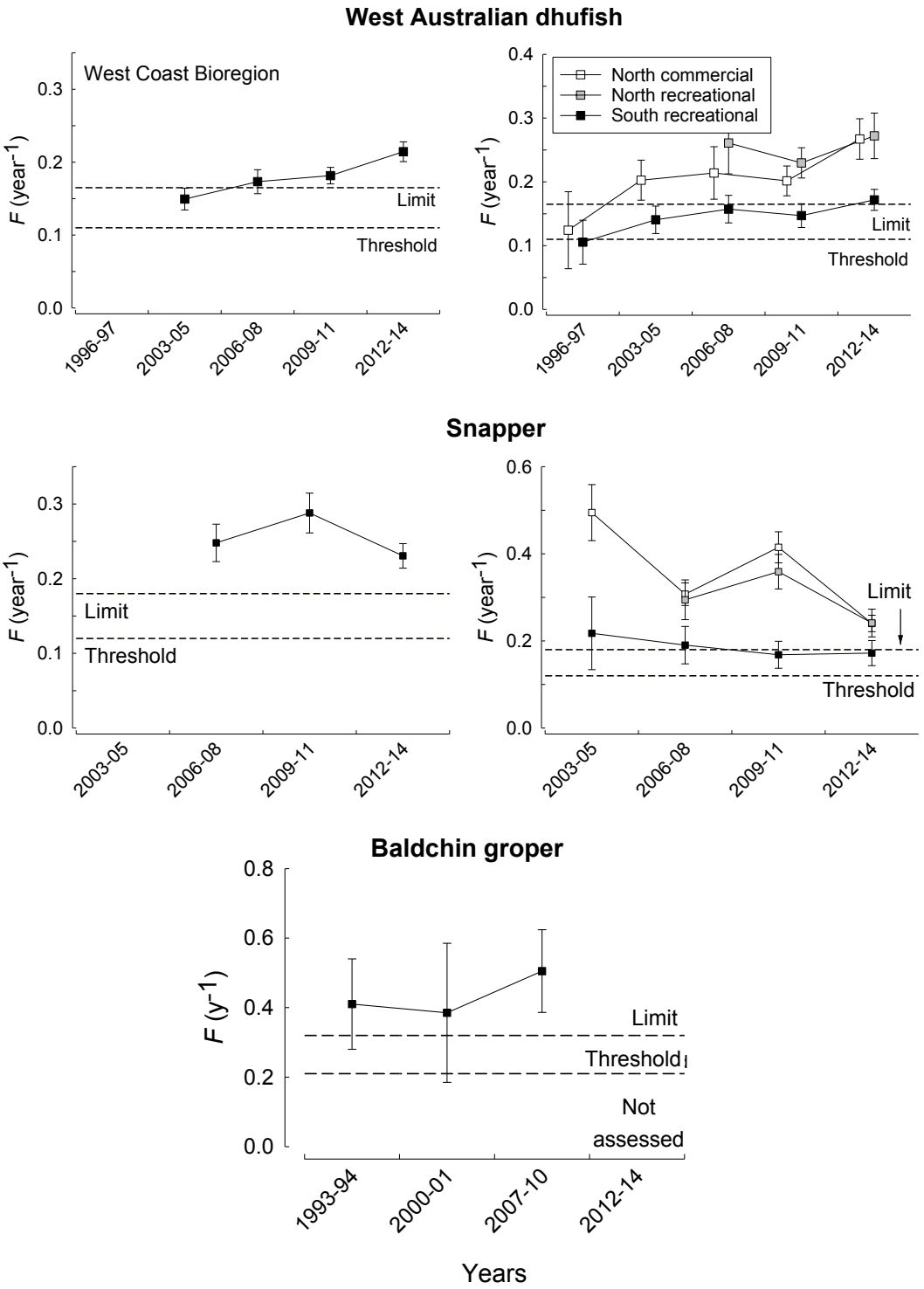
Estimated retained catches of the dominant offshore demersal species by the WCDSIMF have remained below the nominal sustainable catch range for this suite (20-40 t) since the fishery commenced in 2008. However, catches of offshore demersal species have increased gradually to 20 t in 2018 from 7 t in 2011, the majority being landed in the South-west Area.

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).

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 (dashed lines) 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 norther half of the West Coast 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 2018, there were no reports of interactions by WCDSIMF fishers. In 2017/18, charter fishers caught and released alive 5 gold-spotted rockcod that were above the maximum size limit and one tiger shark. 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-five WCDSIMF vessels (LFBs) operated in 2018 and employed between zero and three crew excluding the skipper. Fifty-seven licensed charter operators fished in the WCB in 2017/18. 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 2017 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 currently in place for this resource, a stock rebuilding program is underway whereby retained catches are to remain below benchmark levels (currently based on 50% of 2005/06 retained catches) 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 by the commercial sector were maintained below recovery catch benchmarks of 450 t. The retained catch levels of the commercial sector indicate that the fishery performance is considered **acceptable**.

Estimated retained catches of the demersal suite and indicator species (West Australian dhufish, Snapper, Baldchin groper) by boat-based recreational fishers in 2017/18 (from the most recent statewide survey) were above the respective stock recovery benchmarks, i.e. 231 t, 123 t, 48 t and 32 t 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 for the WCDSR will be developed in 2020. Current recreational catches and the impact of post-release mortality will be considered during the development of the Harvest Strategy and in response to the next stock assessment due in 2020.

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. 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.

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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.

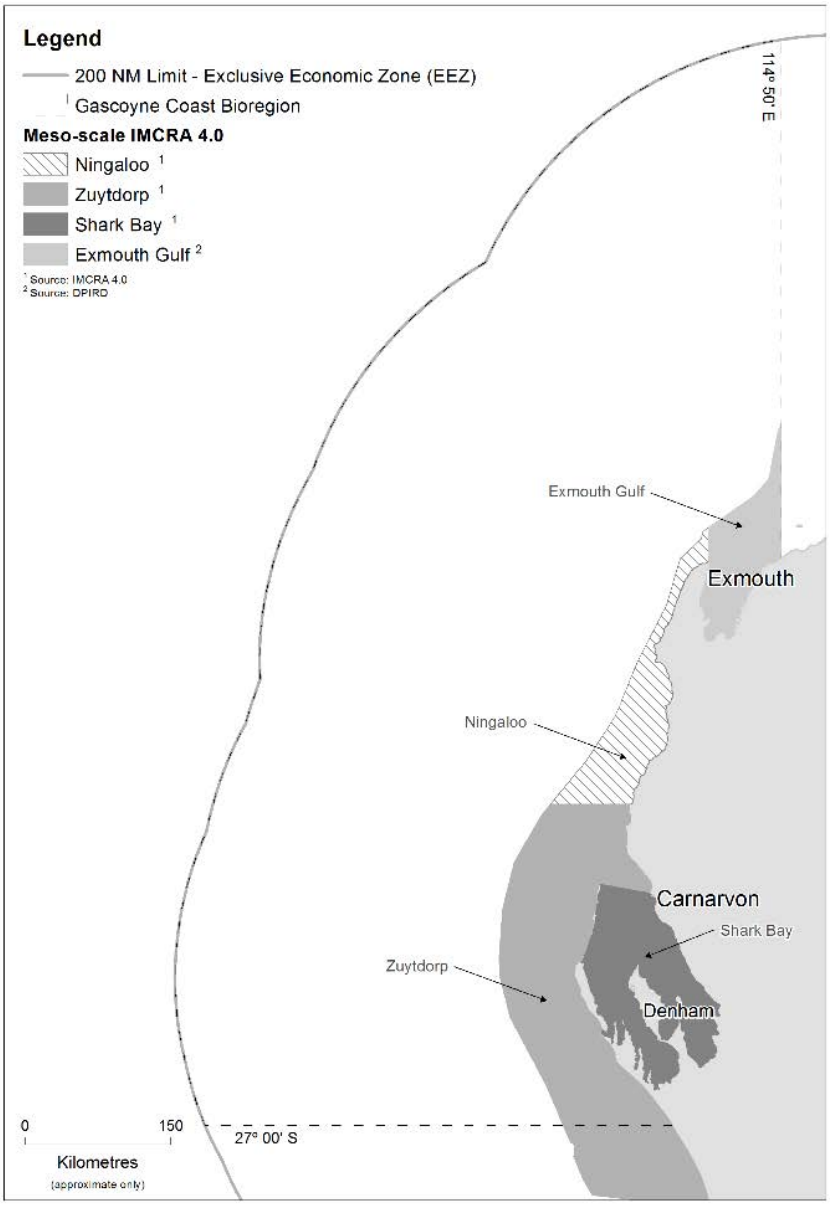
The waters off the Gascoyne Coast are also strongly influenced by the southward-flowing Leeuwin Current, generated by flow from the Pacific through the Indonesian archipelago. This tropical current becomes evident in the North West Cape area and flows along the edge of the narrow continental shelf where, 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, owing 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

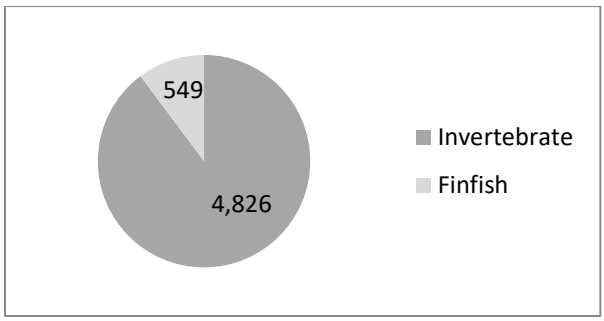
Climate Change

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;
- Increase 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, 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.



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).

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.

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 had 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.

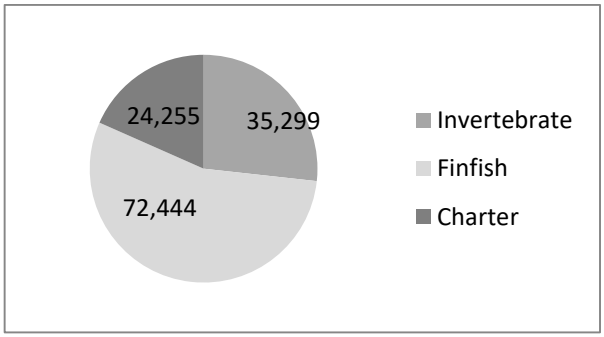
Recreational Fishing

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 and 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.



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 and live rock.

Tourism

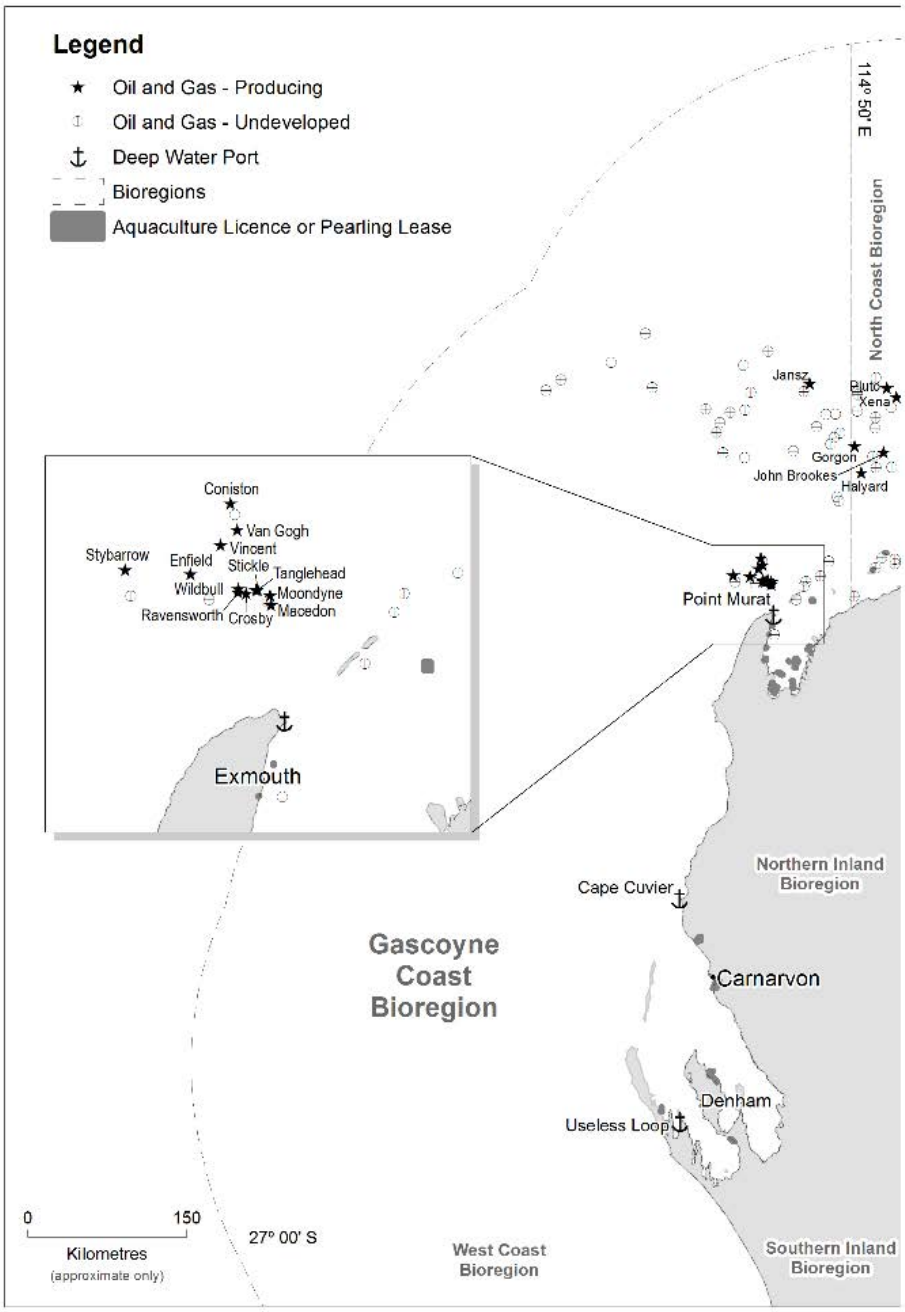
The Gascoyne Coast Bioregion is a focal point for winter recreation by the Western Australian community. Apart from its scenic beauty, the main attraction of the coastline for tourists is the quality of marine life. The region supports extensive scuba diving and snorkelling activities, particularly inside 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, 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.



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 include:

Spatial Closures

The Department of Fisheries 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 and Day *et al. 2012*[1]). 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.

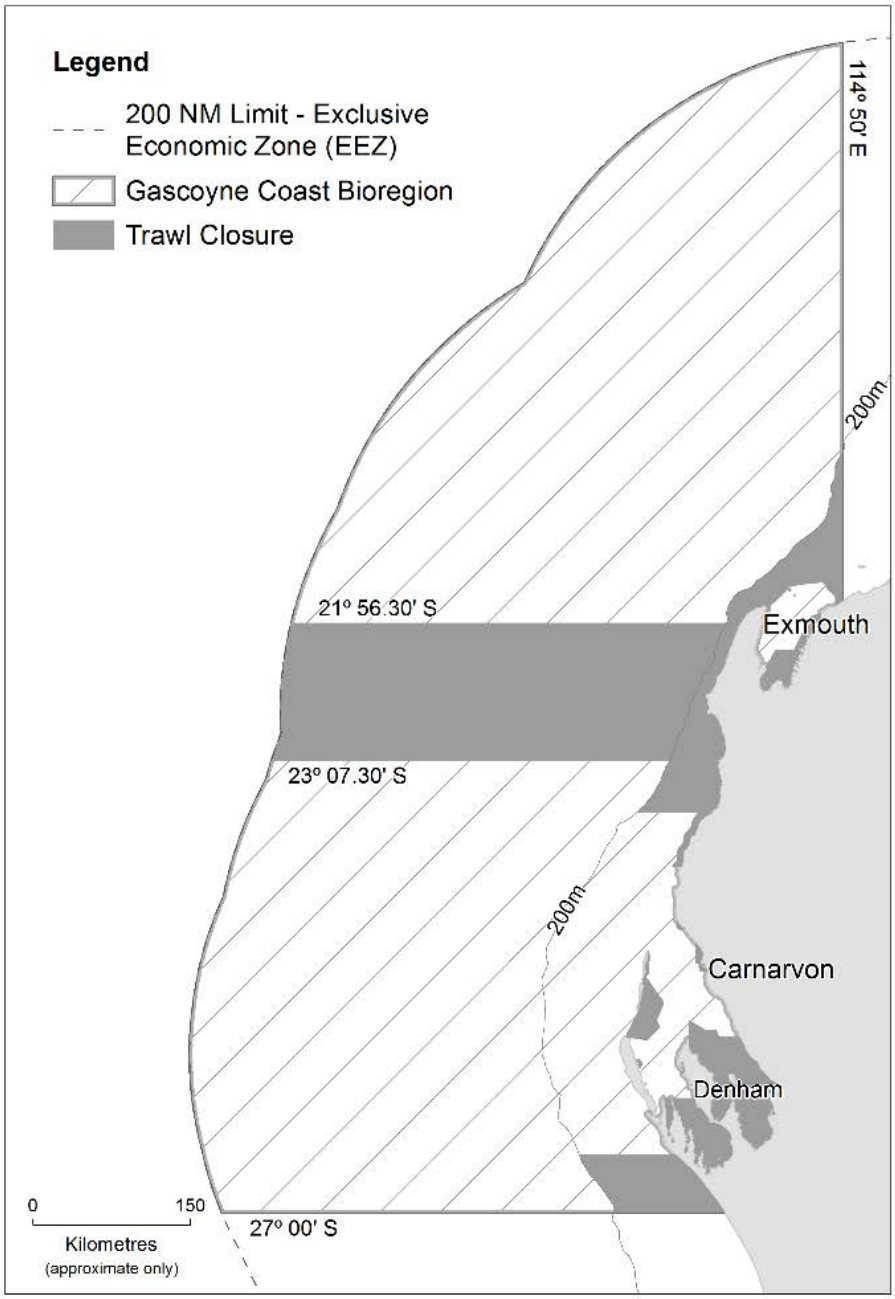
The Commonwealth Government has recently implemented its marine bioregional planning which includes a number of protected areas in Commonwealth waters between Shark Bay and the Northern Territory border (see Gascoyne Overview Figure 6).

GASCOYNE ECOSYSTEM MANAGEMENT TABLE 1

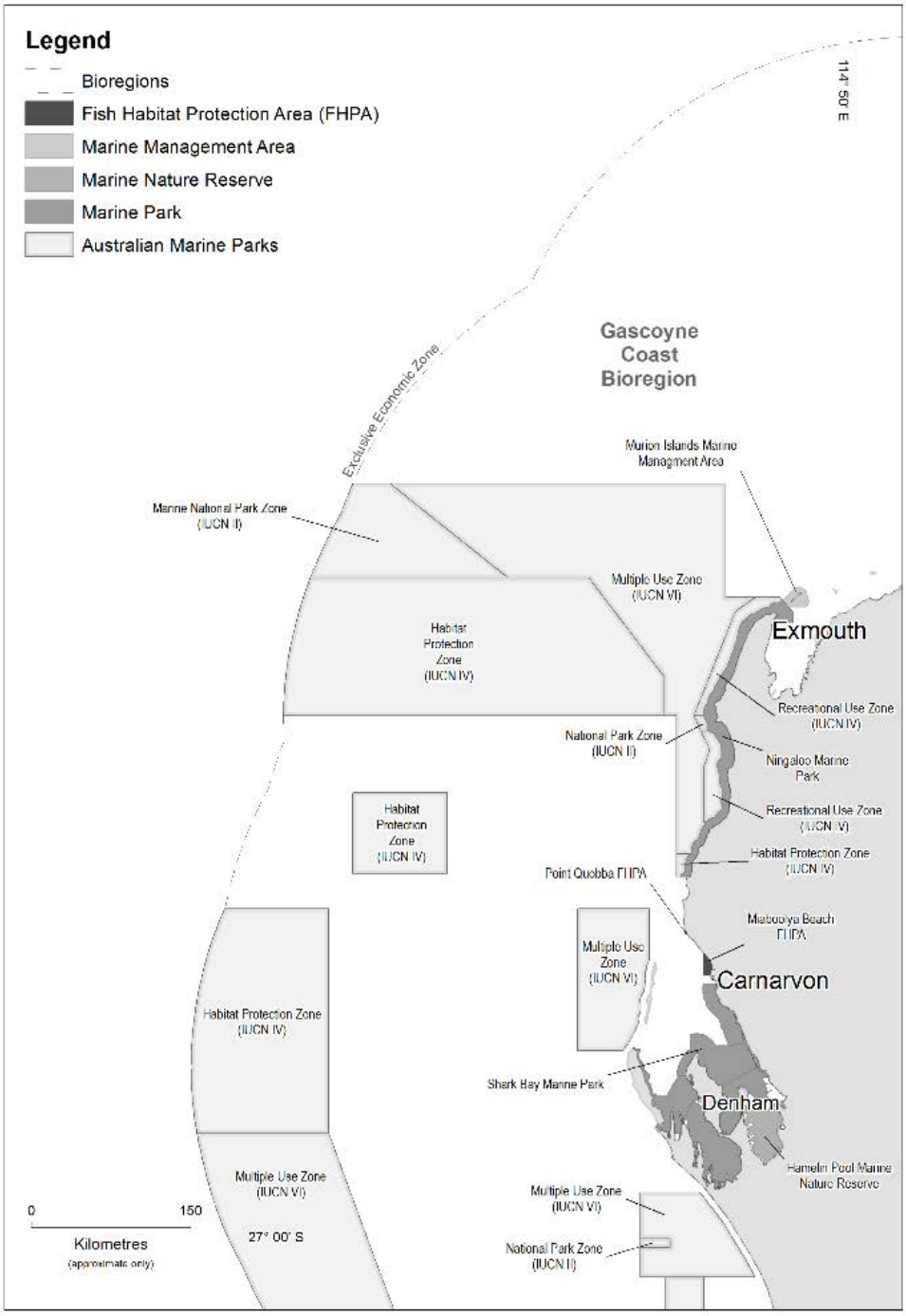
The areas and proportions of the Gascoyne Coast Bioregion making up State Waters and all continental shelf waters, out to 200 m depth, which are consistent with IUCN criteria for classification as marine protected areas.[1] This table does not yet include the closures that may be implemented by the Commonwealth 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.
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 (Fletcher, *et al*., 2010) (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

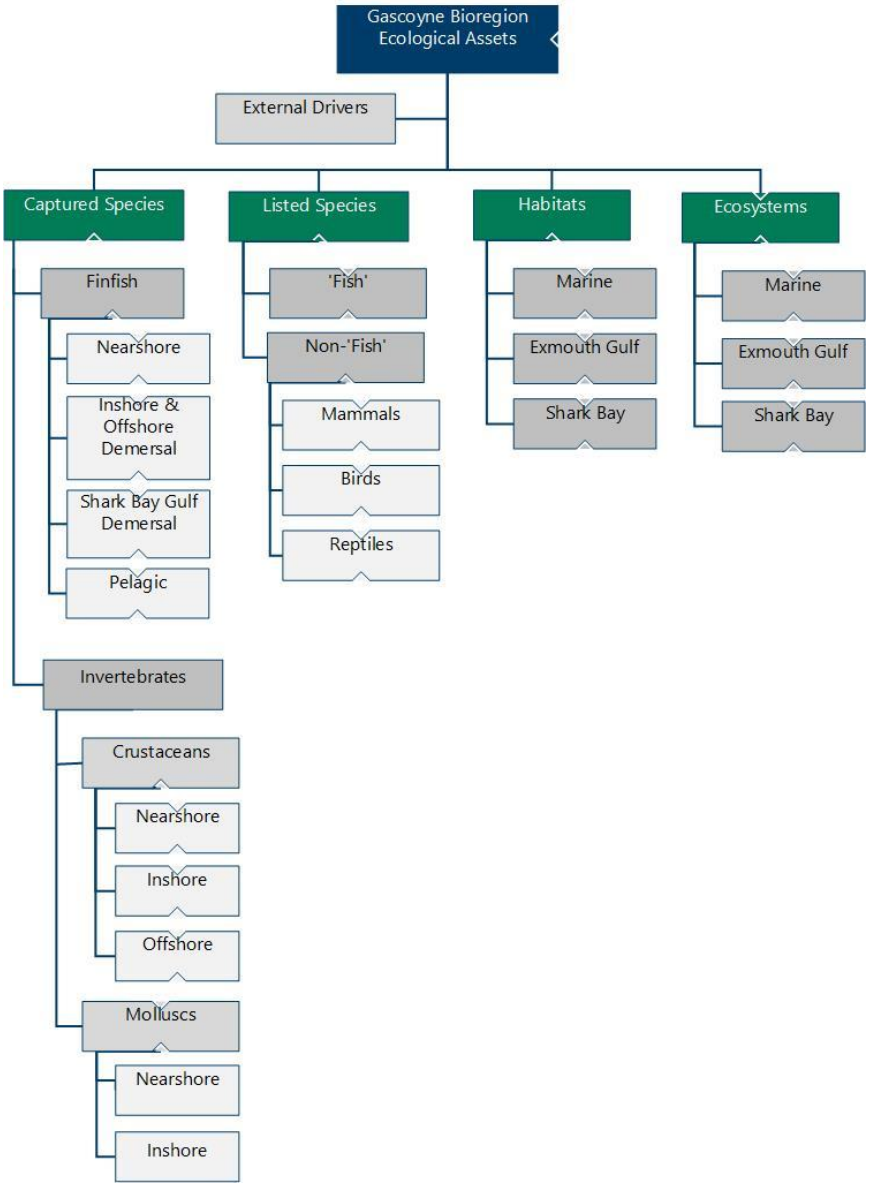
External factors include those impacting at the bioregional-level that are likely to affect the ecosystem as whole and may not fall within the

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	MODERATE 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 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.

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

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 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 have 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 has now been completed as part of a three-year FRDC-funded project (2010/535) that 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 supports a diverse fish fauna and is noted for its high quality of both 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)	MODERATE

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	HIGH

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	MODERATE

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 (Fletcher and Santoro 2012). 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 also supports the majority of the catch 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	MODERATE
Molluscs (Scallops)	Inshore	MODERATE

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	MODERATE
Crustaceans (Prawns)	Inshore	MODERATE
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. 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 gaining Marine Stewardship Certification in 2015. Additional certification for Blue Endeavour prawns for the Exmouth fishery is being sought in 2018.

Stocks in the West Coast Deep Sea Crustacean Managed Fishery, that operates primarily in the Gascoyne bioregion, are considered adequate with the fishery gaining Marine Stewardship 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 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	MODERATE

Statutory reporting indicates there are a low number of interactions with sawfish. However, increasing the understanding of the number and

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

nature of the interaction of trawl fisheries in the bioregion with sawfish was raised as an issue through the MSC process.

Non-Fish

Listed species	Risk
Birds and Reptiles	MODERATE
Mammals	LOW

While there are a number of listed species in the Gascoyne bioregion, only sea snakes and occasionally turtles are encountered in the trawl catches. The number of turtles captured now is very low and most of these are returned alive. Both groups are typically returned to the sea alive.

Captures of both turtles and sea snakes are recorded and their status at release are monitored and reported. However, 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 MSC process and continues to form part of the information requirements for certified fisheries

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 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 (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 and Zuytdorp and Exmouth Gulf ecosystem (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 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 longterm 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. Given the low levels of activities in these depths, there is little detailed information on these environments.

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 results from tourism and other boating related activities. There are no major pressures on seagrass communities, which are 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 virtually no impact on 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 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 through an FRDC project 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	MODERATE
Exmouth Gulf ecosystem	Marine	MODERATE

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 is also a key component of maintaining Marine Stewardship Council certification for the Exmouth Gulf Prawn Managed Fishery and is also being investigated in FRDC project 2015/027.

Ecosystems

Approximately 29% (335 nm^2) 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.

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.

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	MODERATE
Shark Bay Gulfs ecosystem	Marine	LOW

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 coral 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 fishery footprint is also a key component of maintaining Marine Stewardship Council certification for the Shark Bay Prawn Managed Fishery.

Ecosystems

The current level of fishing by all methods has not noticeably affected the trophic/community structure in Shark Bay. A 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)1. Therefore, the closed areas provide protection to those species more vulnerable to trawling (Kangas *et al.* 2007).

1Kangas MI, Morrison S, Unsworth P, Lai E, Wright I, and Thomson A. 2007. Developm ent 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 2019

M. Kangas, S. Wilkin, P. Cavalli and N. Moore

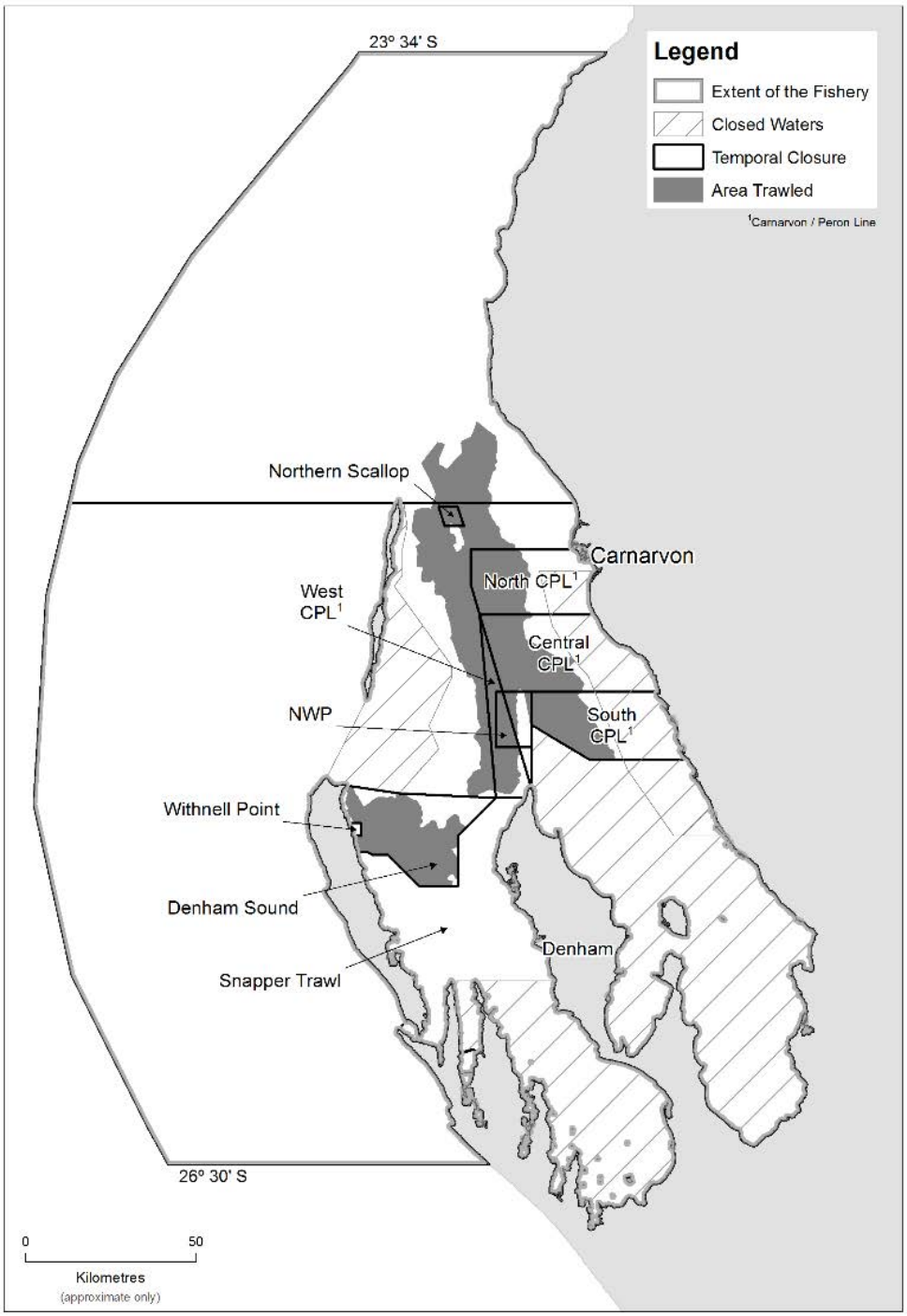
OVERVIEW

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. 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 the RAR by Kangas et al. (2015) (www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_2.pdf).

SUMMARY FEATURES 2019

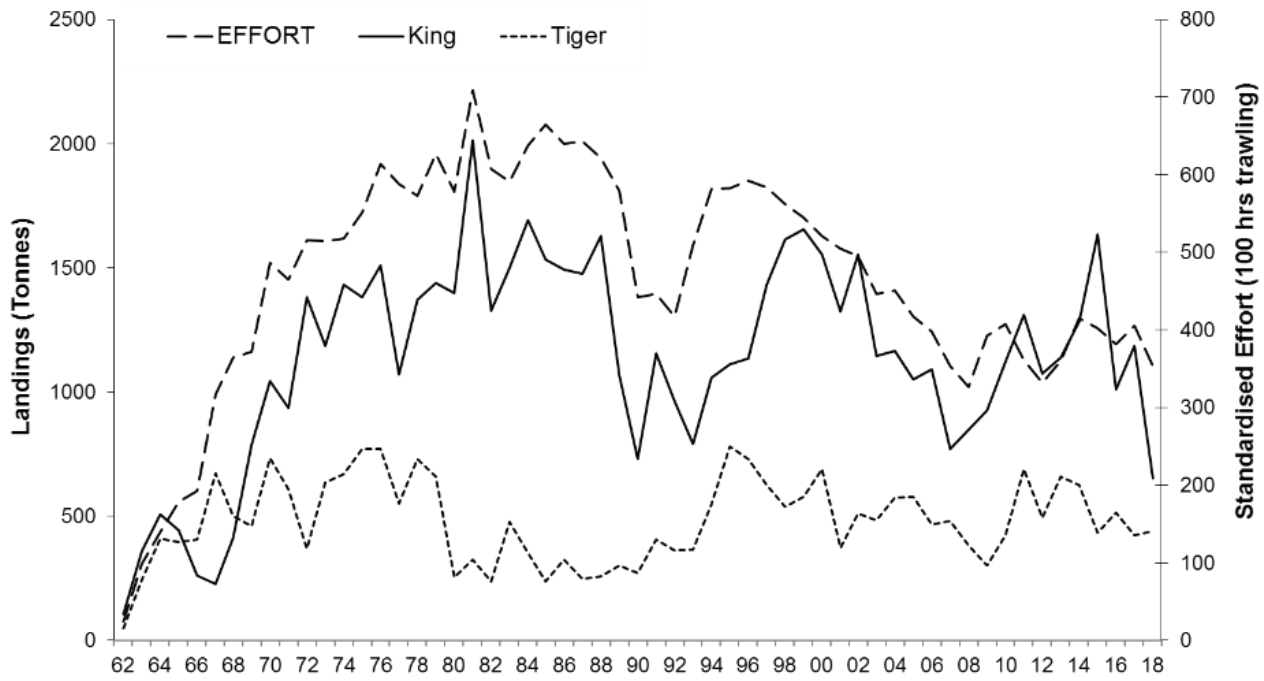
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (1350-2150 t)	Total Catch 2018: 1091 t	Acceptable
Recreational fishery	Total Catch 2018: NA	NA
EBFM		
Indicator species		
Western King Prawn	Moderate Risk: Breeding stock (HS): Above target	Adequate
Brown Tiger Prawn	Moderate Risk: Breeding stock (HS): Above target	Adequate
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Moderate Risk	Adequate
Ecosystem	Low Risk	Adequate
Economic (GVP $21.6 m)	Moderate Risk	Acceptable
Social (4 amenity)	Low Risk	Adequate
Governance	Moderate Risk	Acceptable
External Drivers	High Risk	Adequate



SHARK BAY PRAWN FIGURE 1.
Map showing boundaries of Shark Bay Prawn Managed Fishery.

CATCH AND LANDINGS

The total landings of target prawns in Shark Bay in 2018 were 1,091 t, with 652 t of western king prawn, 438 t of brown tiger prawn and 1 t of endeavour prawn (Shark Bay Prawn Figure 2). The recorded landings of byproduct were 90 t of coral prawns, 29 t of mixed finfish, 37 t mantis shrimp, 28 t of cuttlefish, 9 t of squid, 3 t of bugs (*Thenus orientalis*) and 1 t of octopus. Scallop and blue swimmer crab landings are reported in 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 1962-2018.

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 more than 50 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 previously applied (Shark Bay Prawn Figure 1). Analysis of a stock-recruitment relationship for western king prawns showed that the spring spawning stock has never been reduced to levels where it had a significant effect on recruitment.

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), and was 69 kg/hr in 2018, which was at the lower end of historically observed recruitment levels. This indicates that 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 2018 indicated a catch prediction (Caputi *et al.* 2014) for western king prawns between 725 and 1,090 t with the catch of 652 t below the prediction.

In 2018 the mean spawning stock survey catch rate was 25.7 kg/hr, which is just above 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 2018 were the lowest recorded since the 1970s and well below the target catch tolerance range. However the overall mean catch rate of 18.4 kg/hr was within the lower end of the catch rate range.

The recruitment surveys have highlighted a declining trend in the size of western king prawns. 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 NCPL in June after it was closed was 21.9 kg/hr. There was a slight increase in August to 35.0 kg/hr and then catch rates declined to 22.4 kg/hr by September. The brown tiger prawn spawning stock level in NCPL was therefore above the target reference level of 25 kg/hr between June and August. 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 70.9, 8.3 and 10.5 kg/hr respectively in the SCPL. As such the SCPL fully opened in July 2018 due to the higher level of brown tiger stocks in the NCPL compared to 2017 and a combined catch rate of the two areas in June being 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 2019.

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 305 to 460 t. The total catch (438 t) was within the catch tolerance range and the catch prediction.

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) with fishing effort in 2018 being 35 thousand trawl hours. 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 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 second annual audit for this fishery. This comparison indicated that the majority of the most common 20 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 reduction devices have been fully implemented since 2003 and reduce the quantity of small fish and invertebrates retained in trawls. **Low** risk.

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 four 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 generally reduced the occasional capture of turtles in trawl nets (Shark Bay Prawn Table 1). **Low** risk

SHARK BAY PRAWN TABLE 1.
Protected species interactions recorded in the daily logbooks during 2018

Species	Alive	Dead	Unknown
Turtles	87	0	0
Syngnathids	166	8	0
Sea Snakes	2999	381	0
Saw Fish	0	0	1
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 is likely to be moderate. Performance measures for habitat impact relate to the spatial extent of trawling within the SBPMF. In 2018 the total area trawled, at approximately 743 square nautical miles, was 16% of inner Shark Bay, and 6% of the total fishery. **Moderate** 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. **Low** risk.

SOCIAL AND ECONOMIC OUTCOMES

Social

This industry is a major contributor to regional employment. During 2018, 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 $21.6 million. This value excludes scallops and blue swimmer crabs which are separate Managed Fisheries (see 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 2018 were generally lower than 2017. **Moderate** risk.

GOVERNANCE SYSTEM

Harvest Strategy

The fishery is managed in accordance with the SBP Harvest Strategy. 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 survey index catch rate targets were all met.

The annual fishing levels 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 Fisheries Division of 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. Fisheries 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

On 31 July 2018 an amendment to the SBP Management Plan came into effect which provides for arrangements previously outlined under separate long term exemptions and licence conditions. The amendment also provides for increased economic and operational flexibility for licensees by improving transferability of units and provides options for gear configurations. The amendment provides clearer statutory compliance capability allowing for more effective use of compliance resources and complements the improved co-management arrangements introduced in 2016/17 to manage industry (voluntary-agreed) closures within the SBPMF.

Management initiatives for 2018/19 also include undertaking work to address conditions of MSC certification and trialling an approach linking the number of proposed fishing days to the prawn catch rate in the recruitment surveys.

An external review of the research and management of the Shark Bay prawn fishery was undertaken in April 2019. The Department is developing a workplan to address advice provided in the review.

EXTERNAL DRIVERS

Economic

Most of the economic drivers for this fishery were positive for 2018. The cost to fish has stabilised and the lower Australian dollar has improved value to the fishery. Prawn demand in the domestic market was reasonable although prices were lower than in 2017 and the traditional export markets remained stable. 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.

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SAUCER SCALLOP RESOURCE STATUS REPORT 2019

M. Kangas, S. Wilkin, N. Breheny, P. Cavalli, R. Oliver and S. Brand-Gardner

OVERVIEW

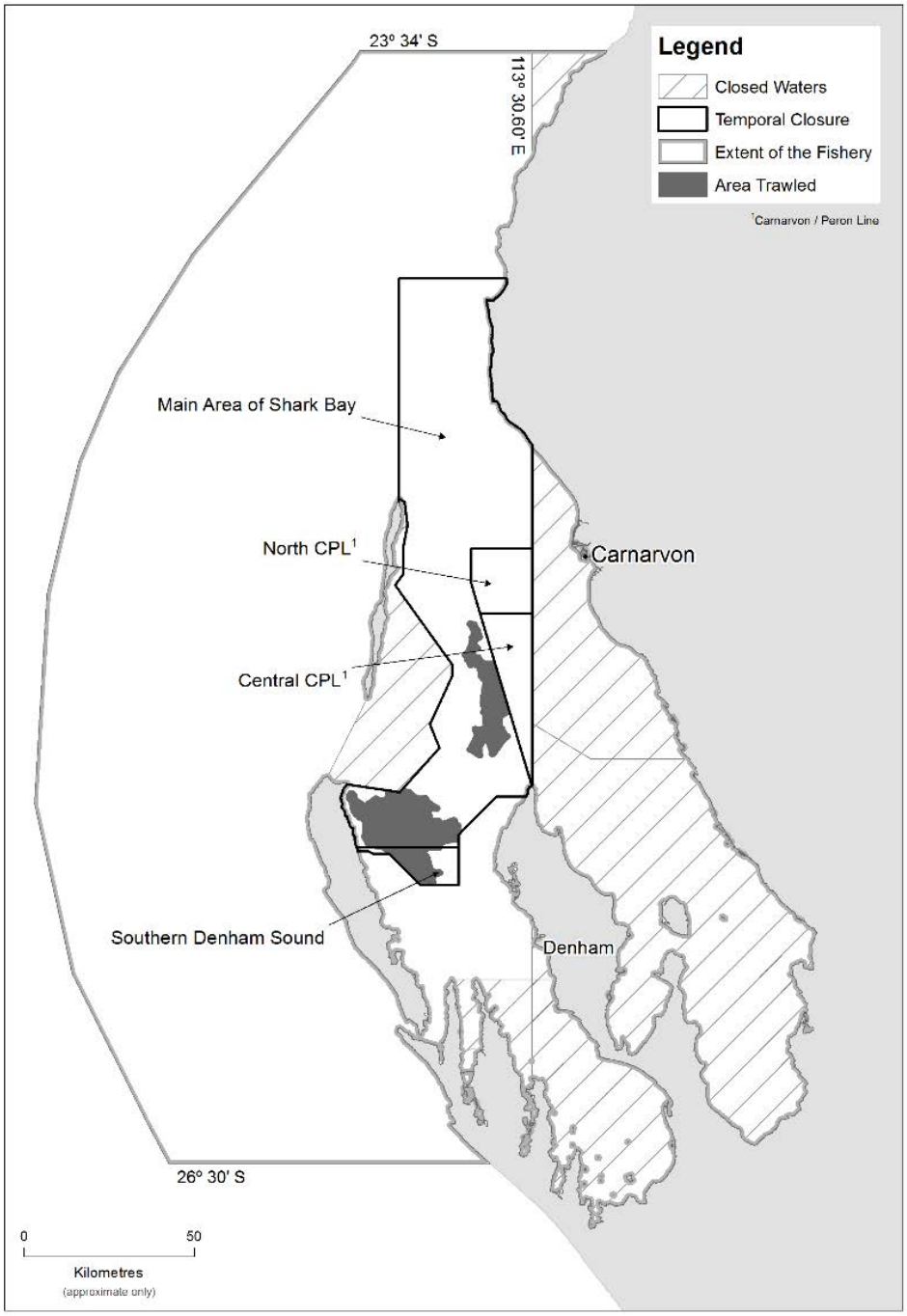
Saucer scallops, *Ylistrum balloti* (formerly *Amusium balloti*), are fished using otter trawls in four separate fisheries in Western Australia. The Shark Bay Scallop Managed Fishery (SBSMF) is usually Western Australia's most valuable scallop fishery with boats licensed to take only scallops (11 Class 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), while the South Coast Trawl is a small fishery (four vessels) that targets scallops on the south coast. 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.

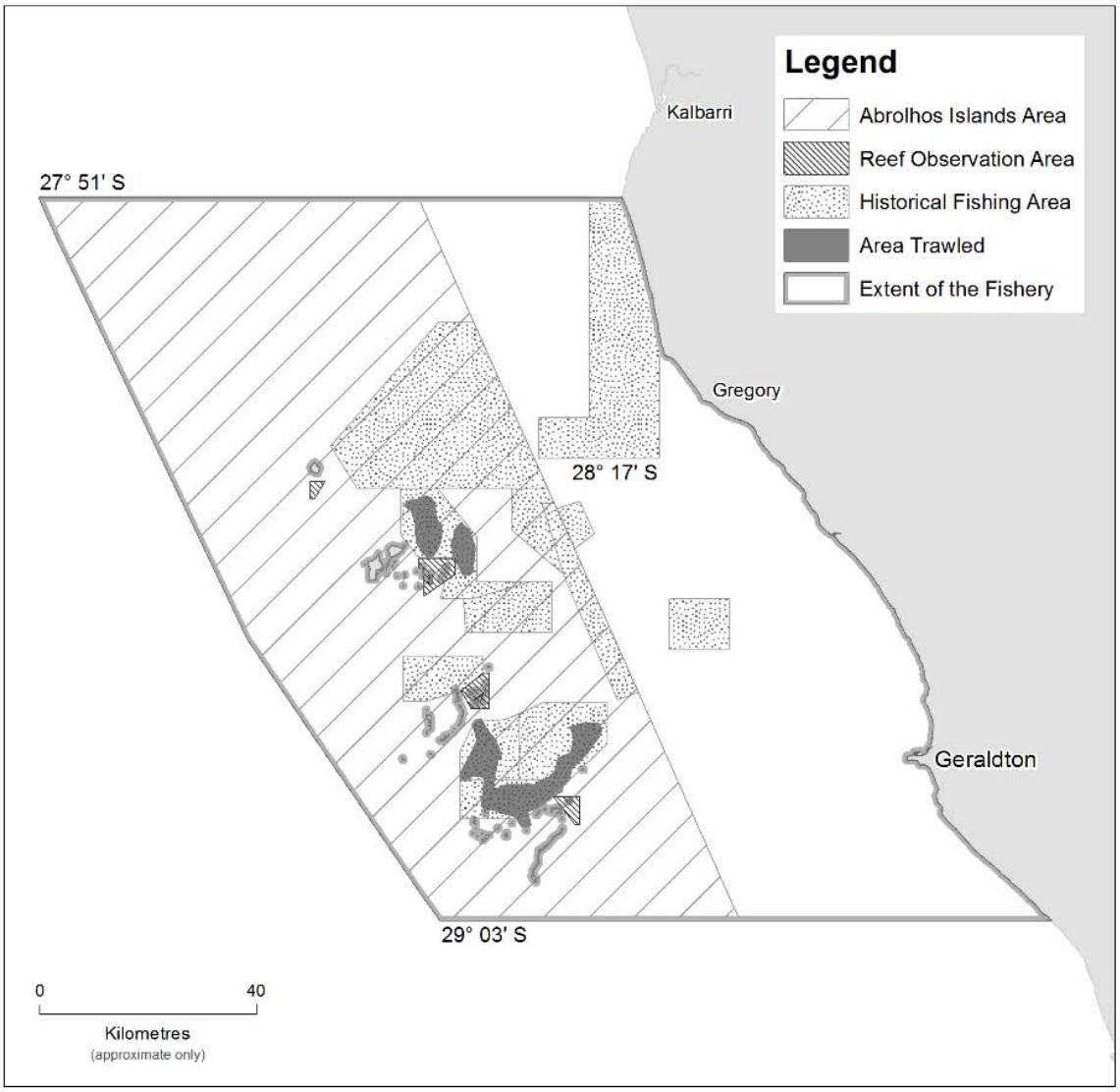
Further details are provided in the RAR at https://www.fish.wa.gov.au/Documents/resource_assessment/resource_assessment_report_003.pdf

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (2018)	Total Catch 2018: 224 t meat weight (1,118 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 $6.5 m)	High risk	Acceptable
Social (3 amenity)	Moderate risk	Acceptable
Governance	Moderate risk	Acceptable
External Drivers	High risk	Acceptable



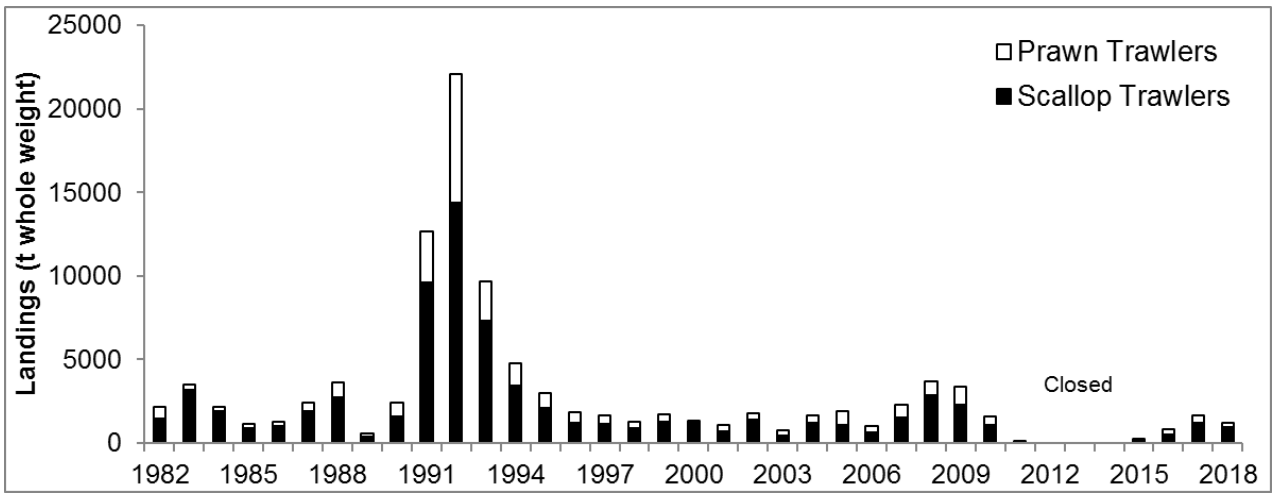
SAUCER SCALLOP FIGURE 1.
Map showing boundaries of Shark Bay Saucer Scallop Managed Fishery.



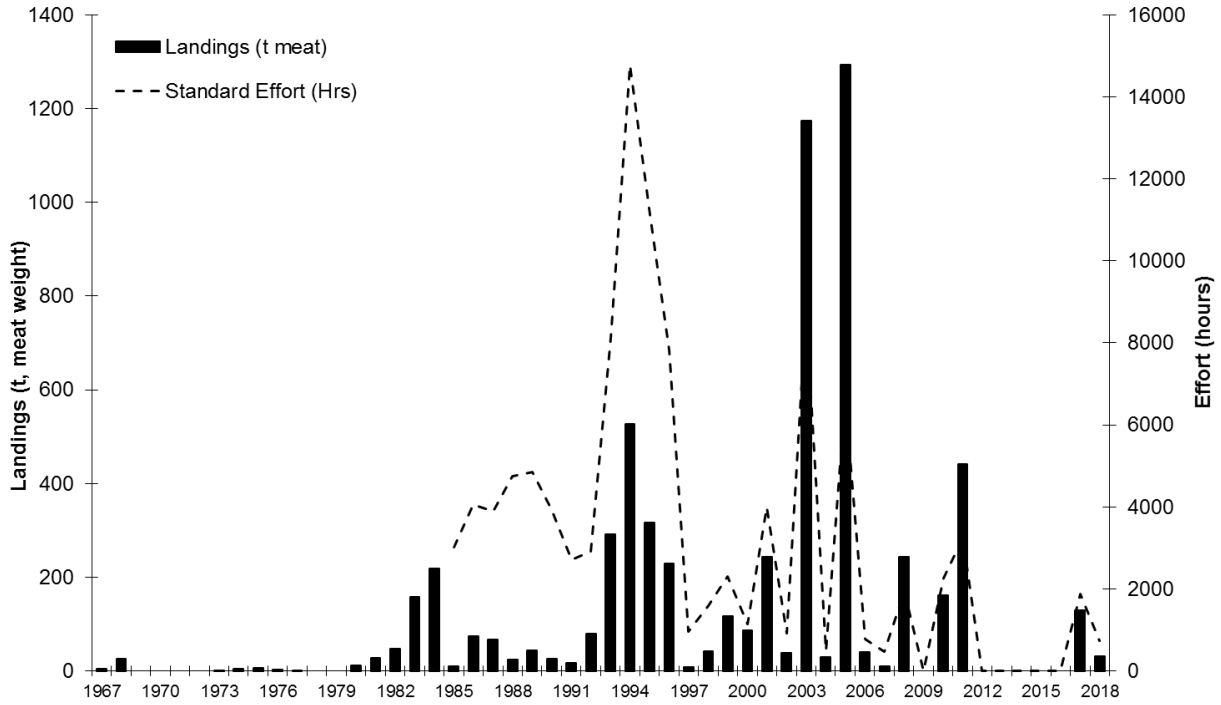
SAUCER SCALLOP FIGURE 2.
Map showing boundaries of Abrolhos Islands and Mid-West Trawl Managed Fishery

CATCH AND LANDINGS

The total scallop landing was 272 t meat weight (1362 t whole weight) in WA in 2018. There was 239 t meat weight (1,197 t whole weight) taken from Shark Bay out of a quota of 271 t meat weight (season 1 March 2018 to 28 February 2019). The Class A boats landed 191 t (80 %) and the Class B boats landed 49 t (Saucer Scallop Figure 3). Minimal by-product was retained by Class A boats in Shark Bay or by vessels in the Abrolhos Islands. The scallop landings in the AIMWTMF were 31.0 t meat weight (154.8 t whole weight) (Saucer Scallop Figure 4), only one boat fished in each of the SWTMF and the South Coast Fisheries.



SAUCER SCALLOP FIGURE 3.
Annual scallop catch (t whole weight) for the Shark Bay scallop fishery, 1982 to 2018. The fishery was closed between 2012 and 2014 and has operated under a trial quota since 2015.



SAUCER SCALLOP FIGURE 4.
Annual scallop catch (t whole weight) and standardised trawl hours fished for the AIMWTMF 1967 to 2018.The fishery was closed in 2009 and 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 pre-season 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. These surveys enable the management arrangements of the fishery to maintain adequate level of breeding stocks and to set a conservative Total Allowable Commercial Catch limit (TACC) for the fishery.

The SBSMF was in a recovery phase between 2012 and 2016 with the fishery being closed between 2012 and 2014. The low stock biomass seems to have been the result of a series of poor recruitment events associated with protracted unfavourable environmental conditions dating back to the extreme 2011 marine heatwave [Caputi et al. 2016, Caputi et al. 2015]. The annual survey in November 2017 indicated that

the stock abundance in both parts of the fishery (i.e. northern Shark Bay and Denham Sound) were within historical ranges and the fishery was considered to have fully recovered. The recovery of the Denham Sound stock was confirmed with the catch achieved during 2018 and the survey abundance in November 2018 and February 2019. However, catches from northern Shark Bay during 2018 were well below expectations and the surveys in November 2018 and February 2019 indicated very low stock abundance in this part of the fishery. Therefore, this part of the fishery is assessed to be inadequate in 2019 and subject to stock recovery strategies.

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

The AIMWTMF is managed using an escapement harvesting strategy. 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) [Gaughan and Santoro 2018].

Annual pre-season surveys showed very low recruitment (1-year old) between 2011 and 2015 as a result of the 2011 extreme marine heatwave and subsequent poor spawning stock. The late 2017/early 2018 pre-season surveys showed a lower level of recruitment compared to the previous year, however the predicted catch, at 55-80 t meat weight was above the target range and the fishery was opened in April 2018. Overall catches were below the predicted range and fishing ceased at a catch rate above the threshold.

South West Trawl Managed Fishery (Sustainable-adequate)

Effort in the South West Trawl Managed Fishery has been related to either the abundance of western king prawn or saucer scallop, which can be highly variable due to sporadic scallop recruitment. Only 1-4 vessels have operated in the fishery since 2005, and have only covered approximately 1-3 per cent of the allowable fishery area. Only one boat fished in the SWTMF in 2018 for a total of 5 boat days for minimal catch. The 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 per cent of the allowable fishery area. Only one boat fished in the SCTF in 2018 for a total of 11 boat days and minimal catch.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Bycatch

Bycatch and protected species interactions for Class B Shark Bay Scallop vessels is discussed in Shark Bay Prawn resource section of this document. Owing to the legislated 100 mm mesh size of the nets, the relatively short duration of the fishing season for Class A vessels and the reduced number of boats operating since the quota trial was implemented, the total bycatch landed is minimal. Grids have been fully implemented in this fishery since 2003. Protected species are occasionally captured but generally released alive due to the relatively short duration of trawls. There were four turtles and two sea snakes reported and returned alive by Class A vessels within the SBSMF in 2018. **Low** risk.

Protected species

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 towards 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 now that grids are compulsory in the fishery their capture has been minimised. No protected species were reported in the AIMWTMF/SWTMF/SCTF fisheries in 2018. **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 13.5% of the allowable trawl area was fished in 2018. Only 1.9% of the allowable area was trawled in the AIMWTMF and <1% in both SWTMF and SCTF fisheries.

Ecosystem

The ecosystem impacts of scallop fisheries are considered to be **low risk**, with the total biomass taken by these operations being small. 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 2018 with support staff in Geraldton and Fremantle. In Shark Bay, an additional 90 crew are employed in the prawn fishery (Class B) that can also retain scallops. The overall GVP for the fisheries that operated in 2018 (including scallop landings for Class B boats in Shark Bay) was $6.5 million.

GOVERNANCE SYSTEM

Harvest Strategy

The harvest strategy for Shark Bay and the Abrolhos Islands fisheries is based on the abundance of scallop during the annual recruitment/spawning stock surveys and for the Abrolhos Islands, cessation of fishing at a catch rate level.

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 2018 for the two separate stocks, were derived from the correlation of the annual landed catch (meat weight) and the mean catch rate (number per nautical mile trawled) of recruit (0+) and residual (1+) scallops for standard survey sites. These predictions are used in determining the conservative TACC for each part of the fishery in a Departmental/industry consultative framework. 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. In 2018, a total TACC of 361 t meat weight (1805 t whole weight) was implemented, however after pre-spawning fishing and completion of both March and June surveys the scallop quota was reduced to accommodate the lower than expected abundance of scallops in northern Shark Bay. The quota was reduced by 25% on 31 August to 270.8 t, of which 239.3 t was achieved.

A formal harvest strategy for the SBSMF is currently under development.

In the Abrolhos Islands, the 2017 survey showed an overall lower level of recruitment than observed in 2016, however the predicted catch for 2018 (at 55-80 t meat weight) was above the target range and the fishery opened in April 2018. The landings however, were lower than the expected range and fishers ceased fishing at a catch rate above the target.

Annual Catch Tolerance Levels

Shark Bay: A catch limit of 1354 t (whole weight) (equivalent to 270.8 tonnes meat weight) was set for 2018 and 1197 t was achieved.

Abrolhos Islands: Catch prediction was above the target range (95-1830 t whole weight) and 155 t whole weight was achieved.

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 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

Following a review of the trial quota management arrangements during 2017, the Department determined that formalising the quota system for the SBSMF would provide for catch share security, operational flexibility, opportunity for licence holders to optimise catch and rationalise effort as well as sustainable management of the

scallop resource in Shark Bay. The Department continued to manage the SBSMF under a quota management system in 2019 and progress the development of a harvest strategy based on a quota management framework, in consultation with industry. This is nearing completion.

A formal harvest strategy for the Abrolhos Islands resource is under development and nearing completion.

EXTERNAL DRIVERS

Strong La Niña events that are typically result in strong Leeuwin Currents and warm sea-surface temperature often result in below-average scallop recruitment in Shark Bay and the Abrolhos Is. Between 2012 and 2014, the SBSMF was closed due to the 2011 marine heatwave event (associated with a strong La Niña) which resulted in reduction of breeding stock and subsequent very poor recruitment for a number of years (Caputi *et al*. 2015, 2016). The AIMWTMF remained closed for 2012 to 2016. Further research continues into understanding recruitment variation (including the collapse) of scallop stocks. **Significant** risk.

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SHARK BAY BLUE SWIMMER CRAB RESOURCE STATUS REPORT 2019

A. Chandrapavan, S. Wilkin, N. Breheny, N. Moore 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 small (<2 t) but regionally important recreational fishery. 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). Further details on biology and assessments can be found in the Resource Assessment Report for this stock (www.fish.wa.gov.au/Documents/research_reports/frr306.pdf).

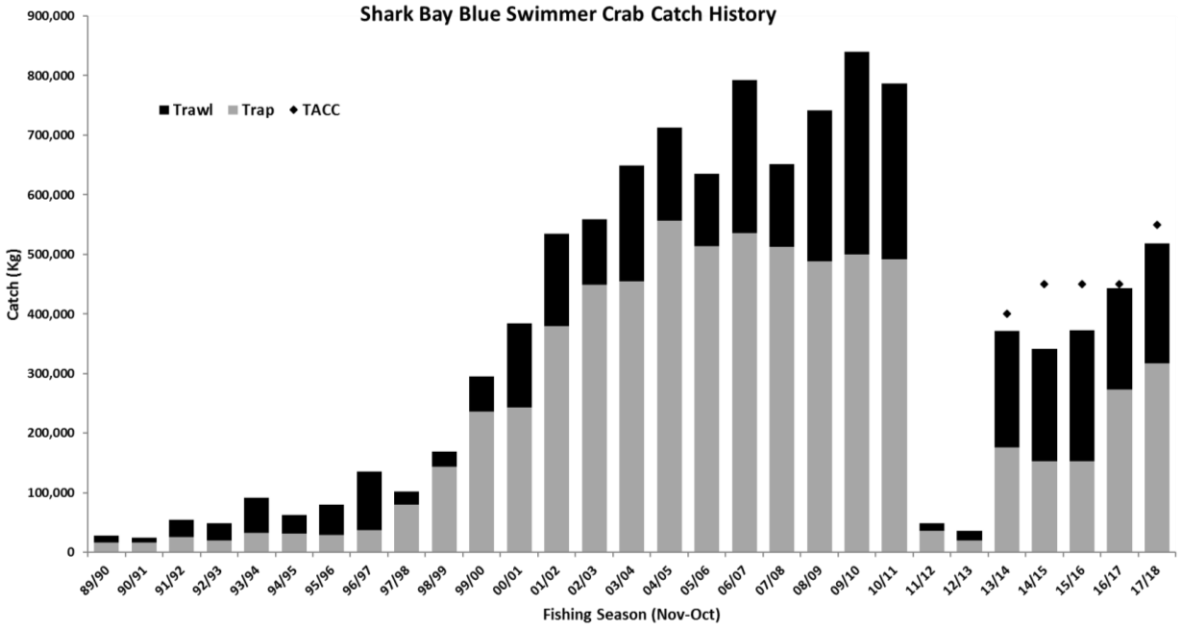
SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (550 t TACC)	Total Catch 2017/18: 518 t	Acceptable
Recreational fishery	Total Catch 2016/17: 1–2 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 $3.2 million)	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 550 tonnes was set for the 2017/18 fishing season (1 November 2017 to 31 October 2018). The total catch landed for the 2017/18 season was 518 t (~94% 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 317.5 t and represented 61% of the total landings for this season. The prawn trawl sector's total catch was 200.8 t which represented 39% of the total landings. The scallop trawl sector only retained 50 kg.

The estimated boat-based recreational catch of blue swimmer crab in the Gascoyne Coast represented 9% of the statewide boat-based recreational catch (kept by numbers) 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 increased to 450 tonnes for the 2014/15, 2015/16, 2016/17 fishing seasons and 550 tonnes for the 2017/18 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.

Shark Bay crab stocks are assessed as part of a multi-species fishery-independent surveys 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 increasing biomass with a MSY point estimate of 671 t. The average commercial trap catch rate was 1.5 kg/traplift during 2017/18, above the Target reference level of 1.4 kg/traplift. A TACC of 550 t was set for the 2018/19 season.

A preliminary harvest strategy has been developed for this fishery which now incorporates a mid-season review. This review during the 2018/19 season found no major changes in the stock indicators so the TACC was maintained at 550 t.

BYCATCH AND PROTECTED SPECIES INTERACTIONS

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.

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).

HABITAT AND ECOSYSTEM INTERACTIONS

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.

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.

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 30-35 workers for the post-harvest processing of the crab catch. The closure of the Shark Bay crab fishery during 2012/13 had a significant socio-economic impact on both the trap and trawl sectors however the resumption of fishing has relieved some economic pressure.

For the trawl sector, approximately 100 skippers and crew were employed in the fishery for the 2017/18 season. 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 and engineering staff based at the small boat harbour and a processing factory at Babbage Island. 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 $6.16/kg. The estimated value of the commercial blue swimmer crab resource from Shark Bay for 2017/18 season was $3.2 million.

GOVERNANCE SYSTEM

Harvest Strategy

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 dynamic model.

A formal harvest strategy document is currently under development.

Annual Catch Tolerance Levels

A TACC of 550 t was set for the 2017/18 fishing season of which 518 t was achieved (~94% 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 **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

The Department undertakes consultation directly with commercial licensees on operational issues, while Annual Management Meetings between the Department and licensees, convened by the Industry Consultation Unit of the Western Australian Fishing Industry Council (WAFIC), 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 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 a Shark Bay crab resource harvest strategy.

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 Department is developing a formal harvest strategy for this resource in consultation with the relevant stakeholders through the Shark Bay Crab Working Group. 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.

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 abides 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.

EXTERNAL DRIVERS

Shark Bay is currently exhibiting 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 2017/18 season.

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 2018 has been the coldest on record, ~ 1.8 °C cooler than average.

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 (NESP 2018). While recent cooler summer water temperatures pose 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 stock.

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EXMOUTH GULF PRAWN RESOURCE STATUS REPORT 2019

M. Kangas, S. Wilkin, I. Koefoed and S. Blazeski

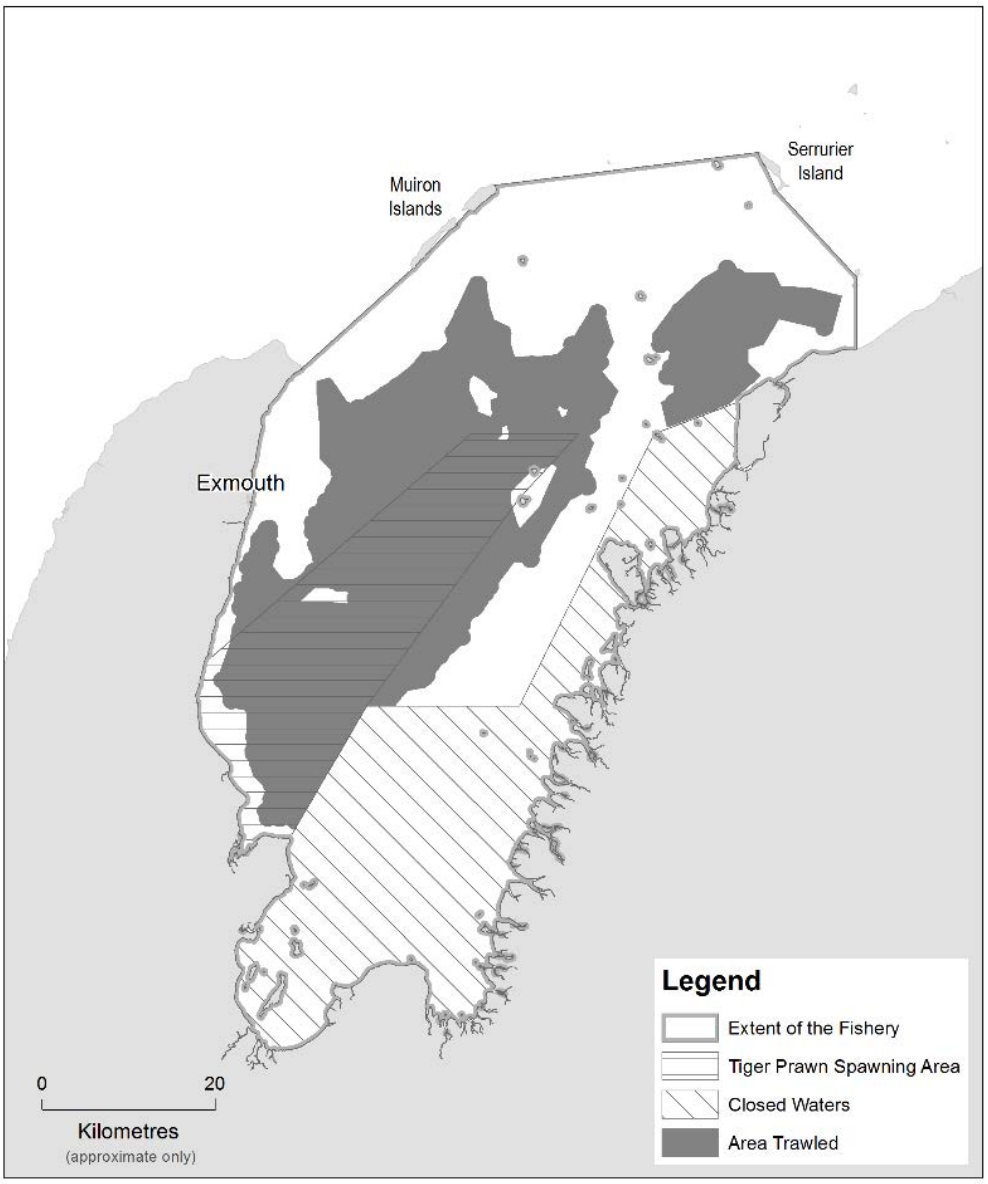
OVERVIEW

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 2014 – 2019* (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. The Commonwealth Government Department of the Environment and Energy (DEE) 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 2019

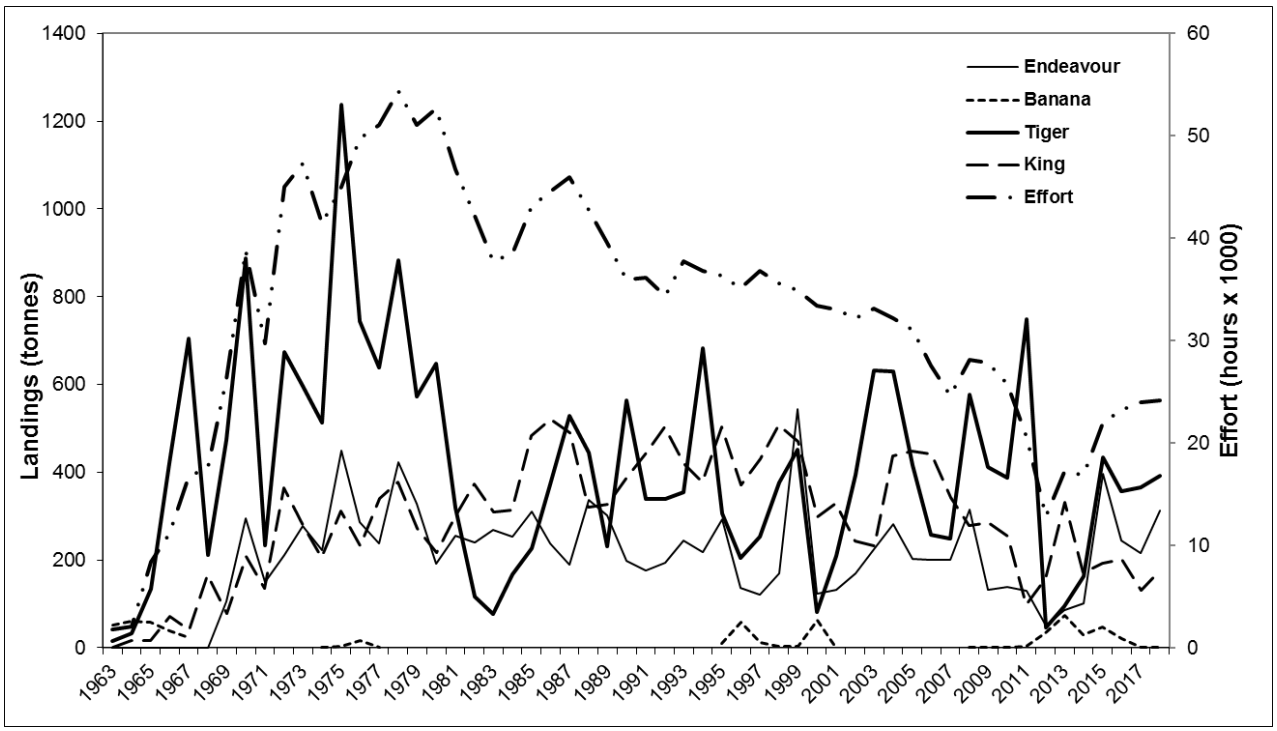
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (2018)	Total Catch : 880 t	Acceptable
Recreational fishery (NA)		
EBFM		
Indicator species		
Brown Tiger Prawn	Within target catch range Breeding stock above target	Acceptable Adequate
Western King Prawn	Below target catch range Breeding stock above target	Acceptable Adequate
Blue Endeavour Prawn	Within target catch range Breeding stock above target	Acceptable Adequate
Ecological		
Bycatch	Low Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Low Risk	Adequate
Ecosystem	Low Risk	Adequate
Economic (GVP $12.2 m)	Moderate Risk	Acceptable
Social (3 amenity)	Moderate Risk	Acceptable
Governance	Moderate Risk	Acceptable
External Drivers	High Risk	Adequate



EXMOUTH GULF PRAWN FIGURE 1.
Map showing boundaries of the Exmouth Gulf Prawn Managed Fishery.

CATCH AND LANDINGS

The total landings of prawns in 2018 were 880 t, comprising 392 t of brown tiger prawns, 174 t of western king prawns and 313 t of blue endeavour prawns (Exmouth Gulf Prawn Figure 2). Recorded landings of by-product were; 0.9 t of blue swimmer crab (*Portunus armatus*), 2.2 t of squid, 2.8 t of bugs (*Thenus orientalis*), 20.4 t of coral prawns, 7.5 t of cuttlefish, 1.2 t mantis shrimp and 0.3 t of 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 1963-2018.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

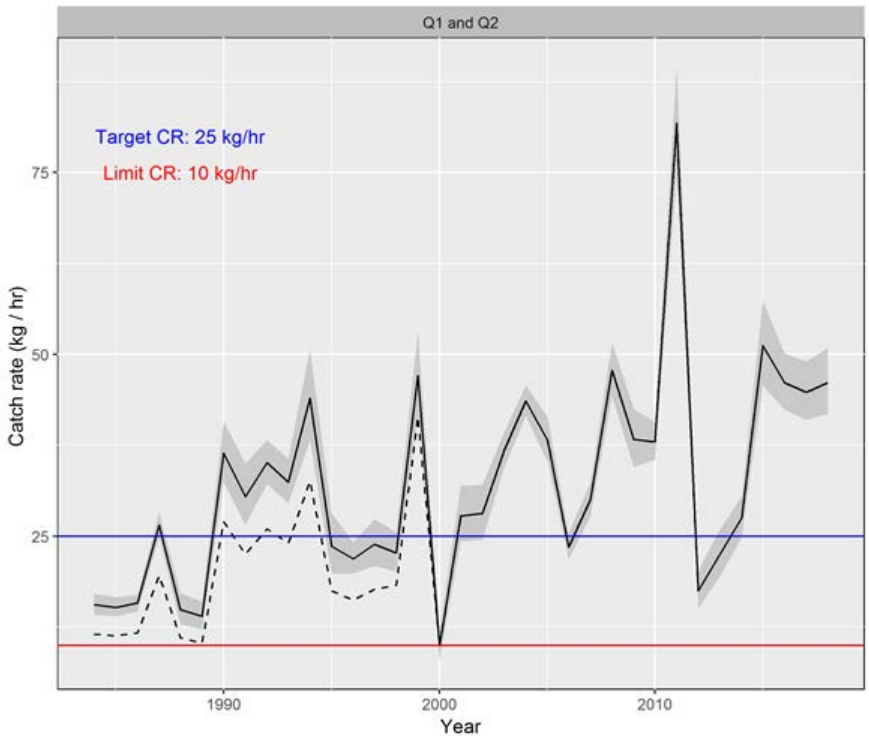
Brown tiger prawns (Sustainable-Adequate)

The status of the stocks 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 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 (DOF 2014). The standardised spawning stock surveys carried out from August to October 2018 had an average catch rate of 46.3 kg/hr, well above the target level (Exmouth Gulf Prawn Figure 3), indicating that the stock is highly 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 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 (DOF 2014) with a catch prediction of 370 t and a range of 295 to 440 t for 2018 (this revised prediction was derived using lower historical landings in recent years). The total catch (392 t) was within the catch tolerance and prediction range.

The standardised fishing effort in 2018 was 24.1 thousand trawl hours. This is a reduction from historical levels (35 to 50 thousand hours standardised to twin gear). 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 and are used for catch predictions (Caputi *et al*. 2014a) and management decisions, such as spatio-temporal opening of fishing areas. In 2018, the recruitment index was 35.1 kg/hr, which was above the target (30 kg/hr), however fishing was restricted in key western king prawn grounds until August, similar to what occurred in 2017. The spawning stock index for 2018 (commercial catch rates in key western king prawn fishing grounds in August and September) was 30.8 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 2018 these surveys indicated a mean catch rate of 49.8 kg per hour in August and 27.8 kg per hour in September with an average over that period of 38.8 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 1989 to 1998 have been used as the basis for calculating the catch tolerance range of 350 to 500 t and mean catch rate of 12 kg/hr (with a range between 8 and 14 kg/hr). However, due to the apparent negative impacts of increased water temperatures on western king prawn recruitment, and with the level of effort having declined as a result of fleet reductions and targeting larger prawns, a catch range based on the last 15 years of production sets a revised catch range of 100-450 t and a mean catch rate range (8-16 kg per hour). The commercial catch for 2018 of 174 t is at the lower end of the target range with a mean catch rate (7.2 kg per hour) below 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 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 survey catch rate. In 2018, the mean survey catch rate for the blue endeavour prawn spawning stock was 30.6 kg per hour, 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 preliminary 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 2018 of 21.6 kg per hour was above the 10-year mean (2007–16) of 16.7 kg per hour. The preliminary catch prediction was 270 – 410 t and landings (313 t) were within 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 2018 was just above the target catch range and above the average catch over the past 15 years (191 t) [Gaughan and Santoro 2018]. 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. In addition to grids, 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. **Low** risk.

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 low. The increase in reported species numbers, in particular sea snakes and sawfish, in recent years is due to an increase in awareness, education and commitment from both crew and skippers to improve reporting. **Low** risk.

EXMOUTH GULF PRAWN TABLE 1.
Protected species interactions recorded in the daily logbooks during 2018

Species	Alive	Dead	Unknown
Turtle	20	0	NA
Sea Snake	1167	81	NA
Syngnathids	3	1	NA
Saw Fish	4	5	1

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 2018, the performance measure was met as the total area trawled, at approximately 380 square nautical miles (33.4%) of trawlable grounds in Exmouth Gulf, was below the 50% target level. **Low** risk.

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. **Low** risk.

SOCIAL AND ECONOMIC OUTCOMES

The estimated employment in the fishery in 2018 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 $12.2 million for 2018.

GOVERNANCE SYSTEM

Harvest Strategy

The fishery is managed in accordance with the EGP Harvest Strategy. The primary management objective 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 2019.

Annual Catch Tolerance Levels

Total landings and landings of brown tiger and blue endeavour prawns were within the catch tolerance ranges. 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	Revised 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.

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.

Management Initiatives (Stable)

Management initiatives for 2019 include undertaking work to address MSC certification and towards recertification in 2020. The EGP Harvest Strategy was amended in 2018 to include blue endeavour prawns as a target species.

EXTERNAL DRIVERS

External drivers for this fishery include economic and environmental factors.

Most of the economic drivers were positive for 2018. The costs to fish have stabilised and the lower dollar value has increased export potential. The Chinese market demand for prawn product has increased, whether it is wild caught or aquaculture grown. Therefore, the price difference between farmed (tiger prawn) and wild caught prawns almost reached parity. Traditional export markets remained stable. Prawn demand in the domestic market was reasonable although prices were reduced. The focus of the fishing strategy remains on targeting larger prawns during high catch rate periods to maximise fishing efficiency.

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). The heat wave event of 2010/11 may have contributed to the recent extremes in abundance of brown tiger prawns in Exmouth Gulf. The causes of low recruitment periods are being investigated in regard to nursery habitats and environmental factors (including temperature).

Higher than average water temperatures in the last five years 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.

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WEST COAST[1] DEEP SEA CRUSTACEAN RESOURCE STATUS REPORT 2019

J. How and L. Orme

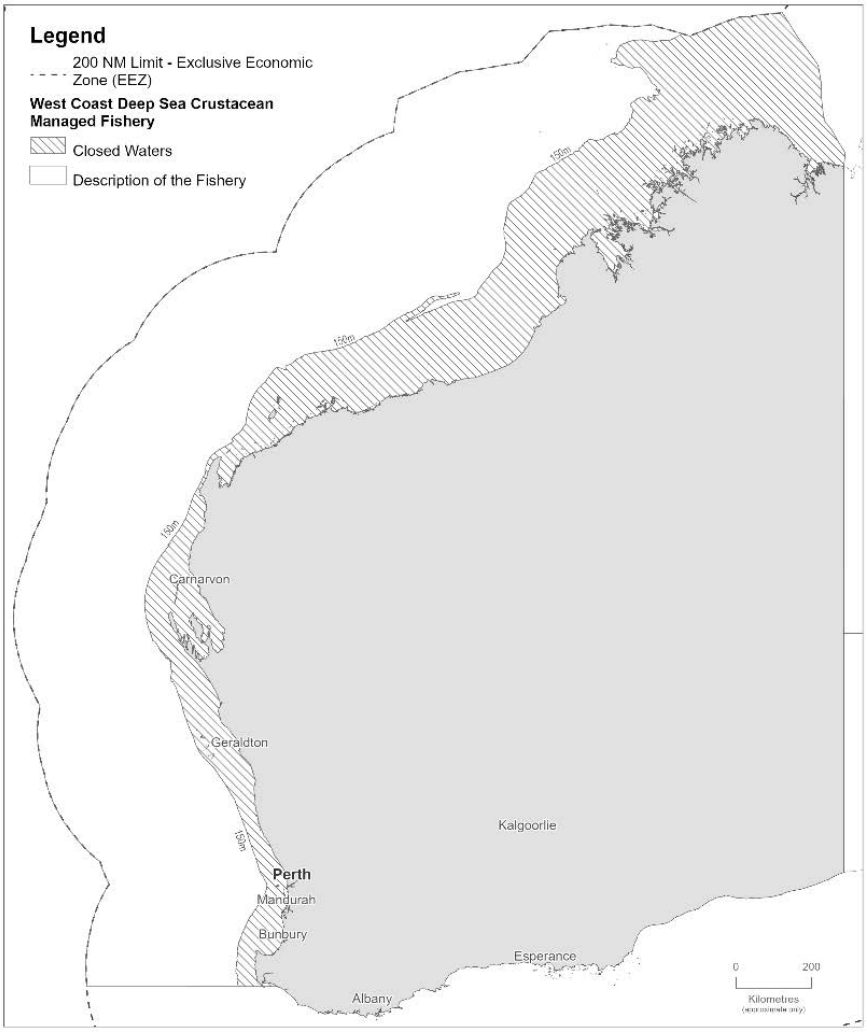
OVERVIEW

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 the 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).

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery: (154 t TACC)	Total Catch 2018: 153.9 t	Acceptable
Recreational fishery (NA)		N/A
EBFM		
Indicator species		
Crystal crab (*Chaceon albus*)	Above threshold	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Low Risk	Adequate
Habitat	Low Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (GVP $6.3 m)	Medium Risk	Acceptable
Social (low amenity)	Low Risk	Adequate
Governance	Minor adjustments	Adequate
External Drivers	Low Risk	Adequate

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.

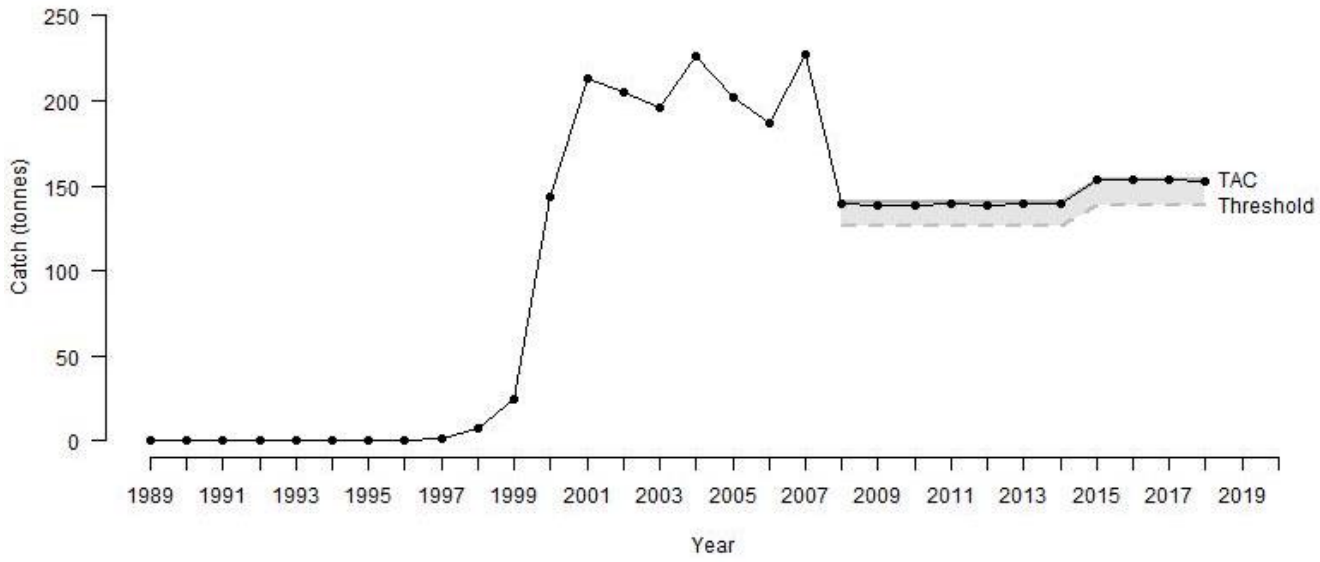
CATCH AND LANDINGS

The total landings from this west coast offshore resource in 2018 as targeted by the WCDSCMF was 153 t. Catches are dominated by crystal crabs, of which 99% of their TAC was landed (Deep Sea Crustacean Figure 2). In addition, almost 0.6 tonnes of giant crabs were landed however, no champagne crabs were landed in 2018. 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.

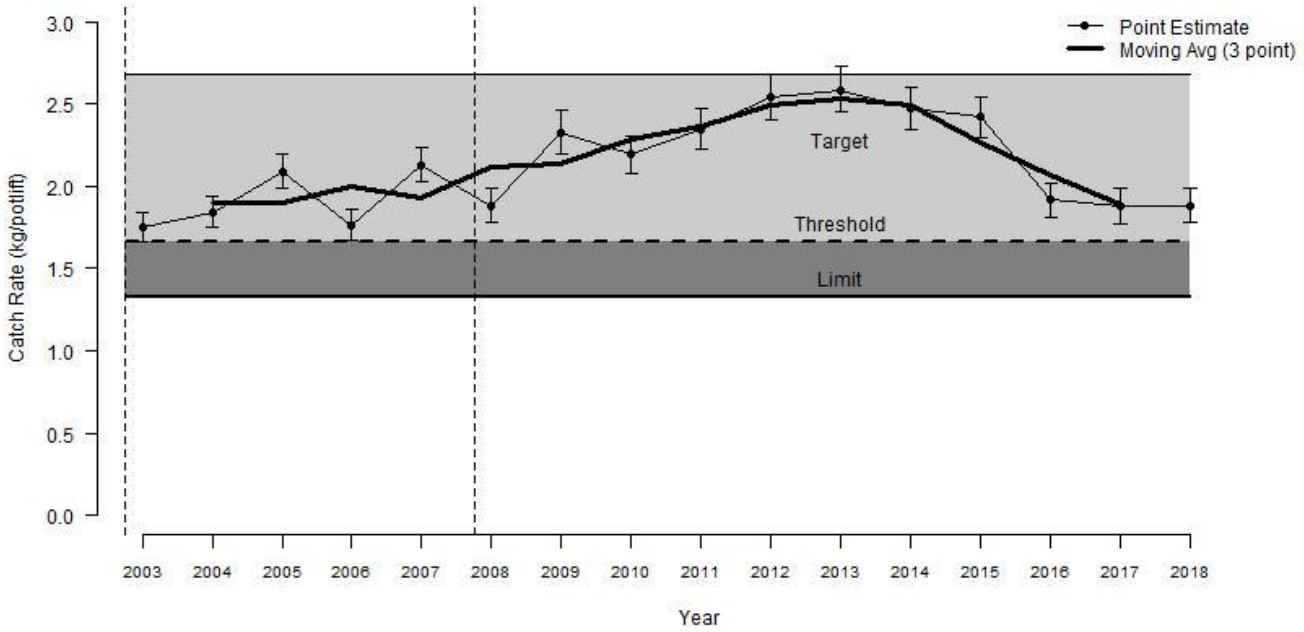
INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Crystal crab

All lines of evidence indicate that it is likely the stock biomass is above its threshold level and therefore **adequate**. The standardised catch rate of legal crystal crabs in 2018 was 1.9 kg/pot-lift (Deep Sea Crustacean Figure 3) similar to the 2017 catch rates and within the target range.



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, shaded) 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 have been no reported interactions of WCDSC gear with protected species in 2018. **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 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 four vessels operating in 2018. **Low** risk.

Economic

The GVP (gross value of production) for the fishery was about $6.3 million in 2018 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 2015-2020 (see Fisheries Management Paper No. 272) is the basis for the setting of the Total Allowable Catch (TAC) for the WCDSCMF.

For 2018:

- The crystal crab TAC was achieved,
- The standardised catch rate of legal crystal crabs was within the target range, and
- The standardised catch rate of the secondary performance indicators: berried females and undersized crabs, were **below** their respective threshold reference points.

The catch of champagne and giant crab were both within their respective target ranges

Consequently, a review of the secondary indices was undertaken and concluded that it was likely due to estimation error in the data supplied by fishers. Therefore, for 2018 the TAC remained at 154 t for crystal crabs, and 14 t for giant and champagne crabs combined. 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.

Annual Catch Tolerance Levels

For the 2018 season (1 January – 31 December 2018) the crystal crab quota was set at 154 t. With an annual tolerance range of > 90%, and based on the catch of 152.2 t, the annual catch is **acceptable**. The combined quota of champagne and giant crab (B Class Units) was set at 14 t. The combined catch of these two species was 0.6 t, which comprised solely of giant crab.

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

To address conditions raised as part of the MSC assessment process, B class units (combined

champagne and giant crab) were split into B class (champagne crab) and C class (giant crab), with individually set TACC (20,020 tonnes and 980 kg respectively). This arrangement came into effect for the 2019 fishing season,

Management initiatives in 2020 will primarily focus on monitoring and assessing its implementation within the fishery. Additionally, a memorandum of understanding with the industry regarding the use of approved bait sources was established and implemented.

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.

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GASCOYNE DEMERSAL SCALEFISH RESOURCE STATUS REPORT 2019

G. Jackson, S. Walters and S. Turner

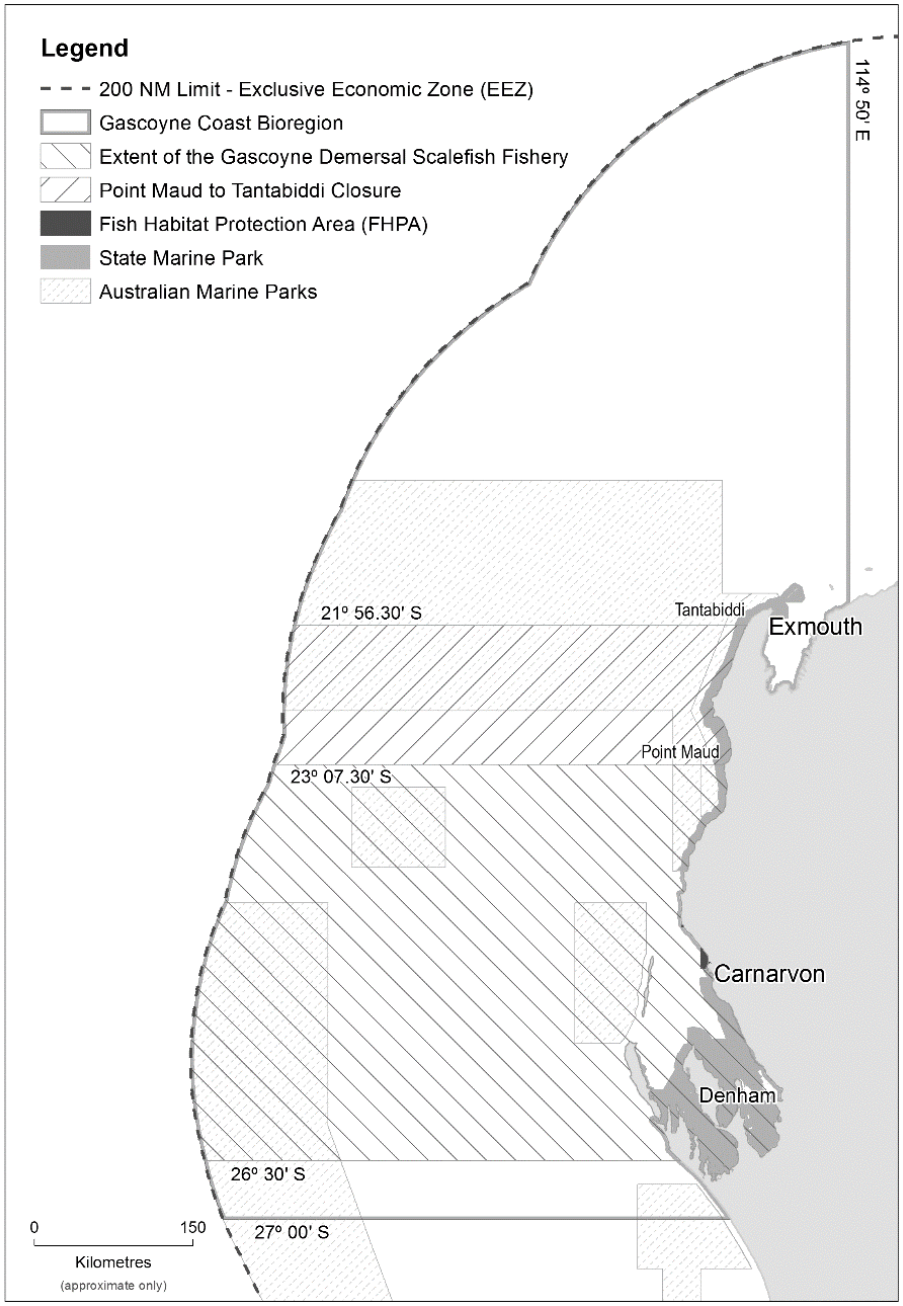
OVERVIEW

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. More details on this resource can be found in Jackson *et al*. (2020)

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (Pink snapper 51 t, Other demersals 227 t)	Total Catch 2018: Pink snapper 45 t, Other demersals 164 t	Pink snapper = Unacceptable 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 & SPR above 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.

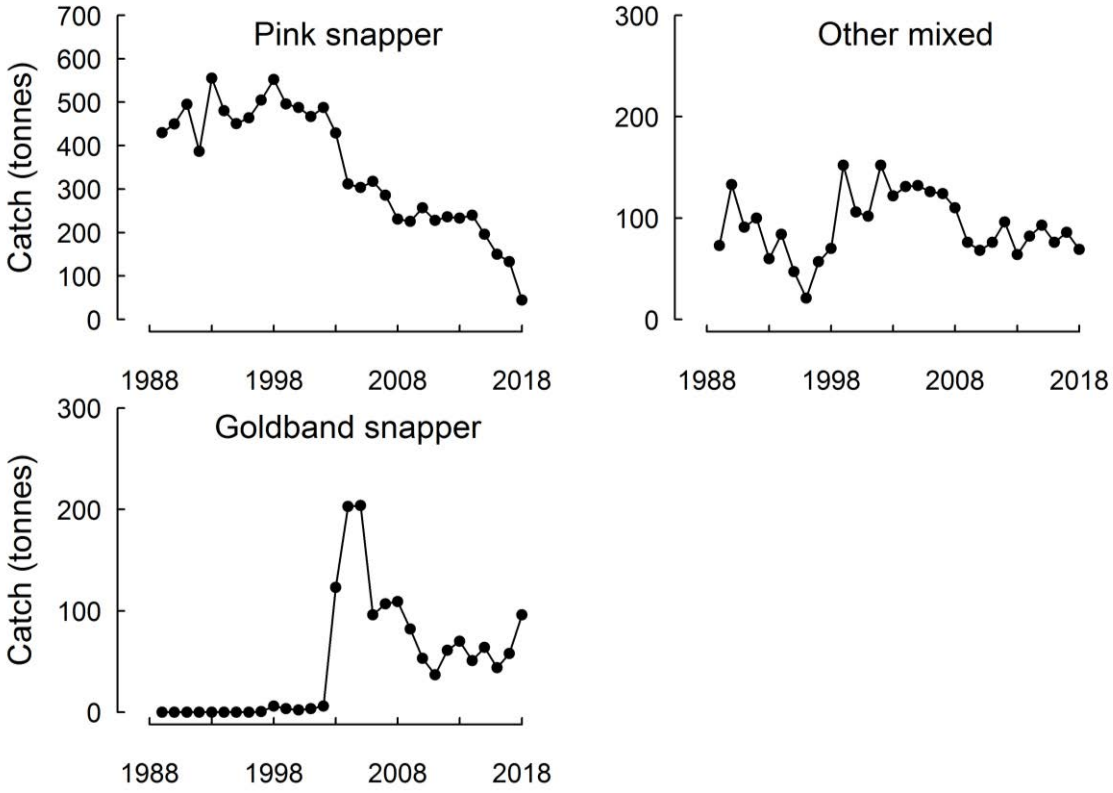
CATCH AND LANDINGS

In 2017/18, the total commercial catch reported by the GDSMF was 210 t, comprising 45 t pink snapper, 96 t goldband snapper and 69 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 144 t (95% CI 125–160) in 2011/12 (Ryan *et al*. 2019). The catch of pink snapper and goldband snapper in oceanic waters of Gascoyne reported by charter vessels in 2018 was 4 t and 6 t, respectively.

GASCOYNE DEMERSAL SCALEFISH TABLE 1.
Total catches of scalefish (excluding mackerel and tunas) taken by GDSMF in the previous five years.

Species	2013/14	2014/15	2015/16	2016/17	2017/18
Pink Snapper	240.0	195.8	149.8	133.3	45.1
Goldband Snapper	50.9	63.5	43.6	58.2	95.7
Other Jobfish	3.4	4.3	4.4	6.2	9.4
Red Emperor	10.1	10.9	10.0	13.5	10.0
Ruby Snapper	4.2	5.1	1.2	1.8	2.6
Other Snappers	1.1	1.7	1.5	2.5	1.4
Spangled Emperor	2.0	2.5	2.6	2.3	1.2
Redthroat Emperor	6.1	10.9	8.0	9.3	6.6
Other Emperors	0.3	1.3	0.6	<1.0	<0.5
Rankin Cod	6.9	8.0	10.5	10.8	6.8
Other Cods	11.2	11.3	10.7	12.1	9.5
Eightbar Grouper	3.5	1.9	1.6	2.2	2.4
Mulloway	8.6	9.0	6.4	4.6	2.7
Trevallies	6.8	7.9	3.6	2.4	<1.0
Other Species	18.0	18.6	15.1	17.2	15.2
Total	373.1	352.7	269.5	277.2	209.5



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 1988/89-2017/18.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Pink snapper Oceanic Stock (Inadequate)

Following the first integrated age-based assessment in 2002 which indicated the oceanic spawning stock was below the threshold (30% of unfished level) at that time, the TACC was reduced in 2003/04 from 564 t to 338 t and then again in 2006/07, to 277 t, to assist stock rebuilding.

The most recent (2017) assessment, which incorporated age composition data up to 2014/15, and catch rates up to 2015/16, indicated that the spawning biomass was around the limit (20% of unfished level).

Based on this assessment, the status of the oceanic pink snapper stock is **inadequate.** Additional management action was taken in 2018 to assist recovery and to rebuild the oceanic stock to the target level within two generation-times (i.e. by 2038).

Goldband snapper (Adequate)

Commercial fishing for goldband snapper in the Gascoyne began as the Shark Bay Snapper Managed Fishery developed into a more year-round fishery from around 2000 onwards with vessels moving offshore and outside the traditional peak pink snapper season (May-August) (Marriot *et al.* 2012). This resulted in a wider range of demersal species contributing to the overall commercial catch with the goldband snapper catch increasing rapidly over short-period to peak at ~300 t (GDSMF and 'wetline' vessels combined) in 2002-2003 before stabilising in recent years at around 40-60 t.

Based on biological data collected during 2010-2013, the SPR was well below the threshold level. Based on the weight of evidence, the status of the goldband snapper stock in the Gascoyne is **adequate** at current levels of fishing.

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 therefore 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 therefore 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 2018, 13 GDSMF vessels fished at some point during the season (16 in 2017), 7 of which fished for more than 10 days during the traditional peak (pink snapper) season (10 in 2017), typically with a crew of 2-3. Commercial fishing and associated fish processing are 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 Bioregion 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).

The GDSR therefore provides a high social amenity with **moderate risk.**

Economic

The estimated GVP of GDSMF was in the range $1-5 million in 2018 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 Gascoyne 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. It defines the ecological, economic and social objectives and establishes the explicit rules that determine the appropriate catch levels for the GDSR. The GDSR Harvest Strategy was approved by the Minister for Fisheries in 2017.

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 harvesting 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 - The pink snapper Total Allowable Commercial Catch (TACC) had been set at 277 t from 2006/07 onwards. For a range of economic and operational reasons the entire TACC had not been caught in any season since then.

Consequently, the landed pink snapper catch since 2006/07 had mostly been ~230-240 t, an ‘annual tolerance’ range considered to be the level where the TACC had ‘effectively’ been reached.

However, in the fishing years between 2014/15 and 2016/17, the landed catch was substantially lower, below this range and was therefore **unacceptable**.

In addition, the pink snapper catch rate in each of the last fishing years had fallen substantially below the threshold level of 500kg/standard boat day and was also therefore **unacceptable**.

Discussions with commercial fishers at completion of the 2015/16 and 2016/17 fishing seasons identified that a number of factors may have contributed to the current status of the oceanic stock and associated poor performance of the fishery including: loss of experienced skippers to the industry, low peak season prices, increased interactions with sharks (depredation), and poor recruitment (absence of smaller fish) due to environmental conditions. The increased level of interaction with sharks has resulted in recent changes in fishing operations such as gear used (number of hooks per line) and locations and times fished.

In May 2018, management changes were introduced prior to pink snapper peak spawning period (June-August) to help rebuild the oceanic spawning stock including a 3-month pink snapper spawning closure adjacent to Bernier Island and an 81.5% reduction in the TACC (from 277 t to 51 t).

In 2017/18, the landed pink snapper catch was 45 t, i.e. within this revised TACC.

Goldband snapper – Within the combined TACC for other mixed demersal species (see Harvest Strategy) there is a maximum limit of 100-120 t for goldband. The catch of 96 t landed in 2017/18 (an increase of 65% from 2016/17) was **acceptable**.

Recreational:

Catch tolerance levels for recreational and charter pink snapper catch are under development.

The 3-month pink snapper spawning closure adjacent to 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 and Denham only).

Consultation

A cross-sectoral working group was formed in 2016 to develop the Harvest Strategy for this resource, which was finalised and published in late 2017.

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.

Management Meetings are held between Fisheries 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.

Focused recreational consultation occurs with Recfishwest. Broader recreational consultation processes are facilitated by Recfishwest under an SLA.

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

Management Initiatives

The 2017 stock assessment indicated that the pink snapper spawning stock was around the limit level. In accordance with the GDSR Harvest Strategy, a management review was undertaken. The reference group was convened to provide recommendations on management strategies to recover pink snapper.

Consultation on management proposals occurred in March 2018 and included a 3-month pink snapper spawning closure adjacent to Bernier Island and an 81.5% reduction in the commercial pink snapper TACC (from 277 t to 51 t).

In May 2018, these management proposals were approved by the Minister for Fisheries and implemented prior to the 2018 pink snapper peak spawning period (June-August) to help rebuild the pink snapper oceanic spawning stock.

The Department is working with the reference group to implement a recovery plan for pink snapper that provides milestones and control rules to ensure recovery is achieved within acceptable timeframes in accordance with the GDSR Harvest strategy.

EXTERNAL DRIVERS

Under the Offshore Constitutional Settlement, commercial vessels licensed by the Commonwealth may operate in state 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 snapper, *Etelis carbunculus*) (Hart and Curtotti 2018). While no fishing activity in these waters had been recorded by WDWTF vessels since the early 2000s, there was some limited activity off Shark Bay in 2018 with a total of 9 days fishing recorded (AFMA unpublished data).

Climate change has the potential to impact WA fish stocks through increasing sea surface temperatures, changes in major ocean currents (e.g. Leeuwin Current), rising sea levels, ocean acidification and reduced annual rainfall. Snapper had previously been assessed as high risk due to the effects of climate change, particularly in the Gascoyne (Caputi *et al.* 2015). An FRDC-funded project that is currently underway will investigate whether there have been changes to stock connectivity and biology of snapper related to climate change driven changes in oceanic conditions.

These drivers represent a **high risk**.

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GASCOYNE INNER SHARK BAY SCALEFISH RESOURCE STATUS REPORT 2019

G. Jackson, C. Lyttleton, R. Jones, S. Walters and S. Turner

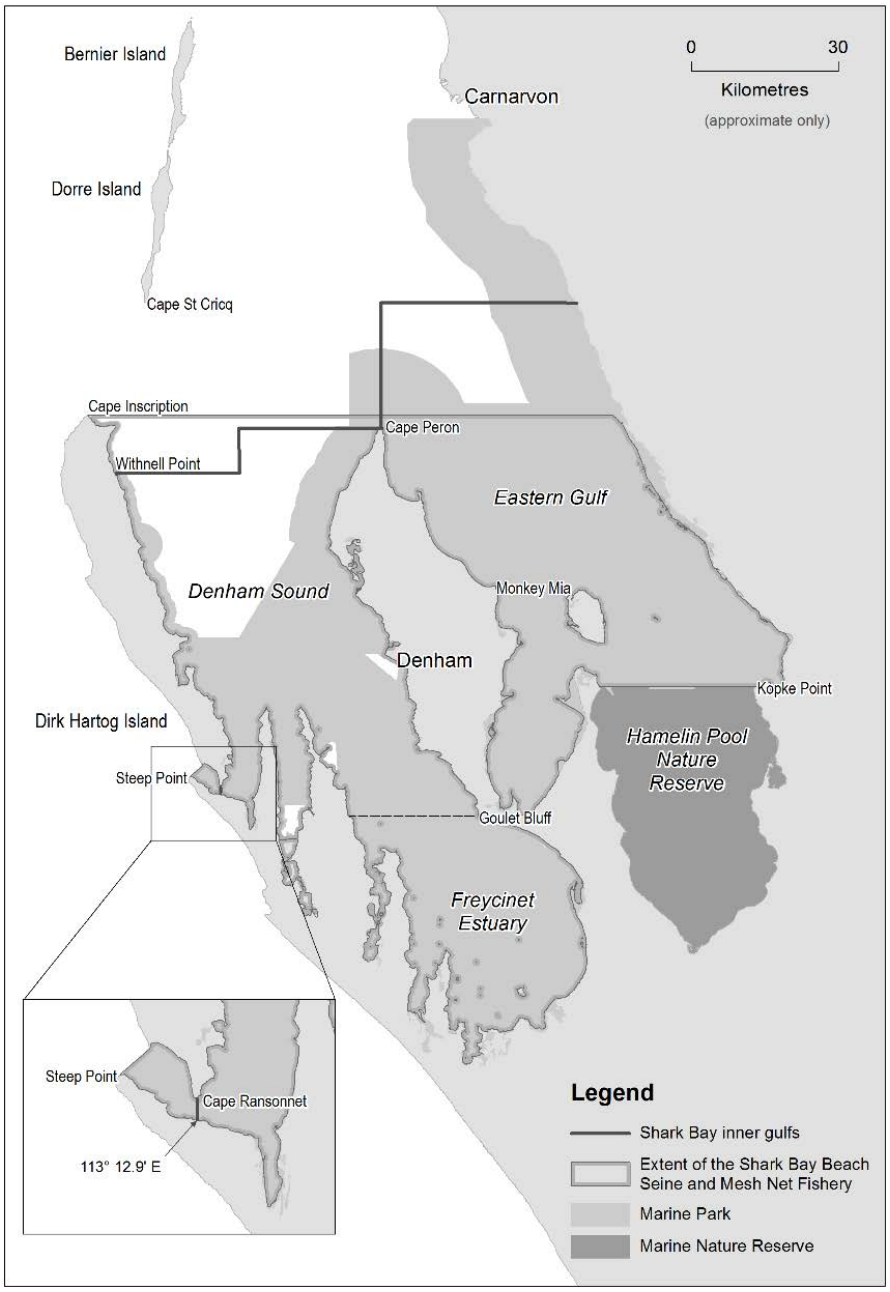
OVERVIEW

The Inner Shark Bay Scalefish Resource (ISBSR) comprises 20-30 scalefish species taken by commercial and recreational fishing 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 (yellowfin *Sillago schomburgkii* and goldenline *S. analis*), 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 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (235-335 t)	Total Catch 2018: 176 t	Acceptable
Recreational fishery (Pink snapper, 26 t)	Total Catch 2018: Pink snapper only, 22 t* (boat-based only)	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

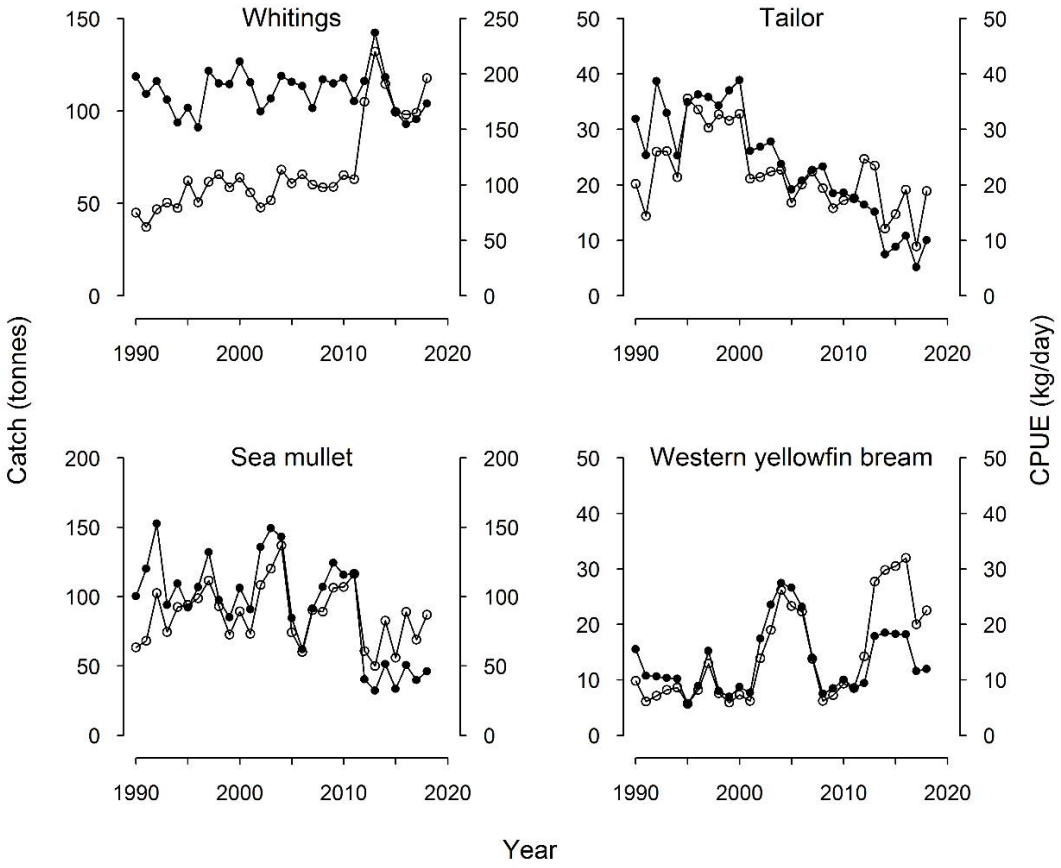
*Based estimates from on-site boat ramp survey conducted 2018/19 (Taylor et al. 2019)



GASCOYNE INNER SHARK BAY FIGURE 1.
Commercial and recreational fishing areas of inner Shark Bay.

CATCH AND LANDINGS

In 2018, the total catch reported by the commercial fishery (Shark Bay Beach Seine and Mesh Net Managed Fishery [SBBSMNF]) was 176 t, comprising 104 t of whiting, 46 t of sea mullet, 12 t of western yellowfin bream, 10 t of tailor and 4 t of other mixed species including 2 t of pink snapper. The total catch of pink snapper reported by charter vessels in 2018 was 3.5 t (all three areas combined). The total estimated recreational catch of pink snapper in 2018 was 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 1990-2018.

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 (1-2 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 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 (40% unfished level) in 2015. On the basis of the evidence available, these pink snapper stocks are **adequate.**

Yellowfin whiting (Adequate)

In 2018, the commercial catch of yellowfin whiting taken by the SBBSMNF was 104 t, which is within the target catch range (93-127 t), with Catch Per Unit Effort (CPUE) at 196 kg/boat day well above the threshold catch rate (75 kg/boat day). The commercial catch of yellowfin whiting in inner Shark Bay has been relatively stable at ~90-120 t since 1990 (Inner Shark Bay Figure 2). Whiting species (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 based on biological data collected in 2014 indicated that fishing mortality was above threshold level. Based on the evidence available, the yellowfin whiting stock in inner Shark Bay is classified as **adequate**.

Sea mullet (Adequate)

In 2018, the commercial catch of sea mullet taken by the SBBSMNF was 46 t and remains well below the target catch range (77-144 t). This maintains the declining trend in catches observed since the early 2000s, down from the higher levels reported 199-2005 that typically ranged from 100–

150 t. The CPUE in 2018 increased to 87 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. A level 3 assessment of sea mullet stock status is underway and will be completed by 2020.

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 2018, the commercial catch of tailor taken by the SBBSMNF was 10 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 2018 increased to 19 kg/boat day which is around 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 2018, the commercial catch of western yellowfin bream taken by the SBBSMNF was 12 t, and remains within the target catch range (7-15 t). The CPUE (22 kg/boat day) was again 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. The recent increase and then decline in both catch and CPUE reflect another strong year class passing through the fishery, as was previously observed in 2002-2007.

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 2018, six vessels operated in the SBBSMNF, employing around 12 fishers. Commercial fishing and associated fish processing are 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).

The Inner Shark Bay Scalefish Resource therefore provides a high social amenity with **moderate risk.**

Economic

The estimated GVP of the SBBSMNF in 2018 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): 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 530 boat days in 2018, the lowest level on record. While the total commercial catch in 2018 at 176 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 2018, the commercial catch of snapper taken by the SBBSMNF was 2 t, well within the notional TACC (9 t all three areas combined).

Recreational:

Recreational (includes charter) catch tolerance levels are only currently in place for pink snapper.

Recreational catches of pink snapper in 2018 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). A further 3 t were reported by charter vessels (Eastern Gulf 0.5 t, Denham Sound 1.7 t, Freycinet 1.2 t). Catches in **Eastern Gulf** and **Denham Sound** were within the respective notional TARCs, and therefore **acceptable** however in **Freycinet** were well above the TARC and therefore **unacceptable.**

Compliance

The Department of Primary Industries and Regional Development undertakes regular compliance inspections at-sea and on-land.

Consultation

Fisheries 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 Fisheries'.

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 number of management initiatives were introduced in 2016 following the 2015 stock assessment that indicated the spawning biomass of all three inner gulf pink snapper stocks were above the target (40% of the unfished level). These initiatives were designed to increase the amenity of recreational fishing. They included the removal of the 70 cm maximum size limit of inner gulf pink snapper and an increase in the daily bag limit from one to two per person per day. The Freycinet Estuary tag lottery system, which was introduced in 2003 as a key component of the recovery strategy, was also removed and replaced by an individual possession limit of 1 day's bag limit of whole fish or 5kg of fillets within the Freycinet Estuary management area.

Following on from these changes, two 12-month boat ramp surveys of recreational fishing in inner Shark Bay have now been completed in 2016/17 and 2018/19. Data collected indicates that management arrangements in place to ensure sustainability of pink snapper stocks are adequate in Eastern Gulf and Denham Sound but not so in Freycinet where additional management is required to reduce the recreational catch of pink snapper below the maximum acceptable catch levels.

EXTERNAL DRIVERS

The Inner Shark Bay system has been considered relatively stable as a result of its typically low-rainfall and arid environment. However, recent 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 e.g. 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.

Climate change has the potential to impact WA fish stocks through increasing sea surface temperatures, changes in major ocean currents (e.g. Leeuwin Current), rising sea levels, ocean acidification and reduced annual rainfall. Snapper had previously been assessed as high risk due to the effects of climate change, particularly in the Gascoyne (Caputi *et al.* 2015).

These drivers represent a **high risk**.

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NORTH COAST BIOREGION

ABOUT THE BIOREGION

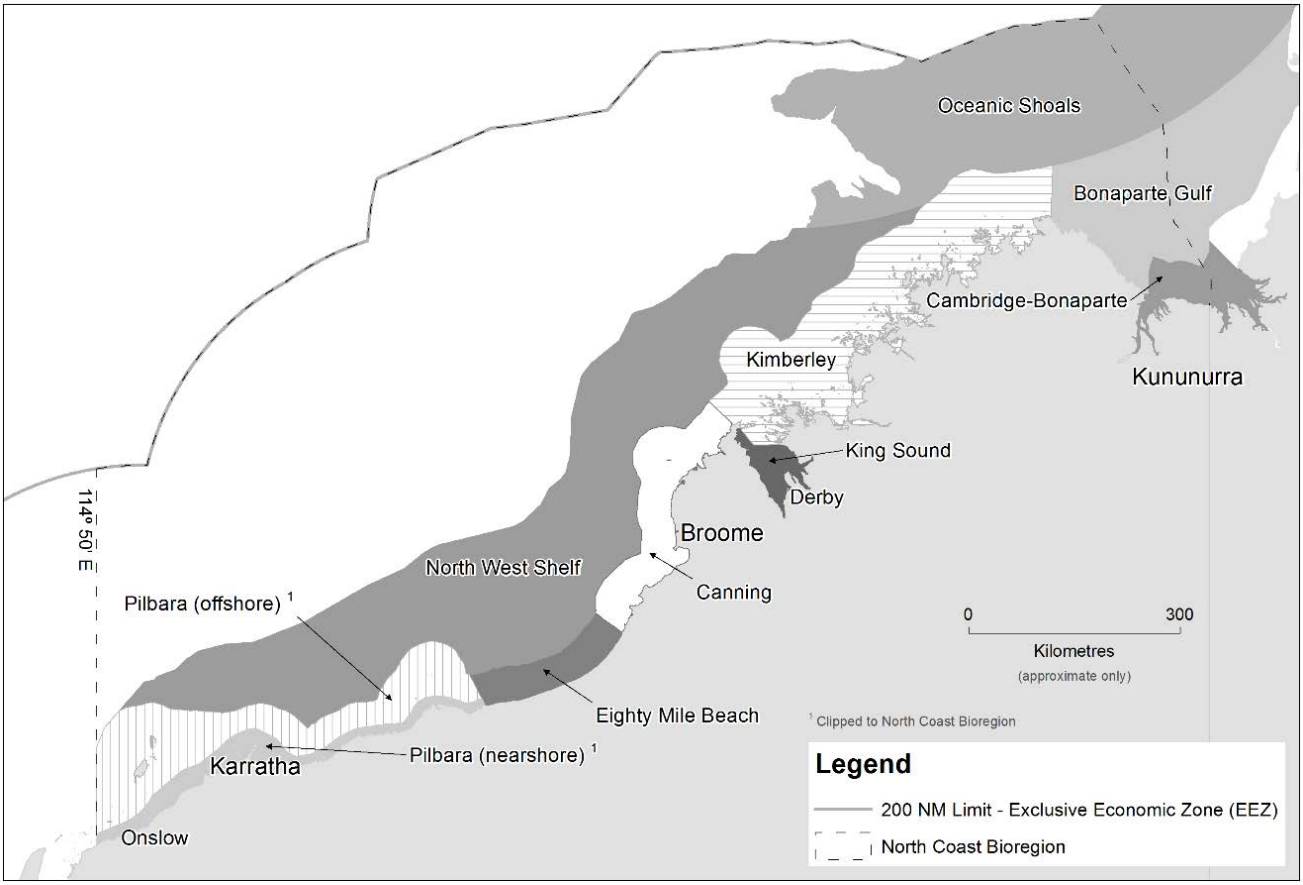
The oceanography of the North Coast Bioregion (North Coast Overview Figure 1) includes waters of Pacific Ocean origin that enter through the Indonesian archipelago bringing warm, low salinity waters polewards via the Indonesian Throughflow and Holloway Currents which flow seasonally and interact with 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 and are 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. Also shown is the MOU box area, established in a bilateral agreement between Australia and Indonesia.

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. Broad 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;
- Increase 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, 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

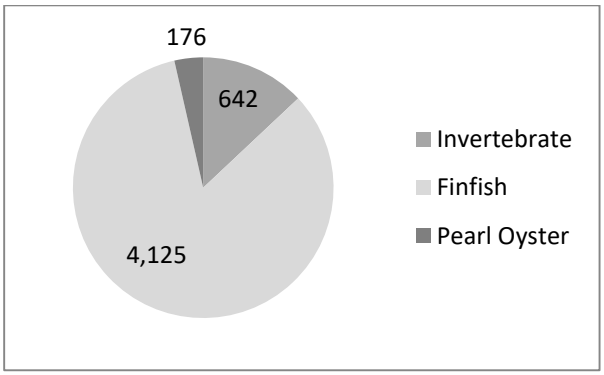
There are 15 different State-managed commercial fisheries operating within the North Coast Bioregion. These fisheries target a variety of species including finfish, crustaceans, molluscs and echinoderms (North Coast Overview Figure 2). The principal commercial fisheries in the North Coast Bioregion focus 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 $10 million. A number of other finfish fisheries operate in the Bioregion, including near-shore beach seining and gillnetting for barramundi and threadfin salmon (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.

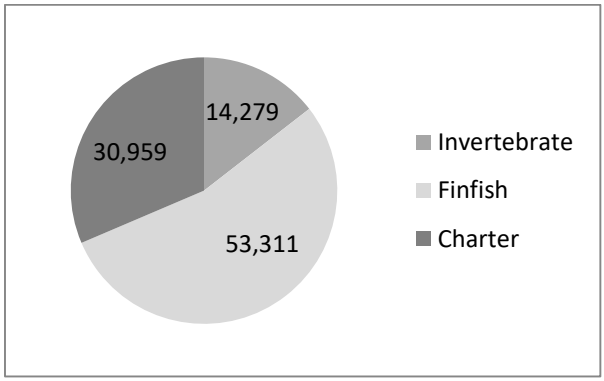
A traditional artisanal fishery also exists in an area south of Roti Island, encompassing Scott Reef, Browse island, Cartier Island and Ashmore Reef known as the MOU box. The MOU Box within the Australian EEZ over which there is a bilateral agreement between the Governments of Australia and Indonesia. 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 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.

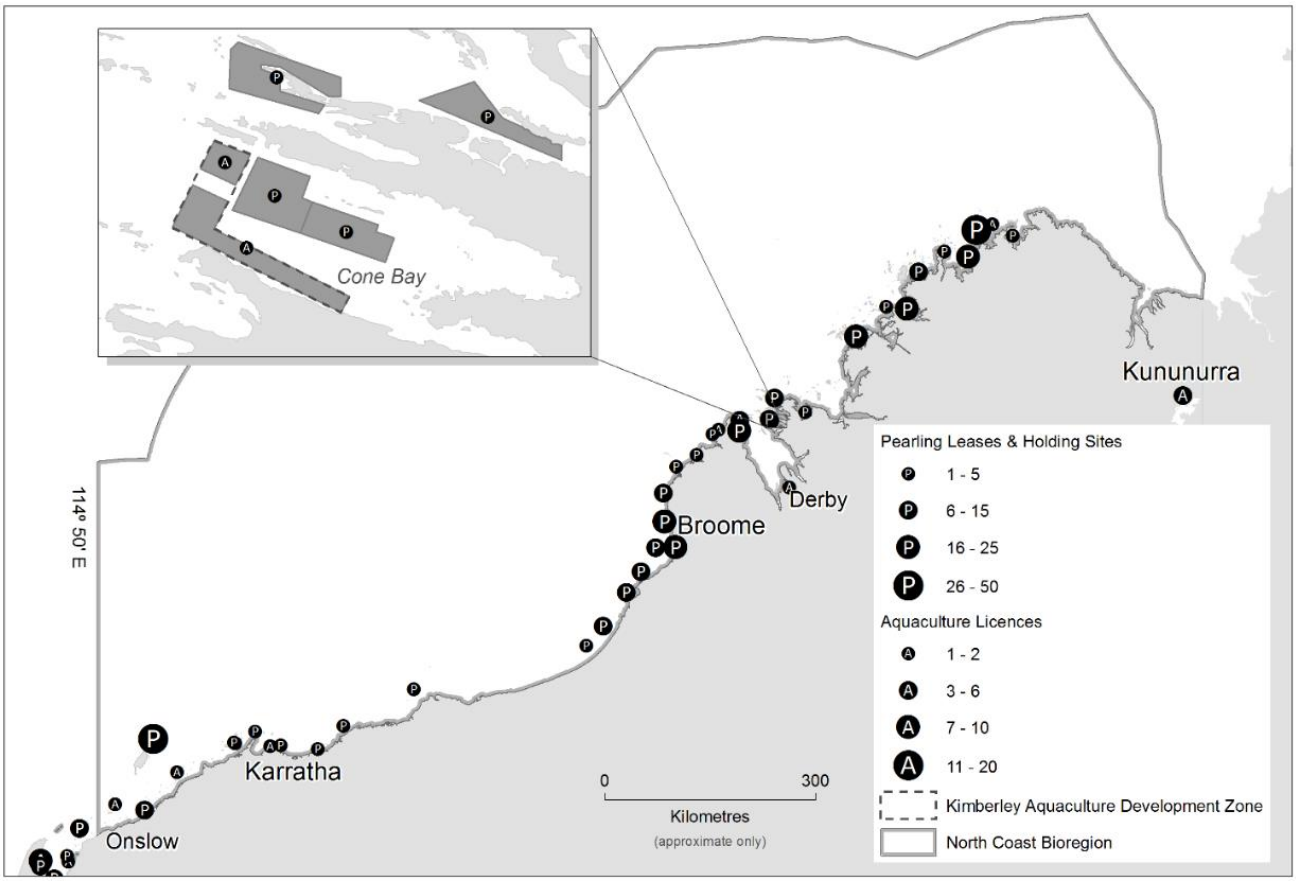


NORTH COAST OVERVIEW FIGURE 3
Recreational catches (by number) in the North Coast Bioregion. Finfish and invertebrate catches were as assessed in the statewide survey of boat-based recreational fishing in 2017/18[1]. Charter boat catch is for the same period. Estimates of shore based recreational catch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

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.



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.

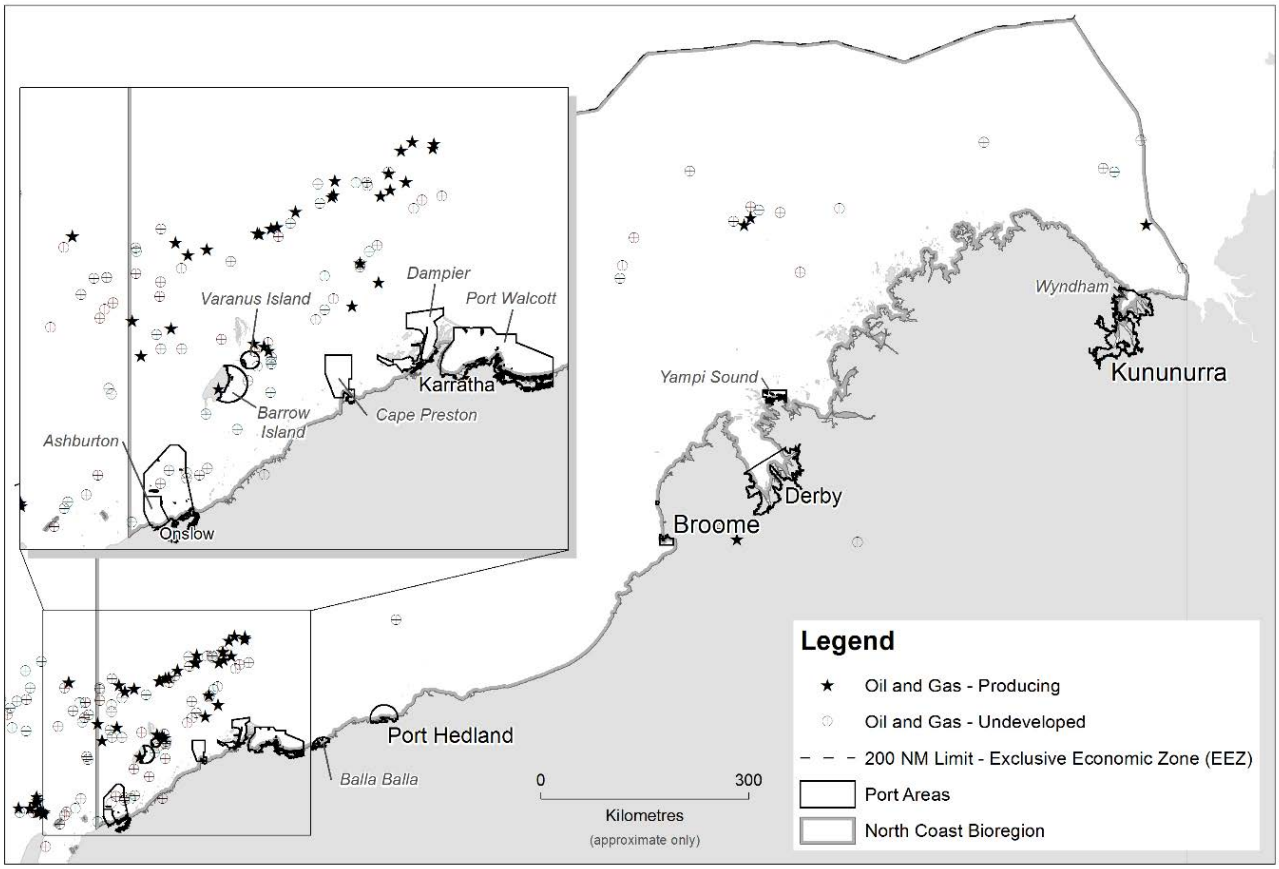
A focus of aquaculture development is provided by the Departments' Broome Tropical Aquaculture Park, which houses a commercial pearl oyster hatchery and the Kimberley Training Institute aquaculture training facility.

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 Wyndam. 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, 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. The Port of 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.

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 has been undertaken as part of a three-year FRDC-funded project (Caputi *et al*. 2015a, b) that assessed the effects of climate change on the marine environment and key fisheries, as well as 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* (see North Coast Ecosystem Management Figure 2), 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 of Fisheries 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).

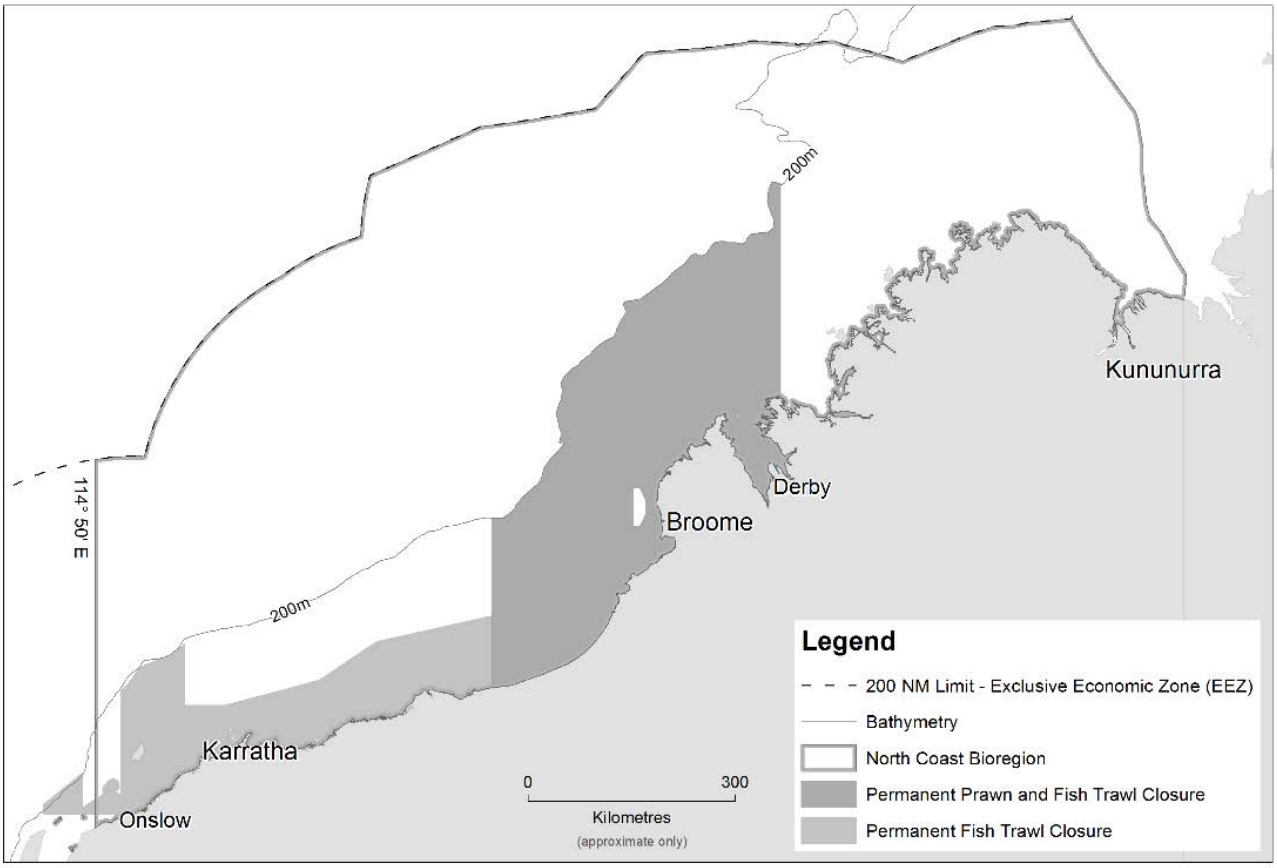
1 Dudley N. (editor) 2008. Guidelines for applying protected area management categories. IUCN. Gland, Switzerland.

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

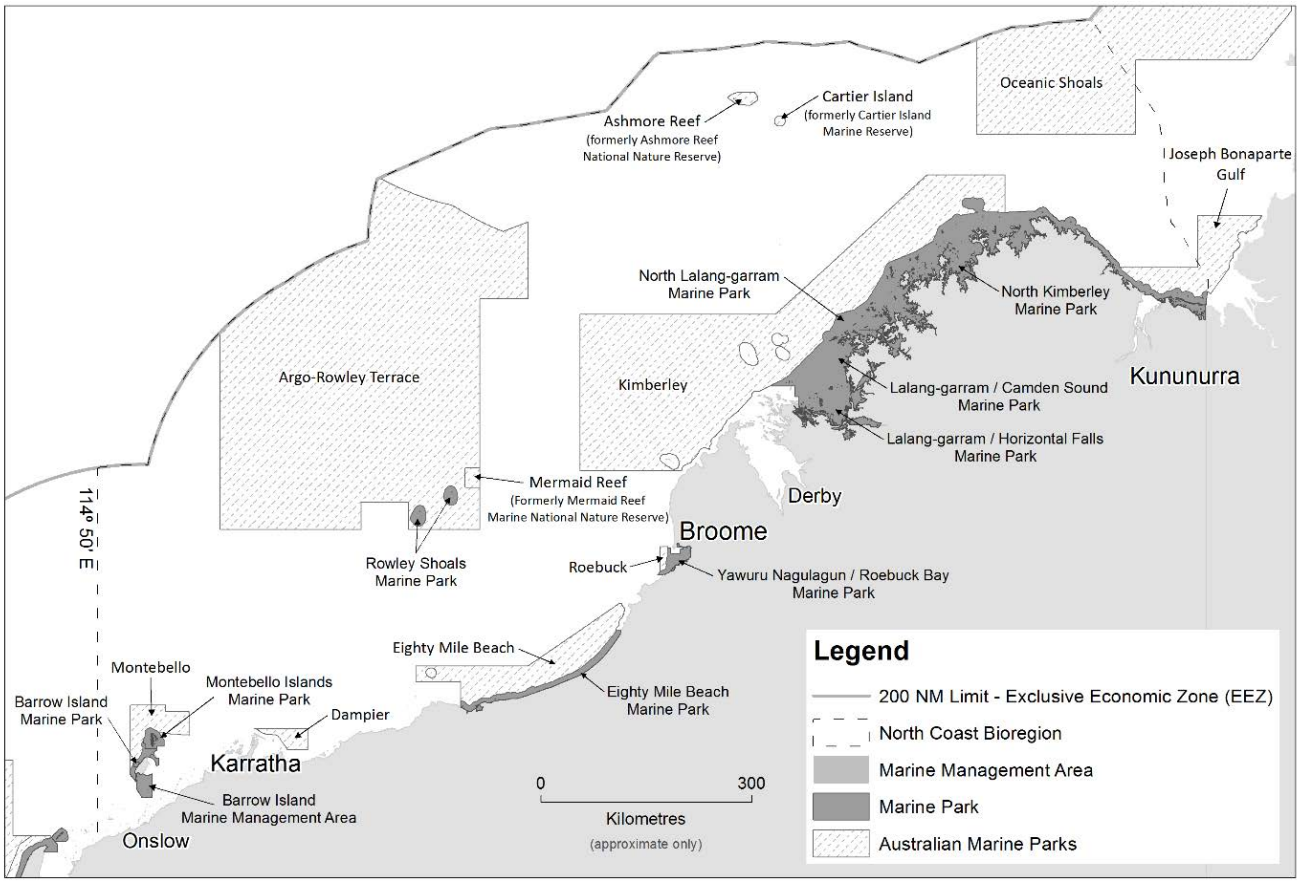
The areas and proportions of the North Coast Bioregion making up State Waters and all continental shelf waters, out to 200 m depth, which are consistent with the IUCN criteria for classification as marine protected areas. This table does not yet include the closures that may be implemented by the Commonwealth 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

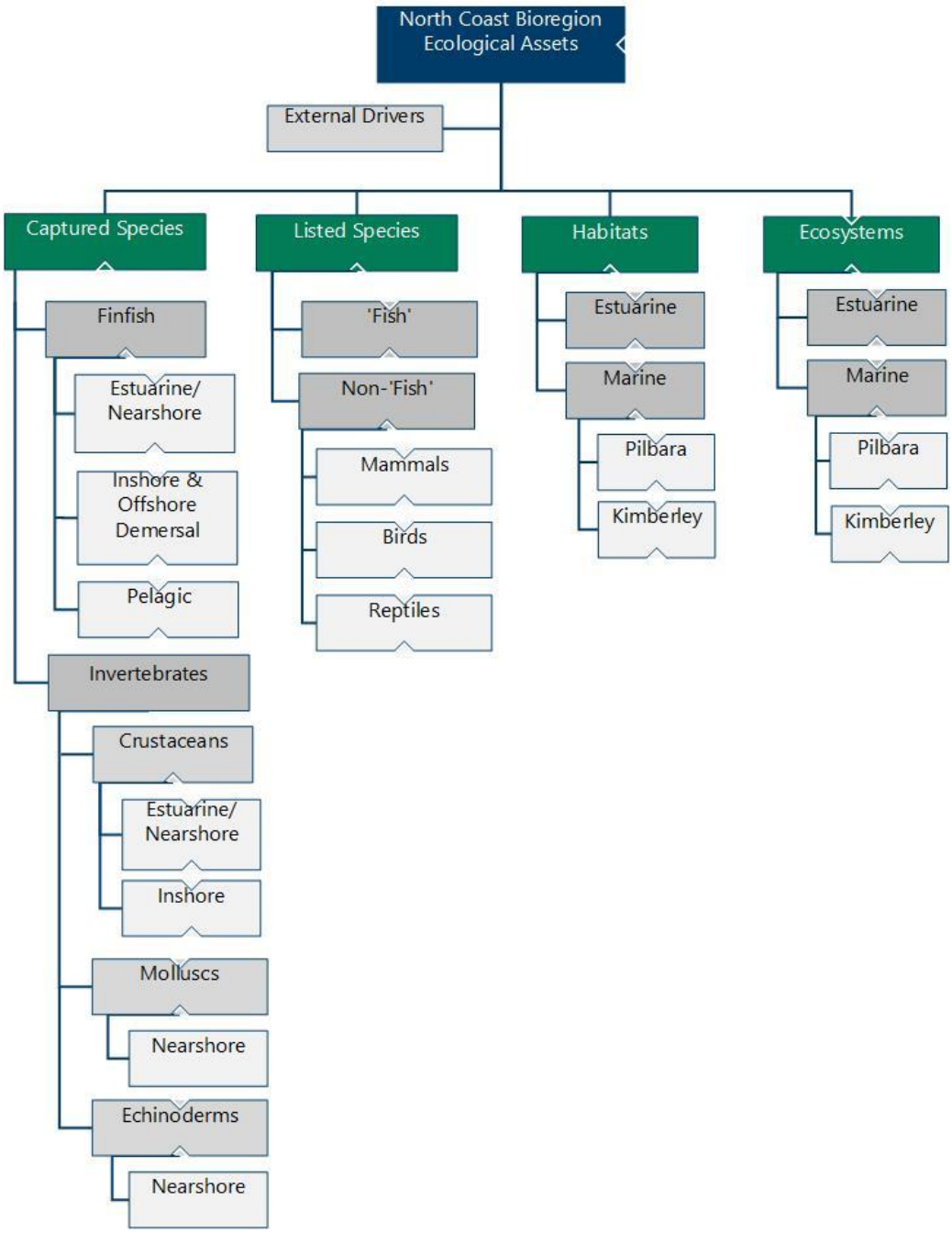
Map showing the North Coast Bioregion and areas closed to all trawling. The areas permanently closed to trawling are consistent with IUCN marine protected area category IV.



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 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.

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

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. Some of the risks identified (e.g. increased turbidity) are being examined under WAMSI 2 projects. In addition, State and Commonwealth marine parks, including totally protected zones, are currently in place or planned.

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 $10 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 salmon (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 salmon. Stocks of barramundi and threadfin salmon 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	LOW

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

A significant commercial invertebrate fishery in this Bioregion, is the Pearl Oyster Managed Fishery, 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. This fishery is undergoing MSC assessment.

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)[2];

The Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007 (ROKAMBA)[2]; and

Any other international agreement, or instrument made under other international agreements approved by the environment minister 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

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

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 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. Grids 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 are 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, 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

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.

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.

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 Kimberly 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 2019

M. Kangas, S. Wilkin, M. Shanks, and S. Brand-Gardner

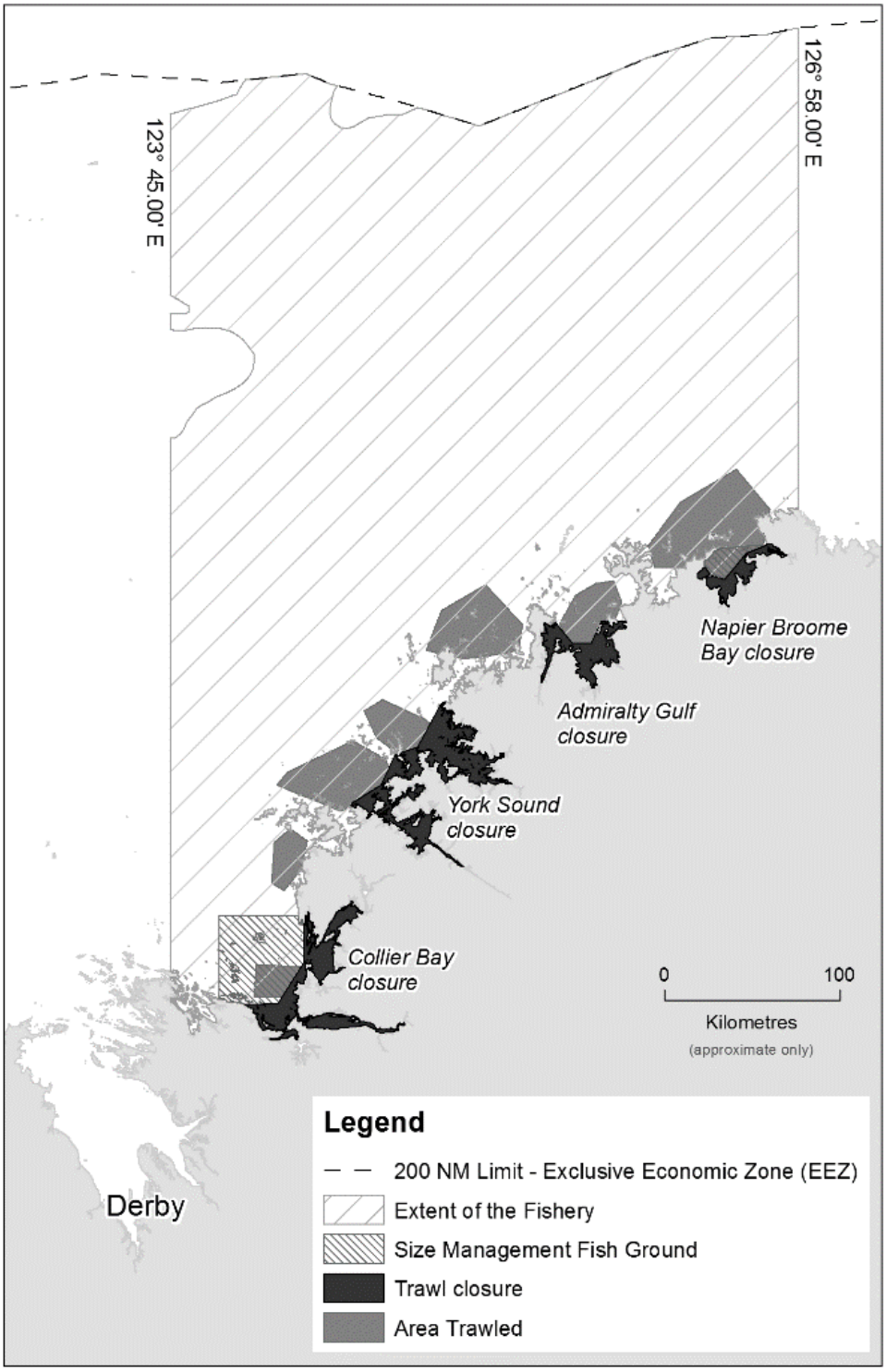
OVERVIEW

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 two of these fisheries. Management of these fisheries is based on input controls, including limited entry, gear controls (maximum headrope units), seasonal and area openings and closures.

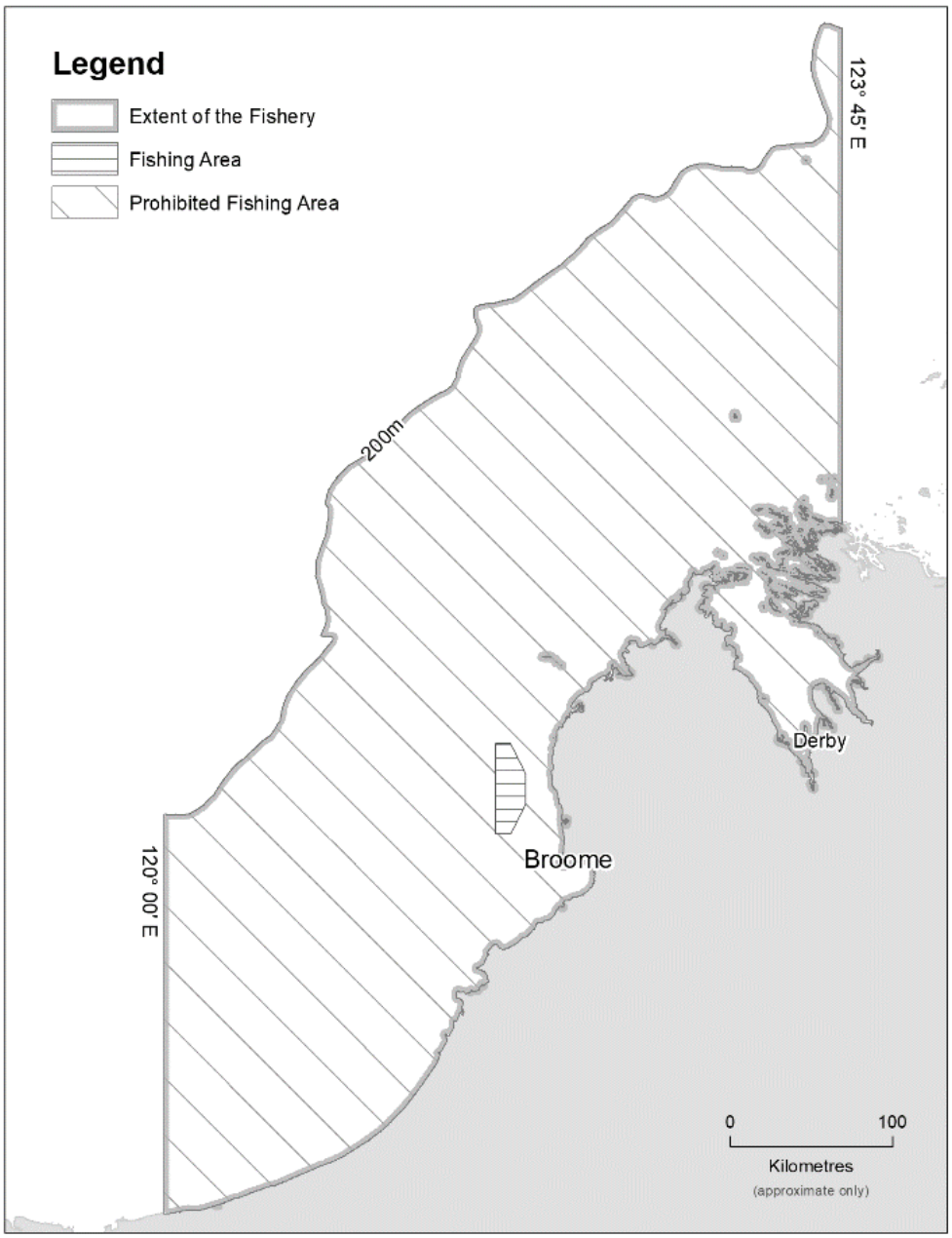
The fisheries have Commonwealth export approval until 2025.

SUMMARY FEATURES 2019

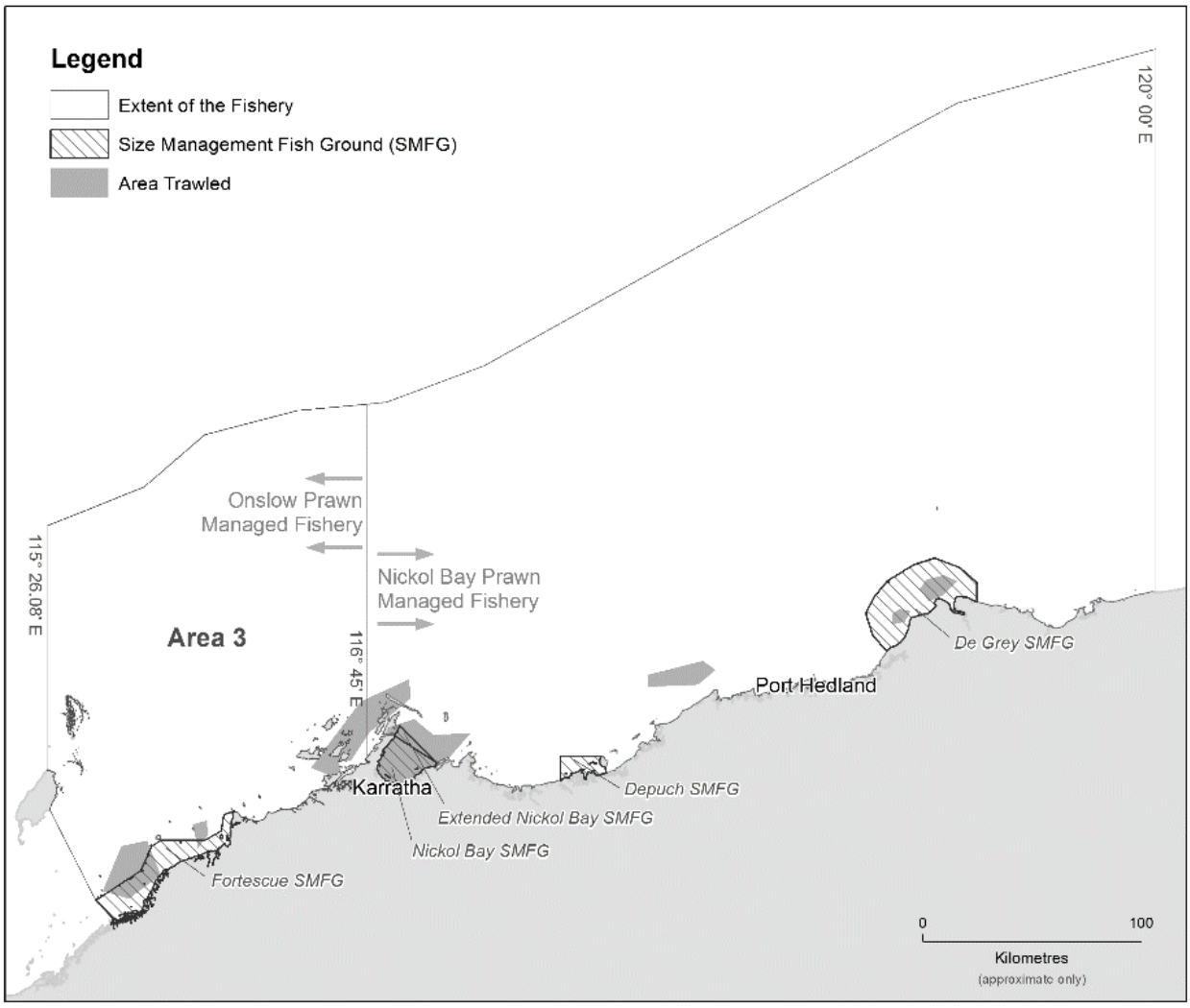
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (2018)	Total Catch: 428 t	Acceptable
Recreational fishery (N/A)		
EBFM		
Indicator species		
Banana prawns (KPMF and NBPMF)	Moderate risk: Catches within predicted ranges	Adequate
Western king prawns (BPMF)	Low risk: Low effort and 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 $5.3m)	High risk	Acceptable
Social (low amenity)	Low risk	Acceptable
Governance	Moderate risk	
External Drivers	Moderate risk (climate)	



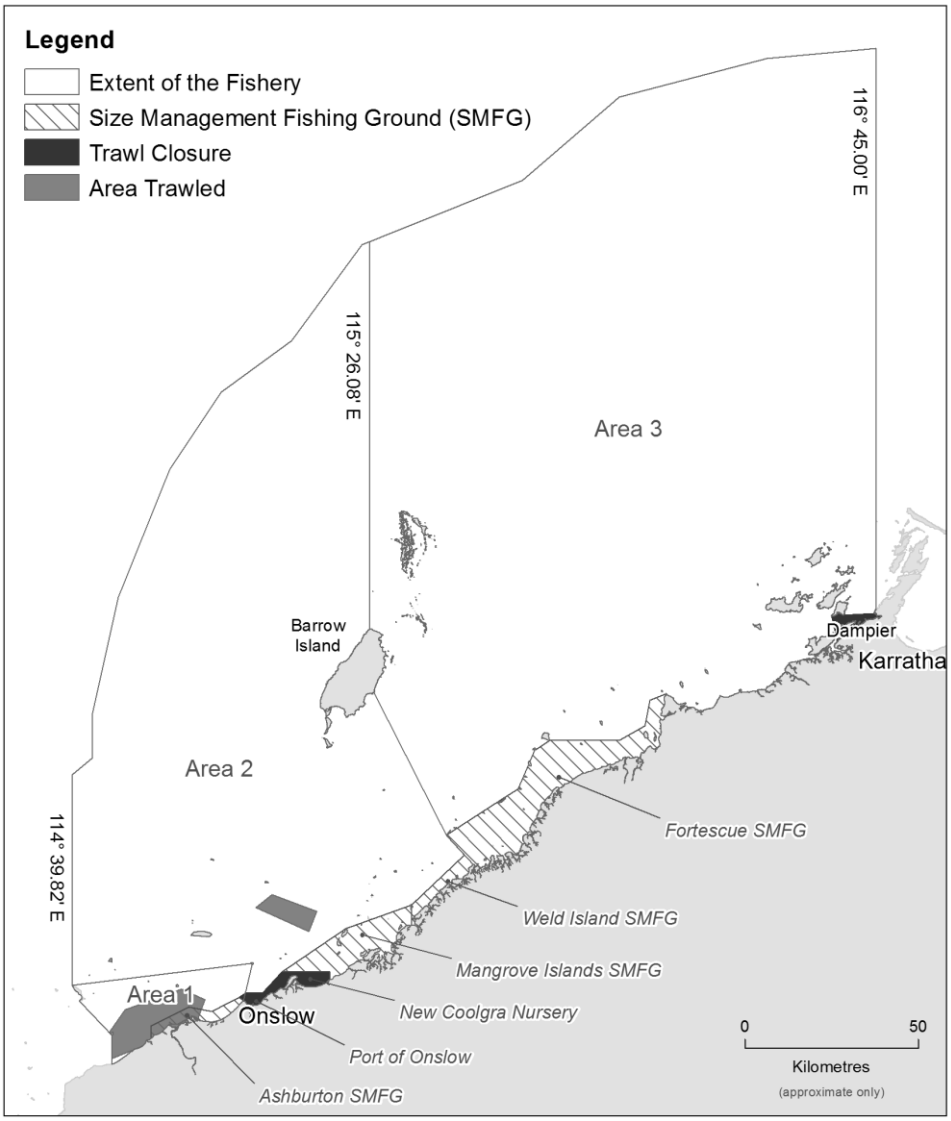
NORTH COAST PRAWN FIGURE 1.
Map showing boundaries of the Kimberley Prawn Managed Fishery



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



NORTH COAST PRAWN FIGURE 4.
Map showing boundaries of the Onslow Prawn Managed Fishery

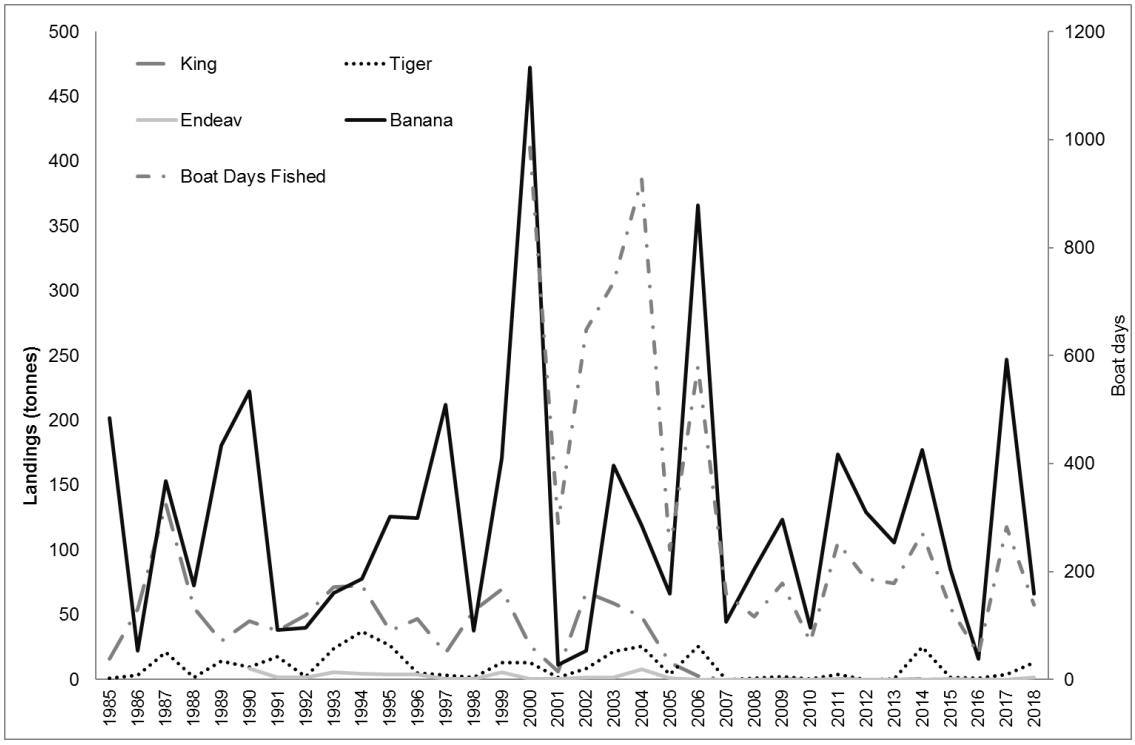
CATCH AND LANDINGS

Kimberley Prawn Managed Fishery (KPMF)

The total landings in 2018 for the KPMF were 333 t. which was the highest catch since 2004. The catch was primarily banana prawns (328 t), with 4 t of brown tiger prawns and 1 t of blue endeavour prawns also taken (North Coast Prawn Figure 5).

The banana prawn landings were within the catch prediction and the higher abundance expected this season resulted in higher effort compared to 2017 as well as the last nine years. There are two fishing periods for the season (April to mid-June, then from August to the end of November) with around 80% of the total landings taken in the first fishing period. Negligible quantities of byproduct were reported.

NORTH COAST PRAWN FIGURE 5.
Annual prawn landings (t) and fishing effort (total adjusted hours) for the Kimberley Prawn Managed Fishery 1980-2018.



NORTH COAST PRAWN FIGURE 6.
Annual prawn landings (t) and fishing effort (total adjusted hours) for the Nickol Bay Prawn Managed Fishery 1985-2018.

Broome Prawn Managed Fishery (BPMF)

Extremely low fishing effort occurred as only two boats 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 2018 season were 81 t (North Coast Prawn Figure 6). This comprised 66 t of banana prawns, which was within the predicted range (60 – 90 t) due to low rainfall, 13 t of brown tiger prawns and 1.5 t of blue endeavour and negligible western king

prawns. Due to the expected low landings of banana prawns in 2018 compared to 2017, fishing effort was less than half at 138 days, compared to 281 boat days in 2017.

Onslow Prawn Managed Fishery (OPMF)

The total landings in 2018 were less than 60 t, below the target catch range. Forty-nine days of fishing effort (509 hours) was undertaken by one boat in 2018, the highest amount of effort since 2011.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Kimberley Prawn Managed Fishery – Banana prawns (Sustainable-Adequate)

Due to a change associated with the fleet structure and economics of fishing, there has been a marked reduction in the number of fishers since 2005 with fishing effort (boat-days) below historical levels (North Coast Prawn Figure 1). However, total catches have generally been in line with seasonal catch predictions. The breeding stock is considered **sustainable-adequate**.

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 recent years in the north coast prawn fisheries. However, 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 2018 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 and sea snakes occur in the general area, only sea snakes and occasionally turtles are encountered in the trawl catches. Both species 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 2018 are:

Kimberley: 242 sea snakes were recorded as being caught, with 220 returned alive. Ten sawfish were recorded with all being returned to the sea alive and only one turtle was reported which was returned to the sea alive.

Broome: The fishery operates in relatively deep water, this combined with very little fishing effort and restricted trawl area, results in minimal interaction, and no interactions were reported.

Nickol Bay/Onslow: There were 14 sea snakes, four turtles and five sawfish reported as captured, with all returned to the sea alive.

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 these fisheries and controls on effort indicate that its environmental impact is likely to be low. The area fished in the four northern prawn fisheries ranged from 3.1% in the KPMF to <1% in the BPMF and OPMF, within the boundaries of these fisheries. **Low** risk.

Ecosystem

Prawn species are generally managed at relatively moderate levels of annual harvest, and this has declined in recent years for economic reasons. Therefore, 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 events. **Low** risk.

SOCIAL AND ECONOMIC OUTCOMES

Social

The estimated employment in 2018 was 40 to 60 people including skippers and other crew for all north coast prawn fisheries combined for a part of the year.

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 - $4.1 M, NPMF - $1.2 M, BPMF and OPMF - negligible.

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 two parts of the season. For the NBPMF, a conservative harvesting strategy of the banana prawn resource provides protection from recruitment overfishing, allowing adequate spawning biomass to survive to the key spawning period each year by opening the key fishing grounds in May. 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 prawn landings were within their allowable range as well as the predicted range whilst brown tiger and blue endeavour prawns were below their allowable ranges.

BPMF: 55 -260 t (**Acceptable**). Minimal fishing occurred in 2018.

NPMF: 90 - 300 t (**Acceptable**).

Banana prawns were just below the allowable range but within their predicted range whilst brown tiger prawns were in the lower end of their allowable range.

OPMF: 60-180 t (**Acceptable**). Effort and catch were low in 2018.

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 that operate within 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. 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.

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).

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NORTH COAST NEARSHORE AND ESTUARINE RESOURCE STATUS REPORT 2019

S. Newman, G. Mitsopoulos, C. Skepper, L. Wiberg

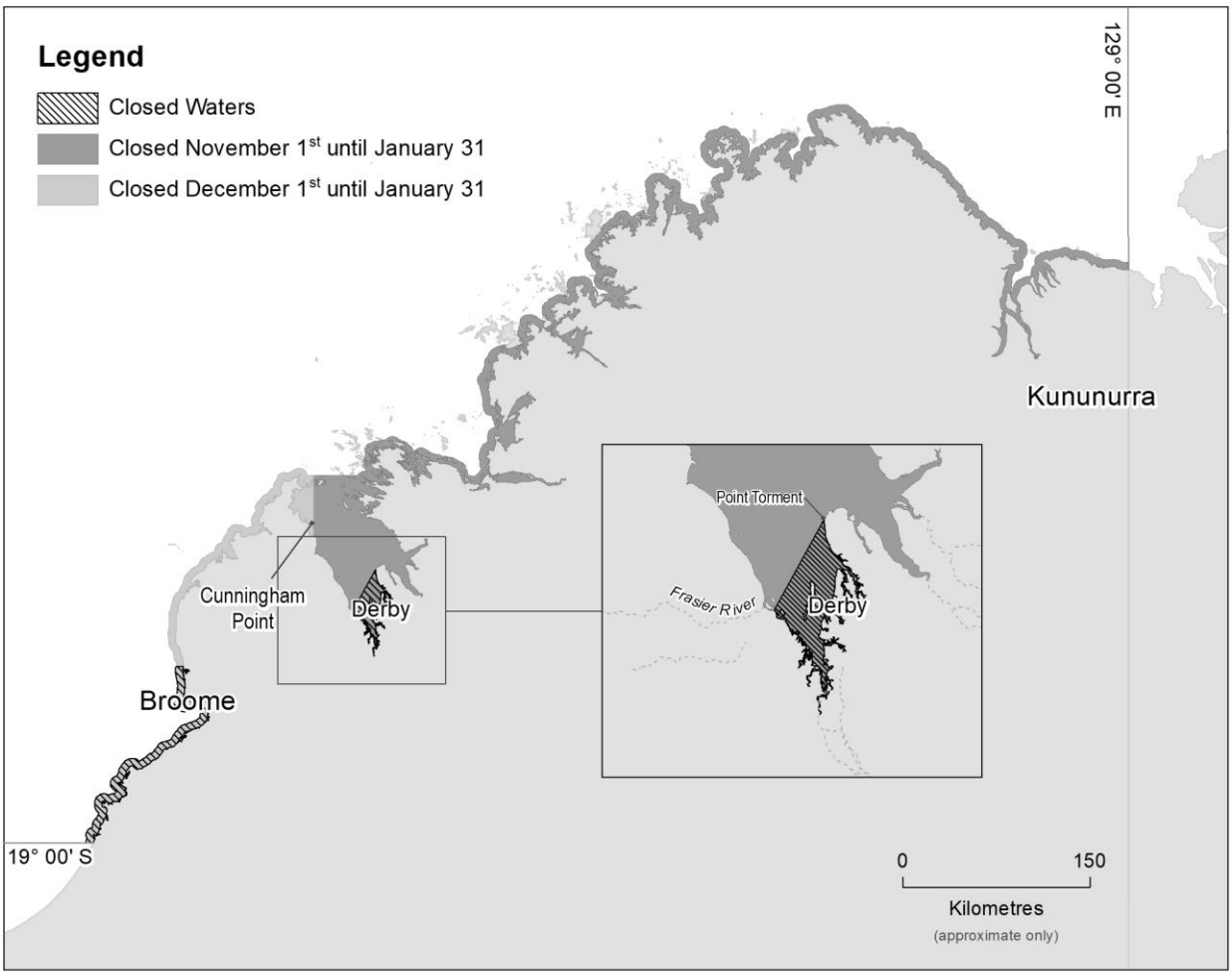
OVERVIEW

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, Whistle Creek and Admiral Bay, and the lower Ord River upstream of Adolphus Island.

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (Barramundi 33-44t)	Total Catch 2018: 91.8t	Acceptable
Recreational fishery	Total Catch 2017/18: 15–26 t (boat-based only)	Acceptable
EBFM		
Indicator species		
KGBF	Medium Risk	
Barramundi	Above target and limit catch range, catch rates are the highest reported, 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 2018 was 91.8 tonnes (t) (North Coast Nearshore and Estuarine Table 1). The total landings of barramundi in 2018 were 60.1t (North Coast Nearshore and Estuarine Table 1, Figure 2), an increase on the 2017 catch of 52.6t, and the highest recorded catch since 1987. The 2018 landings of threadfin from the KGBF were 23.9t (North Coast Nearshore and Estuarine Table 1, Figure 2), higher than the 21.4t reported in 2017.

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 2018 was 60.1t, above the target catch range and also the limit range. The catch rate increased from 115.8 kg/block day in 2017 to 144.88 kg/block day in 2018 (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. Catch of king threadfin in 2018 was 23.1t, an increase from the 20.5t reported in 2017 and well below the average of 74.5t for the 10-

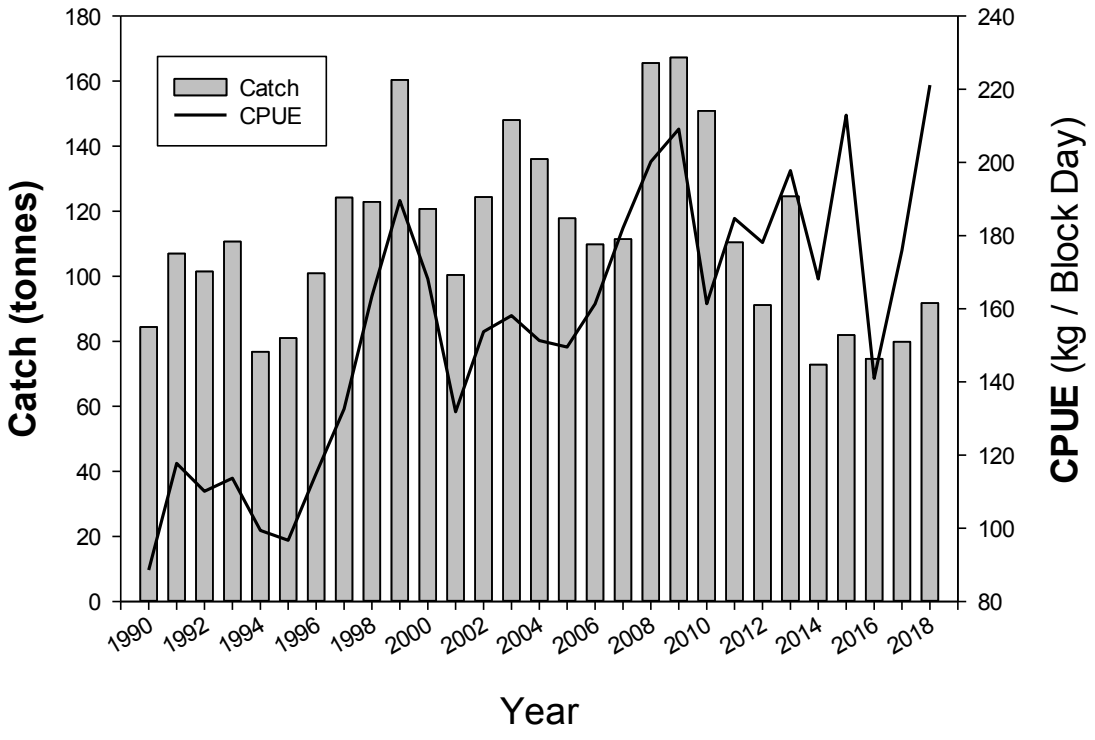
year period from 2004–13. This is due to the low effort levels now demonstrated in the fishery, following the removal of two fishing licenses from the Broome coast area, with the area closed to commercial fishing in late-2013. The lower commercial catches in recent years (post closures) are relatively 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**.

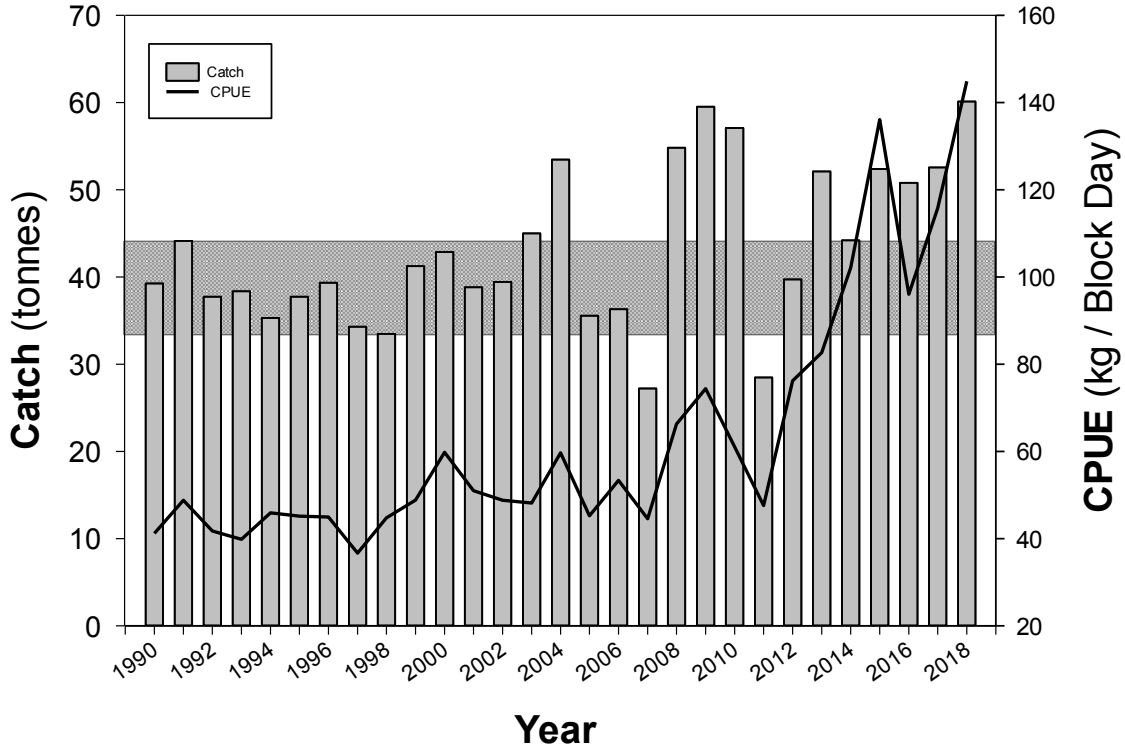
NORTH COAST NEARSHORE AND ESTUARINE TABLE 1
Summary of the reported catch (t) in the Kimberley Gillnet Barramundi Fishery in 2018 and the percentage composition of each of the major species retained.

Species	Catch (tonnes)	Composition %
Threadfin	23.9	26.1
Barramundi	60.1	65.5
Tripletail	0.5	0.6
Black jewfish	4.0	4.4
Sharks*	0.2	0.2
Other fish*	3.0	3.2
Total	91.8	100

*Other fish includes Giant sea 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 2018.



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 2018. 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 2018, 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 2018 season (February to November), four vessels fished in the KGBF with an average crew level of approximately 2.4 people, with an estimate of at least nine 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 2018 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 2019

S. Newman, C. Wakefield, C. Skepper, D. Boddington and N. Blay

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*), rosy threadfin bream (*Nemipterus furcosus*), rankin cod (*Epinephelus multinotatus*), 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 *Northern Demersal Scalefish Resource Harvest Strategy 2017-2021* (NDSR 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 include 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 vessels, 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.

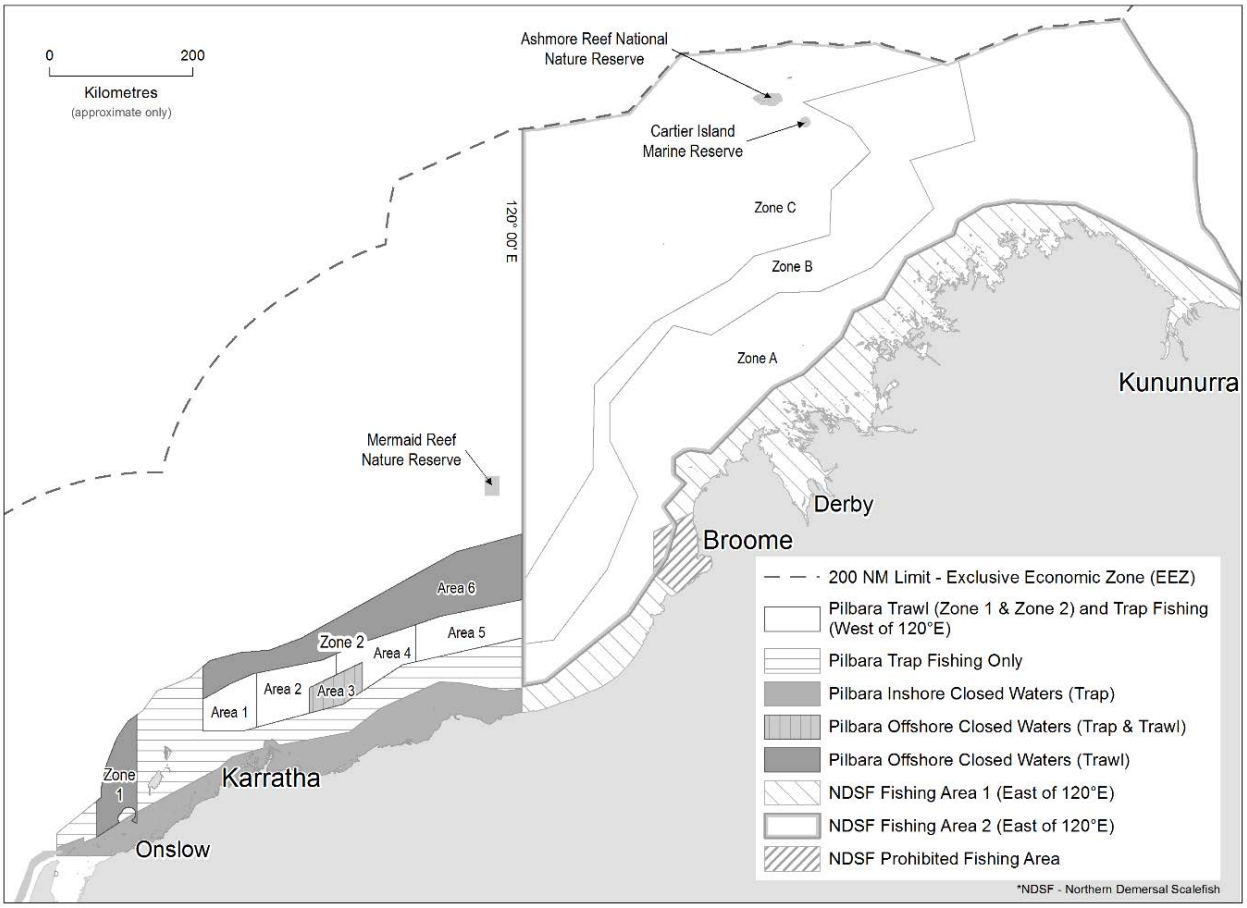
Recreational fishing activities in the NCB are mostly line-based fishing from private boats and charter vessels with effort concentrated around key population centres. The recreational fishery for demersal fish is managed through the use of input controls (e.g. recreational licences) and

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 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery: NDSF PDSF	Total Catch 2018: 1,297 t Total Catch 2018: 2,651 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 $5-10 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 2018 catch of 1,297 t is within the acceptable catch range of 903 to 1,332 t (see Allowable Catch Tolerance Levels) for the fishery. Total catches in each zone (A, B and C) of the NDSMF were also within the range of those recorded since 2008. The majority of the catch is landed from Zone B, with a catch of 1,106 t in 2018. The level of catch in Zone B is the highest reported since zoning was implemented in 2006. 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 2018 (2,651 t), 75% (1,996 t) were landed by the trawl sector, with 21% (563 t) taken by the trap sector and 3% (93 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 2018, 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 457 t and 106 t per year, respectively. The total catch of the trap fishery slightly exceeded the acceptable catch

range in 2018 (i.e. 241-537 t), and was within 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 2020/2021, 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 2016 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 will be processed and used to update the stock assessments in 2019. 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 2018.

Species	Pilbara (PDSF) catch		Kimberley (NDSMF) catch		Total catch
	tonnes	% total	tonnes	% total	tonnes
Goldband snapper (all *Pristipomoides* sp.)	189.1	28	497.8	72	686.9
Bluespotted emperor	381.5	89	44.9	11	426.4
Red emperor	191.4	57	146.9	43	338.3
Saddletail snapper	111.3	37	187.1	63	298.4
Crimson snapper	230.9	78	66.7	22	297.6
Rankin cod	134	75	45.3	25	179.3
Brownstripe snapper	154.9	93	11.3	7	166.2
Rosy threadfin bream	195.4	99.9	<0.1	0.1	195.4
Spangled emperor	36.3	54	31.0	46	67.3
Moses snapper	47.1	81	10.8	19	57.9
Frypan snapper	59.2	99.9	<0.1	0.1	59.2
Barcheek coral trout	18.7	75	6.4	25	25.1
Ruby snapper	1.3	99.9	<0.1	0.1	1.3
Longnose emperor	5.8	57	4.4	43	10.2
Other demersal scalefish	894.4	79	244.2	21	1138.6
Total all demersal scalefish	2651.2	67	1,296.9	33	3948.1

BYCATCH AND PROTECTED SPECIES INTERACTIONS

Kimberley Trap / Pilbara Trap

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.

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 2018, the Kimberley trap fishery reported ~213 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

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**.

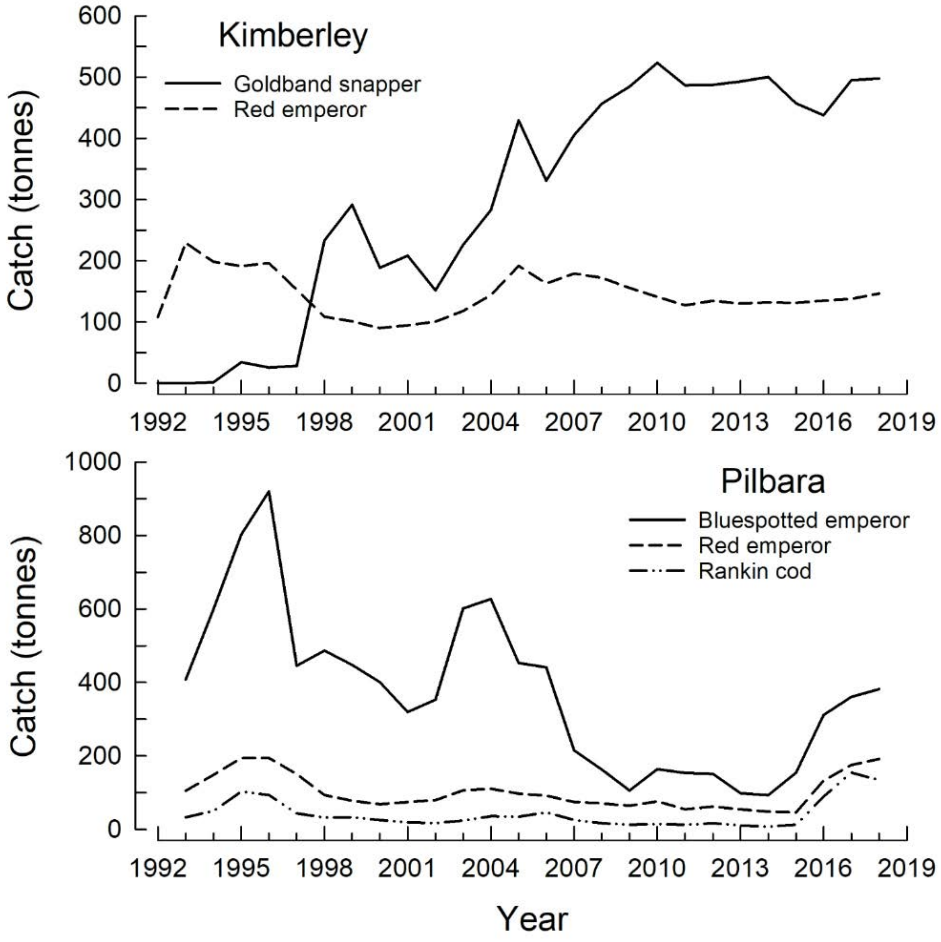
The use of Bycatch Reduction Devices (BRDs) has been mandatory in the PFTIMF since 2006. BRDs are highly effective in reducing reptile (turtles and sea snakes) bycatch. Bottlenose dolphin interactions with BRDs are rare (5.2 per

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 2018 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 2018. [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	3	17	0	20
Pipefish	3	13	0	16
Green sawfish	13	24	0	37
Narrow sawfish	3	1	0	4
Unknown sawfish[b]	2	2	0	4
Seahorses	2	5	0	7
Sea-snakes	51	24	0	75
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 2018.

HABITAT AND ECOSYSTEM INTERACTIONS

Kimberley Trap / Pilbara Trap and Line

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.

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

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.

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: Six vessels fished in the 2018 fishing season, and at least 20 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 2017 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 $5-10 million (Level 3). 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. Social amenity is low because there is little recreational fishing for these offshore species and no specific broader community interests.

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 NDSR 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 2018 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 2018 catches were within the **acceptable** catch range.

Pilbara

The total catch of the trawl fishery slightly exceeded the acceptable catch range in 2018 despite having the same (reduced) annual effort allocations as those imposed since 2008. This increased catch represents an increase in stock abundance following nine years of reduced effort in the western trawl managed areas. The total catch in 2018 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 2016/17, the Department collaborated with permit holders in the Pilbara Fish Trawl Interim Managed Fishery to address the conditions of the re-accredited Wildlife Trade Operation (WTO) approval; this included a logbook validation program, through electronic monitoring.

In 2018/19, the Department will be working with the Commonwealth Department of Environment and Energy and Pilbara Trap licence holders to complete an assessment of the Pilbara Trap Fishery under the EPBC for export approval to secure 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.

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PEARL OYSTER MANAGED FISHERY RESOURCE STATUS REPORT 2019

A. Hart, D. Murphy, S. Blazeski and A. Steele

OVERVIEW

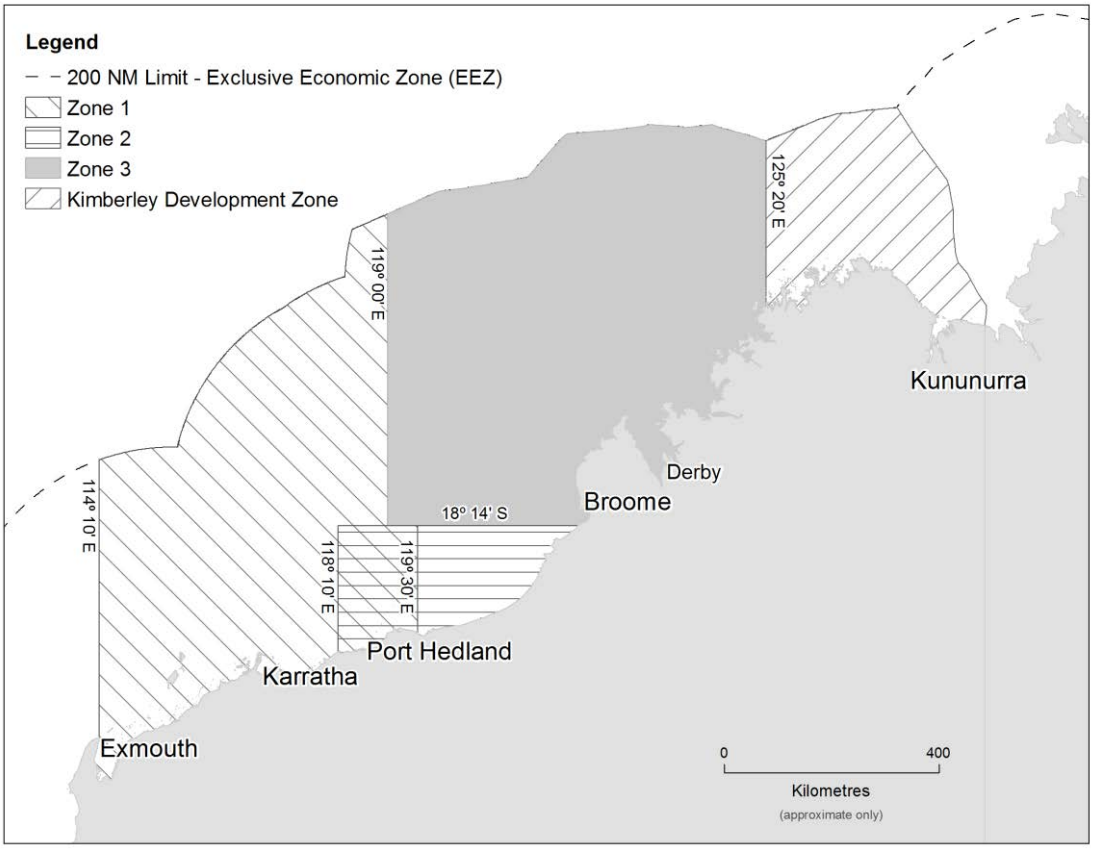
The Western Australian pearl oyster fishery (fishery) is the only remaining significant wild-stock fishery for pearl oysters in the world. It is a quota-based dive fishery, operating in shallow coastal waters along the north coast bioregion and targets the silver lipped pearl oyster (*Pinctada maxima)*. 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 2019

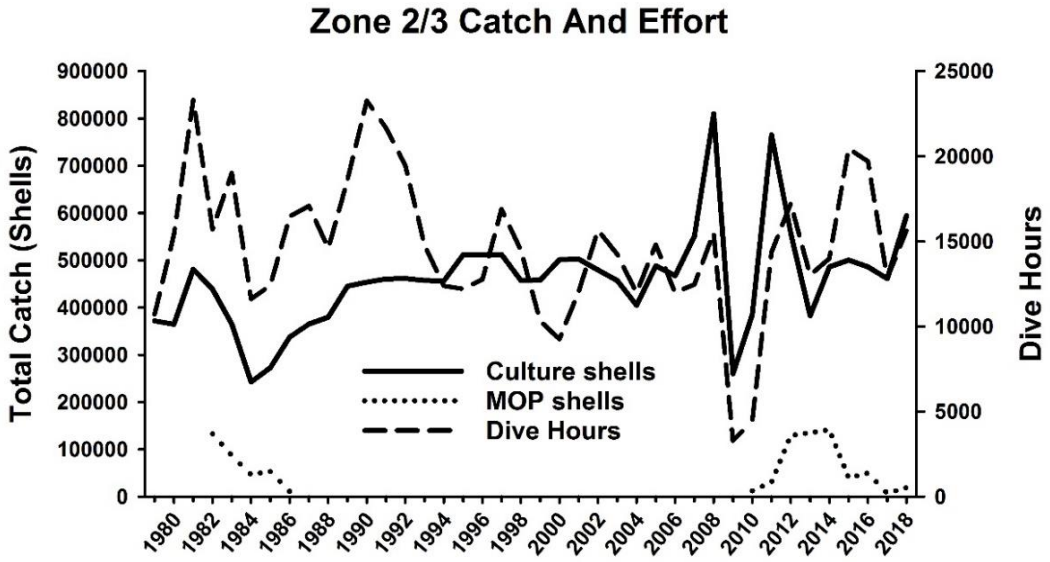
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total catch 2018: 614,002 shells	Acceptable
Recreational fishery	NA	NA
EBFM		
Assessment Indicator		
Silver lipped pearl oyster (*Pinctada maxima*)	Performance indicator above Target	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
Listed Species	Negligible Risk	Adequate
Habitat	Negligible Risk	Adequate
Ecosystem	Negligible Risk	Adequate
Economic (Level 4: GVP $64 M)	Moderate Risk	Acceptable
Social	Low Risk	Acceptable
Governance	MSC certification.	Acceptable
External Drivers	Moderate Risk	Acceptable



PEARL FIGURE 1
Map showing boundary of Pearl oyster fishery.

CATCH AND LANDINGS

In 2018, catch was taken in Zones 2 and 3 with no fishing in Zone 1. The number of wild-caught pearl oysters was 614,002 comprising of 594,468 culture shells and 19,534 Mother of Pearl (MOP) shells (oysters ≥175 mm) (Pearl Figure 2). Total effort was 15,637 dive hours (Pearl Figure 2), an increase of 22% from the 2017 effort of 12,845 hours. Of this total effort, 14,552 hours was focused on culture shell fishing, and the remaining 1,085 hours was applied to MOP fishing. No fishing occurred in Zone 1 in 2017 and 2018 with only 4,594 culture shells taken in 2016.



PEARL FIGURE 2
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 minimal 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 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 above the threshold level, and size-structure of harvested oysters having 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 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 minimal 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 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 16 in 1997 (overall), mostly due to increased fleet efficiency and increased reliance on hatchery-produced pearl oysters. The number of vessels fishing in 2018 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 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 2018 was considered to be approximately $63.5 million, which follows a similar trend to the value reported over the past five years.

GOVERNANCE SYSTEM

Annual Catch Tolerance Levels (Acceptable)

The overall TAC for the fishery for 2018 was 749,610 pearl oysters. This was comprised of a Zone 1 TAC of 54,970 pearl oysters and a Zone 2/3 TAC of 694,640 pearl oysters. The Zone 2/3 TAC is further broken down into an industry maximum harvest level of no more than 639,800 pearl oysters between 100 – 175mm and 54,840 MOP oysters.

Catch tolerance levels used in 2018 are for the Zone 2/3 “culture” fishery only.

TAC (646,000 “culture pearl oysters” in Zone 2/3 in 2019) to be caught in 14,071-20,551 dive hours.

Commercial catch (pearl oysters) for season 2018: 614,002 oysters at 15,637 dive hours.

Both the catch and effort levels were acceptable.

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 relation 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 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 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

A new State Act of Parliament to ensure the sustainability and management of all WA’s aquatic biological resources is currently being considered by Parliament. The *Aquatic Resource Management Act 2019* will replace both the *Fish Resources Management 1994* and the *Pearling Act 1990.* The Department is reviewing the current legislative framework ahead of the introduction 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 at moderate-high risk to climate change effects due to environmental factors affecting the abundance of piggyback spat settlement.

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SEA CUCUMBER RESOURCE STATUS REPORT 2019

A. Hart, D. Murphy, and A. Steele

OVERVIEW

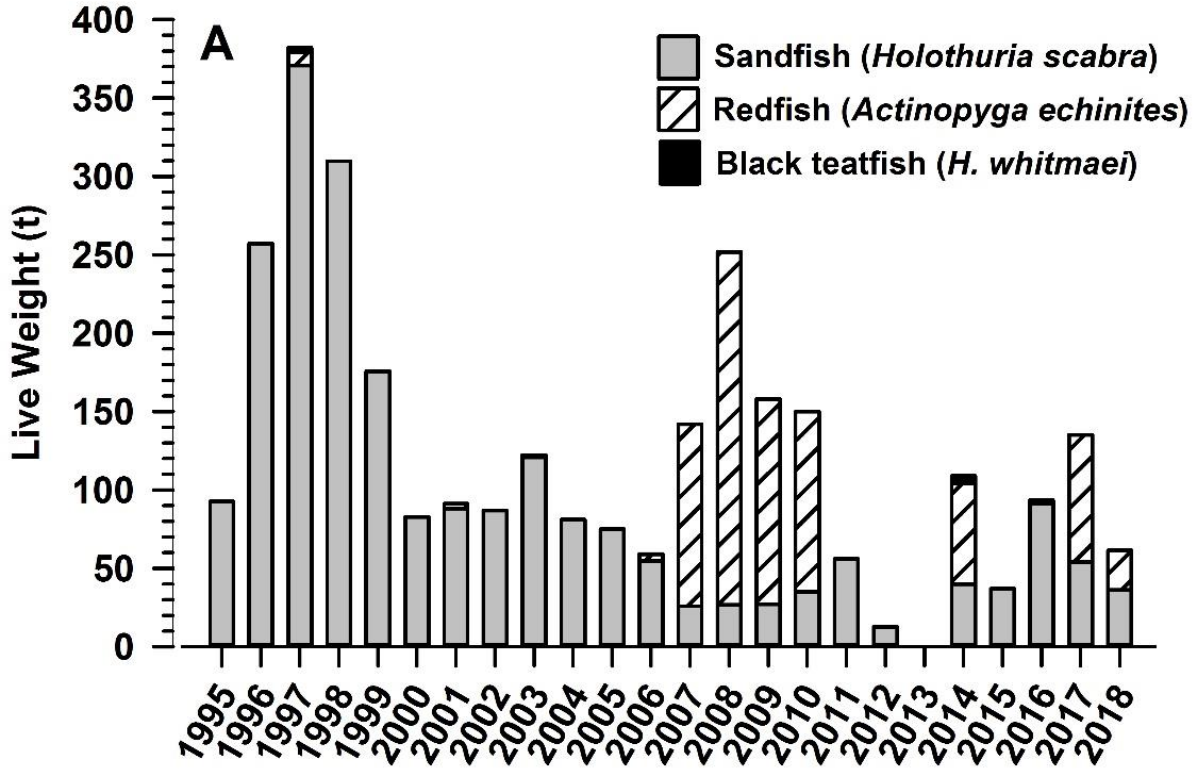
The Western Australian Sea Cucumber fishery is a commercial only fishery, with animals caught principally by diving, and a smaller amount by wading. It targets two main species: sandfish (*Holothuria scabra)* and redfish (*Actinopyga echinites)*. Fishing occurs in the northern half of the State from Exmouth Gulf to the Northern Territory border and 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. This fishery is undergoing assessment for Marine Stewardship Council certification. For further details on the assessment and management of this fishery see the RAR at www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_12.pdf.

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2018: 62 t	Acceptable
Recreational fishery	Total Catch 2018: NA	Acceptable
EBFM		
Indicator species		
Sandfish Catch (Kimberley): 0-100 t	0 t	Adequate
Sandfish Catch (Pilbara): 0-80 t	36.2 t	Adequate
Redfish Catch (Pilbara): 0-150 t	25.4 t	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

LANDINGS

In 2018, both species were targeted, with a total catch of 62 t (Sea Cucumber Figure 1). This catch comprised 36.2 t of sandfish (*H. scabra)* and 25.4 t of deepwater redfish (*A. echinites*). This was lower than the 2017 total of 135 t (sandfish - 54 t; deepwater redfish – 81 t). The industry has adopted a rotational fishing strategy for both sandfish and redfish with limited catch taken for either species in 2012 and 2013, and no fishing for sandfish in the Kimberley in 2018.



SEA CUCUMBER FIGURE 1:
Annual total retained catches (tonnes) in the Western Australian Sea Cucumber Fishery (WASCF) between 1995 and 2018.

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 LOW. 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 low levels.

Pilbara Redfish (Sustainable - Adequate)

Based on the information and analyses available, the current risk level for Pilbara redfish was estimated to be LOW. 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 (medium) levels.

BYCATCH and PROTECTED SPECIES INTERACTIONS (Negligible Risk)

Given the hand only method of fishing no bycatch is taken by the fishery and there are no known protected species interactions.

HABITAT and ECOSYSTEM INTERACTIONS (Negligible Risk)

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. 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.

SOCIAL AND ECONOMIC OUTCOMES

Social effects (Low Risk)

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.

Economic (Low Risk)

The estimated annual value for 2018 was $263,500 based on a total live weight of 62 tonnes and $4.25 per kg. This is only a beach-price value and the processing sector adds significant value.

GOVERNANCE SYSTEM

Annual Catch Tolerance Range (Acceptable)

Commercial: Sandfish(Kimberly): 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.

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, with the Kimberly region currently under review.

EXTERNAL DRIVERS

The remoteness of the currently fished stock and the large tidal ranges where it occurs are natural barriers to uncontrolled expansion of fishing. Marine park planning has to date restricted this fishery from general use zones of some MPAs. Currently, 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 2019

D. Johnston, D. Yeoh and R. Jones

OVERVIEW

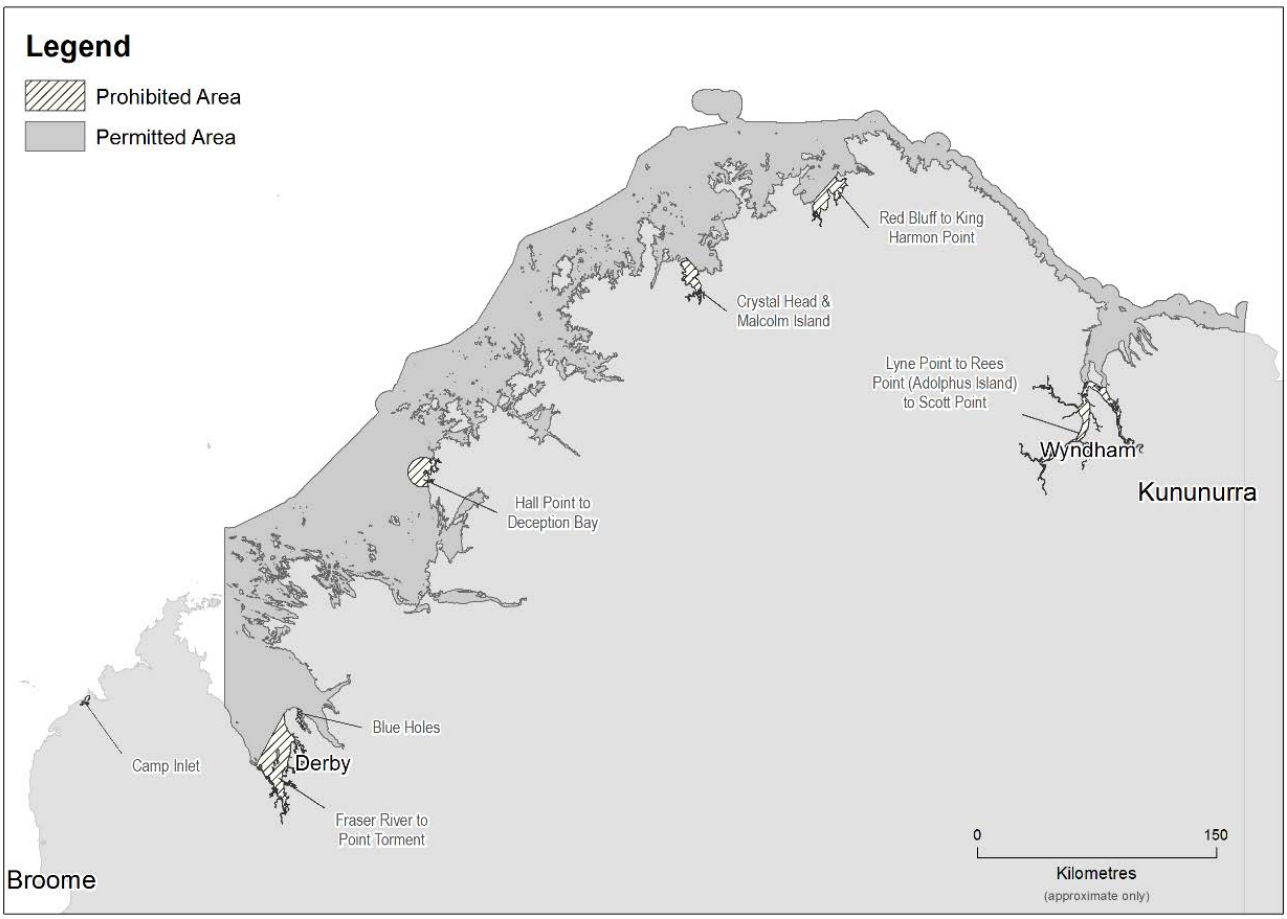
Blue swimmer crabs (BSC) are targeted by the Pilbara Developing Crab Fishery within inshore waters around Nickol Bay using hourglass traps. Recreational fishers for this species use drop nets or scoop nets, with diving for crabs becoming increasingly popular.

Mud crabs (MC) are harvested by the Kimberley Developing Mud Crab fishery using crab traps between Broome and Cambridge Gulf, and Aboriginal Body Corporate Commercial Mud Crab Exemption holders using crab traps and drop nets in waters adjacent to their native title lands. There is also a small recreational fishery for mud crabs.

Management arrangements for the commercial and recreational fisheries of both BSC and MC in the Pilbara and Kimberley, respectively, include minimum size, protection of breeding females, and effort controls, spatial and temporal closures for the commercial fishery (Johnston *et al*., 2015). Further information can be found in the RAR (www.fish.wa.gov.au/Documents/research reports/frr306.pdf)

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2018: 35 t BSC Total Catch 2018: 3.2 t Mud Crab	Acceptable Acceptable
Recreational fishery	Total Catch 17/18 (boat-based only) 1–2 t BSC 2–3 t Mud Crab	 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 North coast crab resource.

CATCH AND LANDINGS

Commercial Sector

The total commercial catch of blue swimmer crabs and mud crabs in the North Coast Bioregion for 2018 was 38 t which was a decrease of 37% from 2017.The North Coast catch accounts for approximately 6% of the State total commercial blue swimmer crab catch of 606 t for 2018. The State total catch of blue swimmer crabs in 2018 was similar to that landed in 2017.

The catch of mud crab for the Kimberley Crab Managed Fishery represents the entire commercial mud crab catch landed in WA in 2018. In 2018 the majority of catch was recorded as green mud crab, while a small proportion was recorded as brown mud crab.

Recreational Sector

The estimated boat-based recreational catch of blue swimmer crab in the North Coast represented approximately 3% of the statewide boat-based recreational catch (kept by numbers) in 2017/18. The estimated recreational harvest range for Blue Swimmer Crab in the North Coast was steady at 1.6 t (95% CI 1–2) in 2017/18 compared with 1.7 t (95% CI 1–3) in 2015/16 and 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 estimated recreational harvest range of Mud Crab in the North Coast 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 6.5 t (95% CI 5–8) in 2013/14 and 7 t (95% CI 5–9) in 2011/12 (Ryan *et al*. 2019).

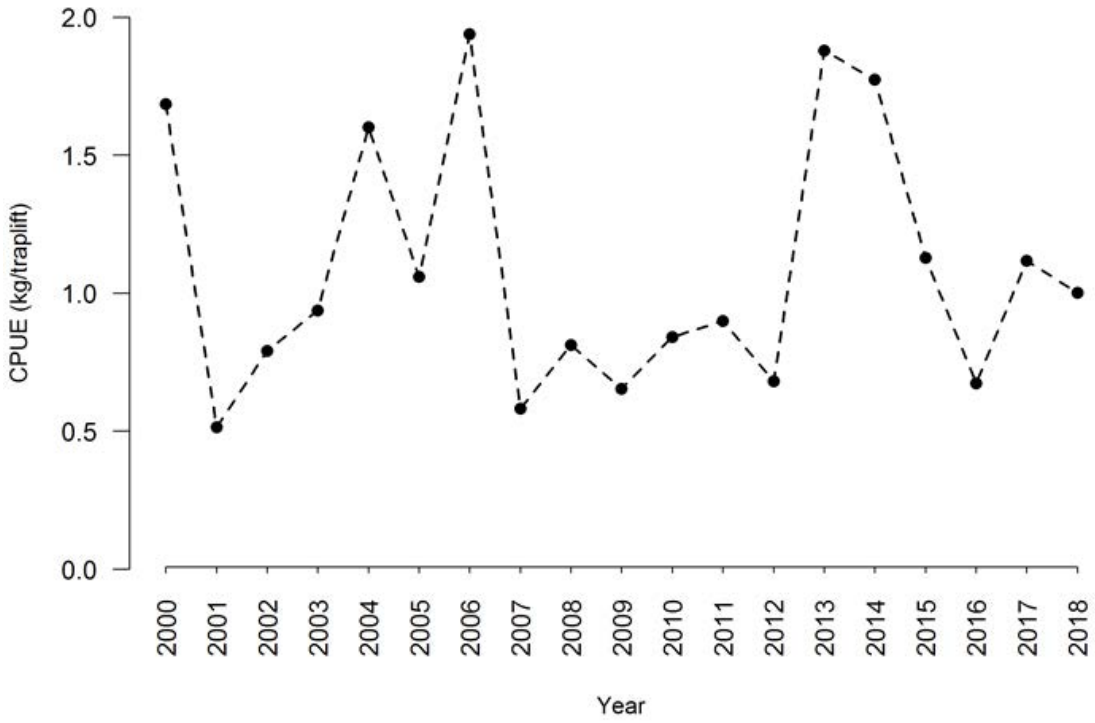
INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Blue Swimmer Crabs (Sustainable-Adequate)

Catch rates from the Pilbara Crab Managed Fishery provide an index of abundance to assess fishery performance. Catch rate increased

significantly in 2013 and 2014 (1.8 -1.9 kg/traplift), but declined to 1.1 kg/traplift in 2015 and 0.8 kg/traplift in 2016, and increased to 1.1 kg/traplift in 2017 (North Coast Crab Figure 2).

The fishery recorded a mean nominal catch rate of 1 kg/traplift in 2018, which represented a 10% decrease in the catch rate from 2017 but remained above the preliminary harvest strategy threshold of 0.6 kg/traplift, indicating there should be adequate egg production under typical environmental conditions. Therefore, the breeding stock is considered **sustainable-adequate**.



NORTH COAST CRAB FIGURE 2.
Annual commercial trap catch per unit effort (CPUE) (kg/traplift) for the Pilbara Blue Swimmer Crab (Portunus armatus) fishery since 2000. Since late 2018, the Pilbara Crab Managed Fishery has been managed under the Pilbara Crab Managed Fishery Management Plan 2018. Prior to this it was managed as a developing fishery by exemption (since 2006) and prior to 2006 via a Fishing Boat Licence condition.

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.

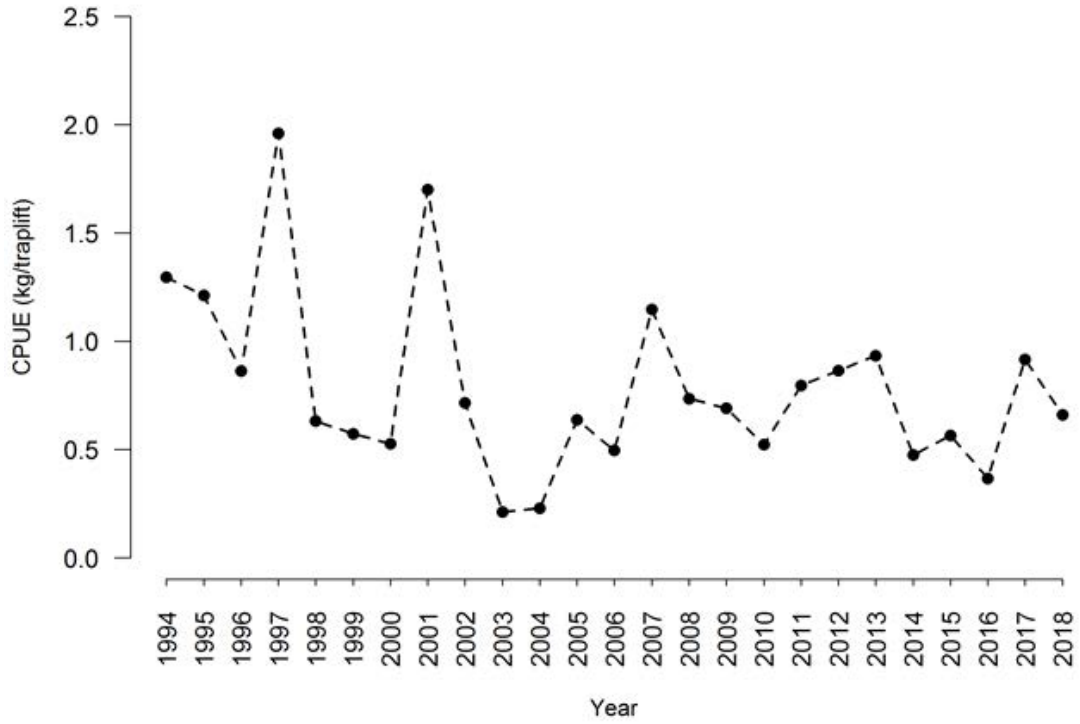
The minimum legal size is 150 mm CW for green mud crab (Scylla serrata) and 120 mm CW for brown mud crab (Scylla olivacea). These are set well above the size at first maturity of 90-120 mm CW for green and 86-96 mm CW for brown mud crab in the North Coast Bioregion. Consequently, breeding stock levels are expected to be adequate to maintain stocks in all current fishing areas under normal environmental conditions.

Catch rates between 2012 and 2015 fluctuated between 0.48 and 0.9 kg/traplift, with a nominal catch rate of 0.37 kg/traplift reported in 2016. This represented a significant (34%) decline from 2015 (0.56 kg/traplift), and was below the (draft) harvest strategy threshold of 0.48 kg/traplift (North Coast Crab Figure 3). The nominal catch rate in 2017 was 0.92 kg/traplift, a considerable increase on the mean catch rate in 2016 and well above the (draft) harvest strategy threshold.

Considering the proximity of the 2016 catch rate to the limit reference level, this fishery was closely monitored during the 2017 season. Catch, effort and catch rates increased in the 2017 season suggesting that stocks are currently being fished at sustainable levels. A nominal catch rate of 0.66 kg/traplift was recorded for 2018, which is a 28% decrease from 2017 but remains above the harvest strategy threshold. The above evidence indicates that the biomass in this management unit is unlikely to be recruitment overfished and that current levels of fishing mortality are unlikely to cause the management unit to become recruitment overfished.

Catch and effort has been at such a low level in recent years, that based on the relatively small

impact of commercial operations, the wide distribution of the species throughout the region, and the minimum legal size set well above size at maturity, the risk to sustainability has been considered to be negligible and currently the breeding stock is considered **sustainable-adequate**. The stock is classified as **sustainable** and the level of fishing is considered **acceptable**.



NORTH COAST CRAB FIGURE 3
Annual commercial trap catch per unit effort (CPUE) (kg/traplift) for combined green and brown mud crabs in the Kimberley Region since 1994 when permissive conditions of fishing boat licenses were issued. Since late 2018, the Kimberley Crab Managed Fishery has been managed under the Kimberley Crab Managed Fishery Management Plan 2018. Prior to this it was managed as a developing fishery by exemption (since 2006) and prior to 2006 via a Fishing Boat Licence condition.

BYCATCH and PROTECTED SPECIES INTERACTIONS

Blue Swimmer Crab

The shift from using set nets to traps in most blue swimmer crab 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.

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

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 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 regularly, and undersized and berried crabs must be returned to the water.

As 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 a **negligible** risk.

HABITAT and ECOSYSTEM INTERACTIONS

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 capture of benthic organisms and only minor dragging of traps on the sea floor occurring in 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.

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 2018, three people were employed as skippers and crew on vessels fishing for blue swimmer crabs along the Pilbara coast. 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 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 2018, 6 people were employed as skippers and crew on vessels fishing for mud crab in the Kimberley Developing Mud Crab Fishery, with effort concentrated between June and September.

Economic

The estimated gross value of product (GVP) for the crab fishery within the Northern Bioregion for 2018 was approximately $282 k (**Level 1** <$1million). The value for blue swimmer crabs was approximately $200 k and mud crabs was approximately $82 k.

Blue Swimmer Crabs: The average beach price for trap caught blue swimmer crabs across all Western Australian fisheries for the 2017/18 financial year was around $6.16/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 (uncooked) mud crabs in the Kimberley for the 2017/18 financial years was around $25.34/kg. 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 control, legal minimum size well below the size at maturity, spatial and temporal closures.

Blue Swimmer Crab

A preliminary harvest strategy has been determined for the Pilbara Developing Crab Fishery where the primary performance indicator is nominal annual commercial catch rates, specifically within the Nickol Bay area due to the majority of fishing historically occurring in this area. The reference period is between 2005 and 2011 as defined by the period when the developing fishery status commenced but following the period of 2001-2004 when exploratory fishing occurred.

As the indicator was above the threshold in 2018, no changes to the management of the fishery occurred for the 2019 season.

Mud Crab

A preliminary harvest strategy has been determined for the Kimberley Developing Mud Crab Fishery where the primary performance indicator is nominal annual commercial catch rate. The reference period is between 2006 and 2011 as defined by when the developing fishery status commenced under exemptions.

As the indicator in 2016 was below the threshold but above the limit, the fishery was closely monitored to ensure adequate stock protection in the 2017 season. As the indicator was above the threshold in 2017 and 2018, no changes to the management of the fishery occurred in the 2019 season.

Annual Catch Tolerance Levels

Pilbara BSC: n/a

Kimberley Mud Crab: n/a

Blue Swimmer Crab

While no formal tolerance range has been developed for the Pilbara Developing Crab Fishery current effort levels in the fishery are considered acceptable. Fishing effort in this region is limited by very hot weather experienced during the summer months, which generally restricts fishing effort to between April and November.

Mud Crab

While no formal tolerance range has been developed for the Kimberley Crab managed Fishery, current effort levels in the fishery are considered acceptable. This fishery is currently being fished at low/precautionary levels due to the low number of fishers operating in the fishery and relatively low effort across a large area of the Kimberley.

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 new Management Plan was implemented for the then Kimberley Developing Mud Crab fishery in late 2018. The Management Plan permits the take of Portunid crabs (including blue swimmer crabs).

A new Management Plan was also implemented for the then Pilbara Developing Crab Fishery in late 2018. An increase of 200 traps (total 600 traps) was allocated in 2016, with the traps able to be used across two vessels. As a precautionary measure to this increase in traps numbers, an annual season closure between 15 August and 15 November (inclusive) was implemented to protect berried and mated pre-spawning females.

EXTERNAL DRIVERS

Levels of recruitment to many of the 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.

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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.

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SOUTH COAST BIOREGION

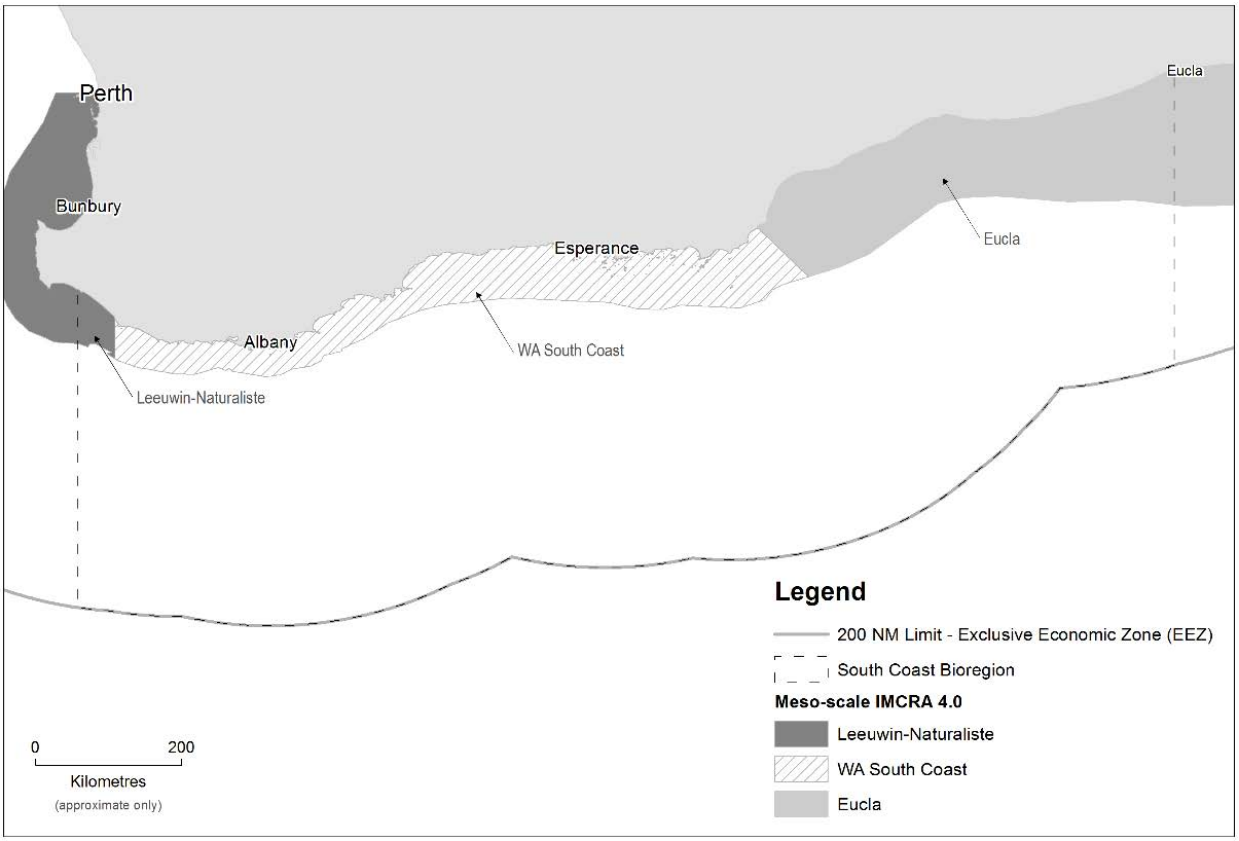
ABOUT THE BIOREGION

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 about 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: 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:

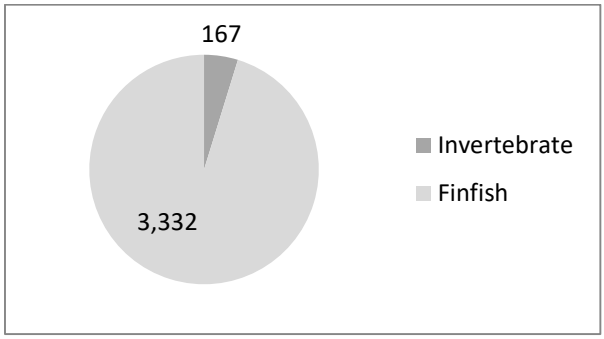
- Increasing frequency of *El Niño*/Southern Oscillation (ENSO) events;
- More years with a weaker Leeuwin Current;
- Increase in water temperature off the west coast of WA, particularly the lower west coast;
- Increase in salinity, which includes some large annual fluctuations;
- Change in the frequency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

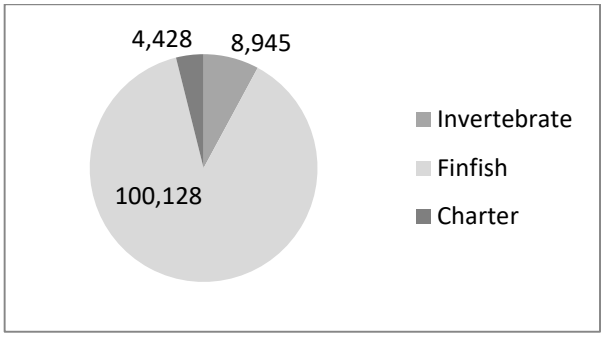


SOUTH COAST OVERVIEW FIGURE 2
Contribution of finfish and invertebrates to the total commercial wild fishery catch originating from the South Coast Bioregion. Numbers represent total catch (in tonnes) based on all major assessed fisheries identified in the Overview section of this report (South Coast 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 at Albany. This activity is restricted to this area 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 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. There is a current South Coast Aquaculture Project aiming to identify a network of suitable areas for aquaculture development, mostly focussed on shellfish including edible oysters. In addition, an offshore abalone farm near Augusta is 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.

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:

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.

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 (in collaboration with Murdoch University) of post-doctoral studies on the finfish community to assess current trends, movement ecology and development of a long term monitoring program for the finfish community within 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.

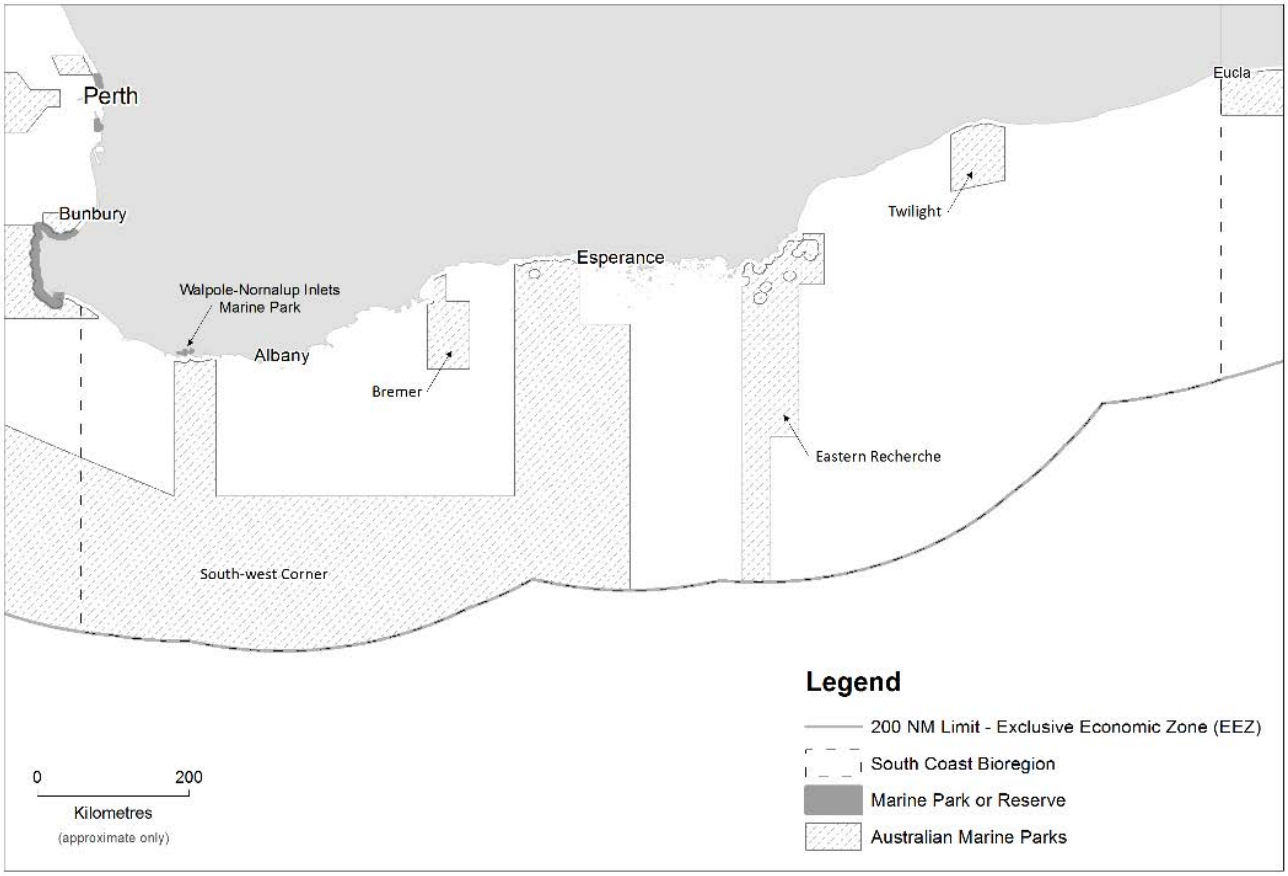
The Commonwealth Government's Marine Bioregional Planning process for the South-West marine region (between Kangaroo Island, South Australia and Shark Bay) was implemented in July 2018. This has resulted in a number of Marine Protected Areas off the South Coast of WA (South Coast Overview Figure 5).

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	
	km2	%	km2	%	km2	%	km2	%
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

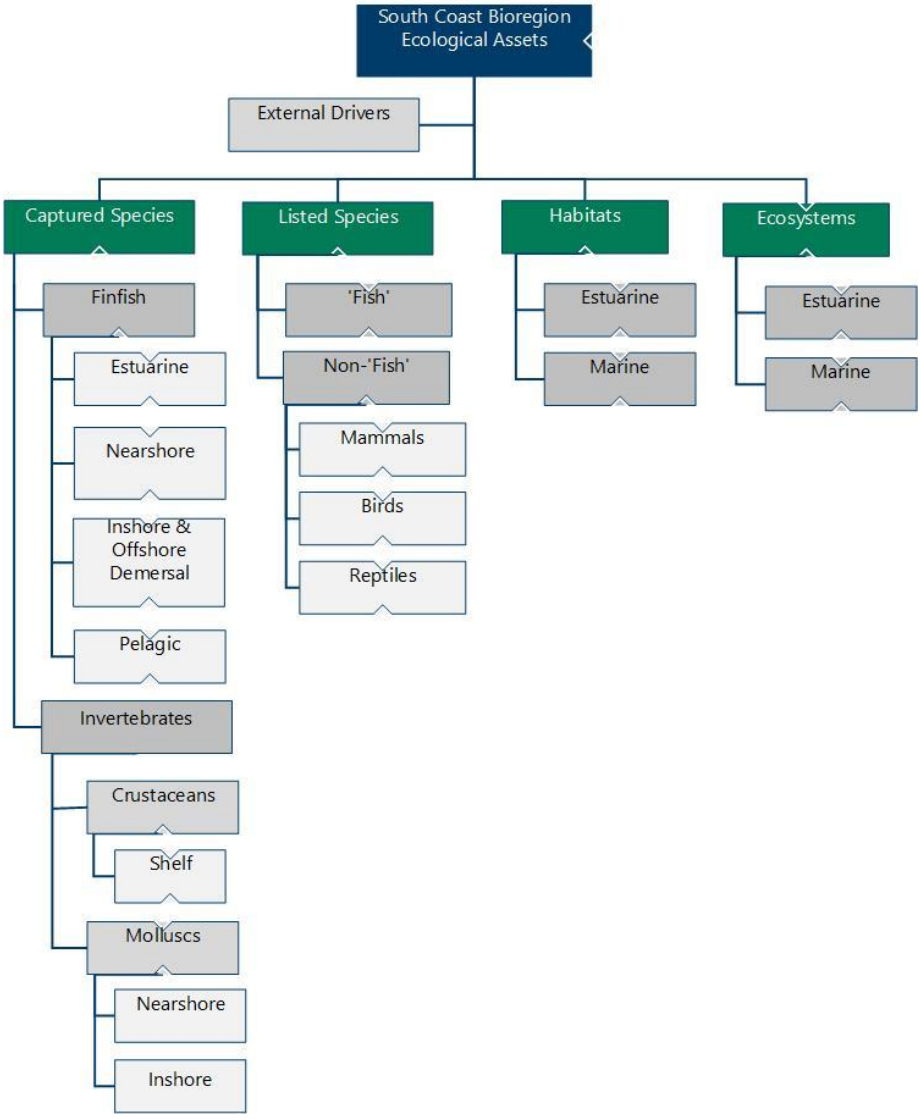
SOUTH COAST OVERVIEW FIGURE 4
Map showing the South Coast Bioregion and areas closed to trawling. The areas permanently closed to trawling are consistent with IUCN marine protected area category IV.



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 diseases1.

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 (e.g. 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

An NRM-funded project that concluded in 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 not returned to pre-virus levels.

INVERTEBRATES

Crustaceans

Captured species	Aquatic zone	Ecological Risk
Crustaceans	Shelf	HIGH

There are some concerns for lobsters and deep sea crabs, with catch rates showing declines. While crystal crab stocks are showing initial signs of recovery, to assist recovery potential effort reductions are being discussed.

Molluscs

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

There are concerns for stocks of abalone in some areas, however overall stocks are maintained at appropriate levels. 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

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.

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	NEGLIGIBLE

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

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. There are no reports of interactions with reptiles in this region.

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, thus, 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 2019

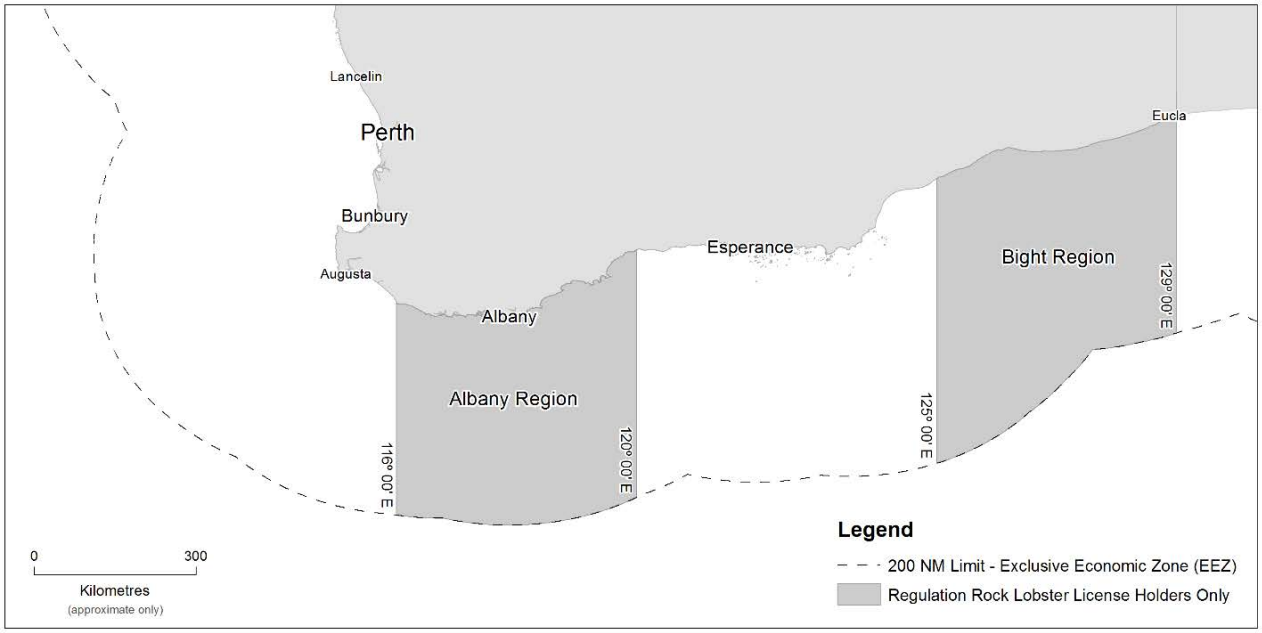
J. How and L. Orme

OVERVIEW

The South Coast Crustacean Managed Fishery (SCCMF) is a multi-species, effort-controlled pot based fishery, with catches of southern rock lobster (*Jasus edwardsii*) and western rock lobster (*Panulirus cygnus*) as well as deep-sea crab species namely, giant crab (*Pseudocarcinus gigas*), crystal crab (*Chaceon albus*) and champagne crab (*Hypothalassia acerba*).

SUMMARY FEATURES 2019

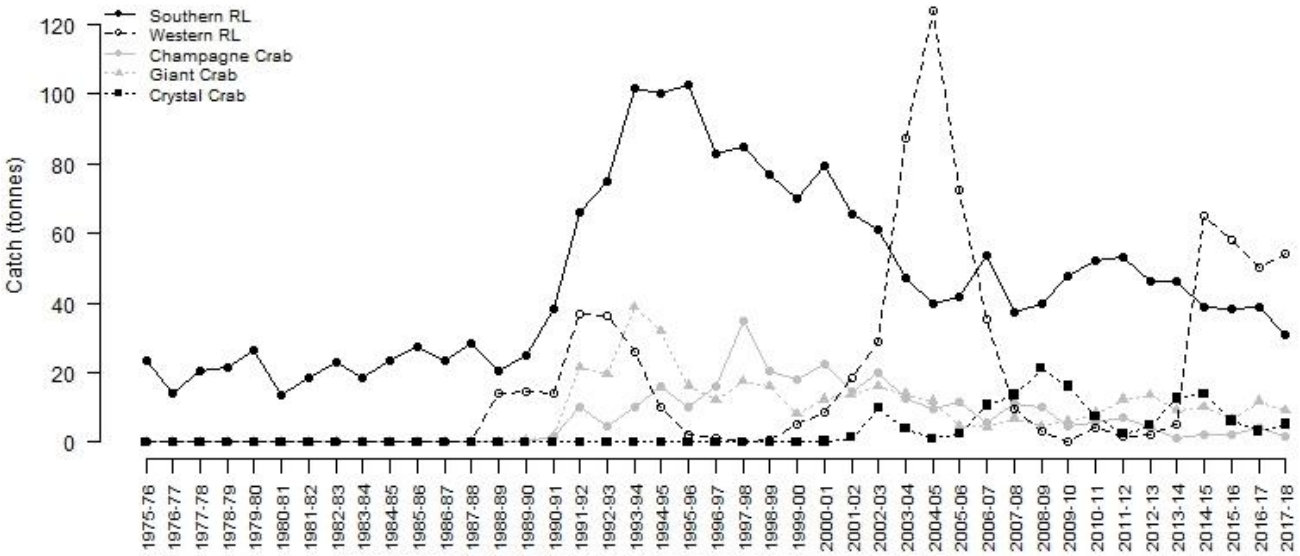
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (1977 pots)	Total Catch 2018: 101.2 t	Unacceptable Management Action Required
Recreational fishery	Total Catch 2018: <5 t	N/A
EBFM		
Indicator species		
Southern Rock Lobster	Above threshold	Adequate
Crystal Crab	Below limit	Inadequate
Western Rock Lobster	Above threshold	Adequate
Ecological		
Bycatch	Low Risk	Acceptable
Listed Species	Medium Risk	Acceptable
Habitat	Low Risk	Acceptable
Ecosystem	Low Risk	Acceptable
Economic (GVP $5.9 m)	Medium Risk	Acceptable
Social (Moderate amenity)	Medium Risk	Acceptable
Governance	Medium Risk	Unacceptable
External Drivers	Medium Risk	Acceptable



SOUTH COAST CRUSTACEAN FIGURE 1.
Map showing boundaries of the South Coast Crustacean Managed Fishery.

CATCH AND LANDINGS

The total landings of crustacean from this resource in 2017/18 accessed by the SCCMF was 101.2 t, comprising 31.0 t of southern rock lobster, 54.1 t of western rock lobster, and 5.1 t of crystal, 9.1 t giant and 1.8 t of champagne crabs (South Coast Crustacean Figure 1).



SOUTH COAST CRUSTACEAN FIGURE 1.
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 2017/18 have been above their historic averages (South Coast Crustacean Figure 1 and 2a). 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).

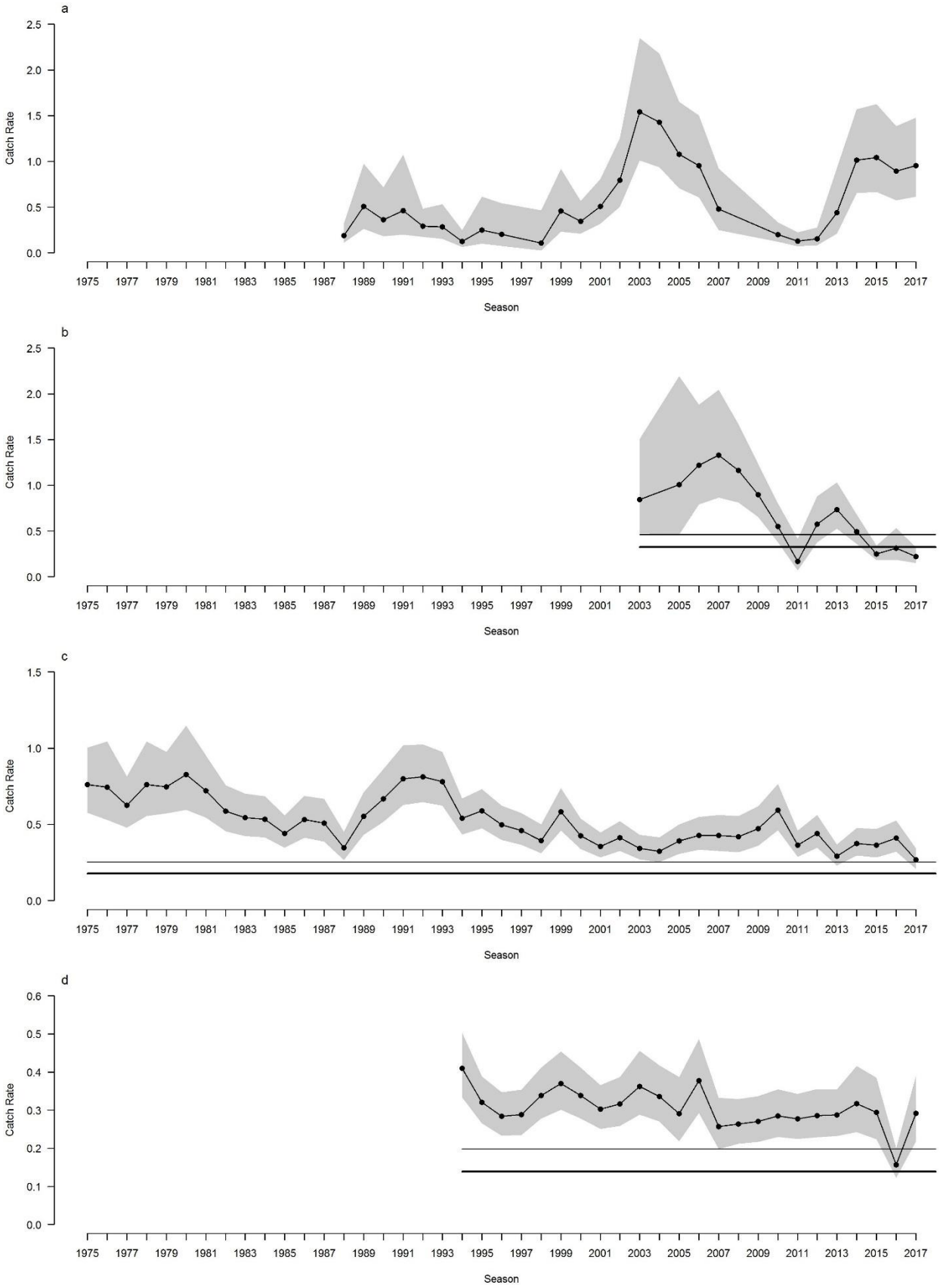
Landings of crystal crabs increased from 3.1 tonnes in 2016/17 to 5.1 tonnes in 2017/18 (South Coast Crustacean Figure 1). Catch rate data (standardised) from monthly returns, and (nominal) from volunteer logbook returns showed a decline in both metrics, resulting in the standardised catch rate being below the proposed limit reference point for crystal crab in Zone 2 (South Coast Crustacean Figure 2b). These catch rate levels are similar to those of the last three season, and in the 2017/18 season resulted in a slight increase catch. However, the current 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 caught (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 being sustainable (Linnane *et al*. 2014) and that the relative catches of southern rock lobster from WA are minimal. For more details see Linnane *et al*. (2014).

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 1).

Standardised commercial catch rates have declined to record-low levels in Zone 3 (Esperance) from the previous season though are just above the threshold reference level (South Coast Crustacean Figure 2c). Given the low catch and low catch rates, the fishery is being closely monitored and management options being considered. The Zone 4 (Bight) standardised commercial catch rate has improved from the very low catch rate in 2016/17 season and is now above the threshold level for this zone (South Coast Crustacean Figure 2d). It is therefore likely that the current level of overall stock depletion is **acceptable** and the SCCMF stock biomass is above its limit level and is therefore **sustainable-adequate**.



SOUTH COAST CRUSTACEAN FIGURE 2.
Seasonal standardised catch rate (line and closed circles with grey 95CI) 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 (Low risk):

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.

Protected Species (Moderate risk):

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. Consultation regarding management response on this matter has progressed, and arrangements are expected to be implements in the 2019/20 fishing season. In the 2017/18 season there were no ASL interactions attributed to the SCCMF.

In the 2017/18 season, there was one whale entanglement attributed to the SCCMF.

Turtles can also get caught in the float rigs of lobster pots. In 2017/18 no turtles were reported to have been entangled in fishing gear from the SCCMF.

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. Both of these fisheries have been assessed as having negligible food chain effects by the removal of crabs and lobsters respectively. 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. **Moderate** risk.

Economic

The beach value of the fishery was about $5.9 million in 2017/18 with the majority of the catch sold live to Asian markets both locally and internationally. **Moderate** risk.

GOVERNANCE SYSTEM

Harvest Strategy (Under Development)

A preliminary harvest strategy has been developed and will be formally presented to industry in upcoming seasons to endorse.

Annual Catch Tolerances

Southern Rock Lobster – 50-80 t

Current fishing level –Acceptable

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 may have in part contributed to the catch of 31 t for 2017/18 being below the level of 50-80 t of southern rock lobster.

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. Noting this, overall assessment of the SCCMF fishing levels is acceptable.

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 (Stable)

Management initiatives will primarily focus on the implementation and refinement of management arrangement pertaining to SLED zones and ASL mitigation measures. Management initiatives will also need to focus on possible effort reduction due to the most recent indicator species stock status and outcomes from future stock assessments. Research priorities will be on the application of a new stock assessment technique for the fishery, and understanding the linkages with fisheries targeting the same species on the West Coast.

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. **Moderate** risk.

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Linnane A, Gardner C, Reilly D, How J. 2014. 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 2019

L. Strain, F. Fabris and R. Jones

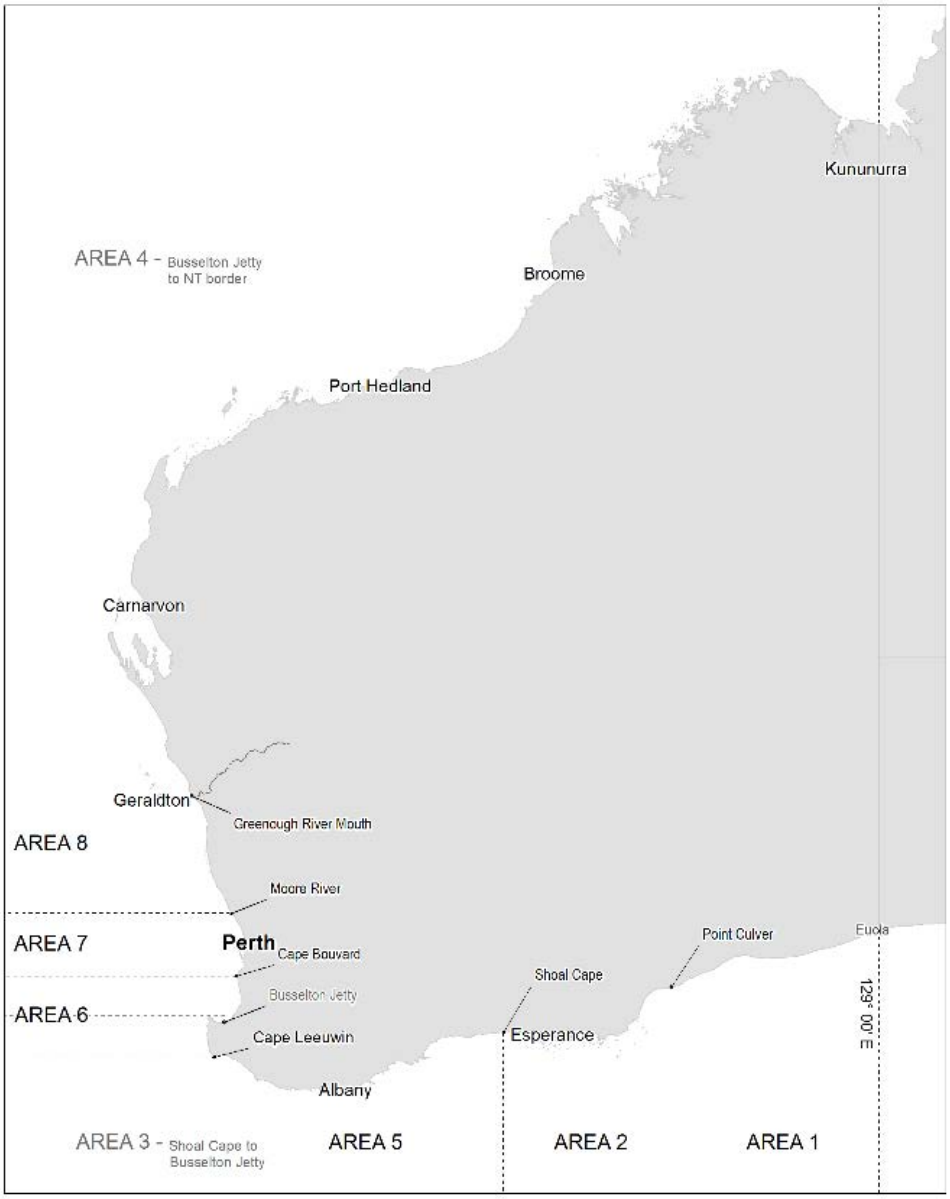
OVERVIEW

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 three management areas, which are allocated annually as Individually Transferable Quotas (ITQs).

Recreational fishing only occurs in the Southern Zone 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.* (2019).

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (74 t)	Total Catch 2018: 61 t	Management Action
Recreational fishery (not formal)	Total Catch 2018: 8 t	Acceptable
EBFM		
Indicator species		
Greenlip abalone (*Haliotis laevigata*)	Area 2 – PI below threshold but above limit Area 3 – PI below limit	Inadequate – High risk
Brownlip abalone (*Haliotis conicopora*)	Area 2 – PI below threshold but above limit Area 3 – PI above target	Adequate
Ecological		
Bycatch	Negligible	Adequate
Listed Species	Negligible	Adequate
Habitat	Negligible	Adequate
Ecosystem	Negligible	Adequate
Economic (GVP $3 m)	High	Management Action
Social (amenity)	Medium	Acceptable
Governance	High	Management Action
External Drivers	High	Management Action

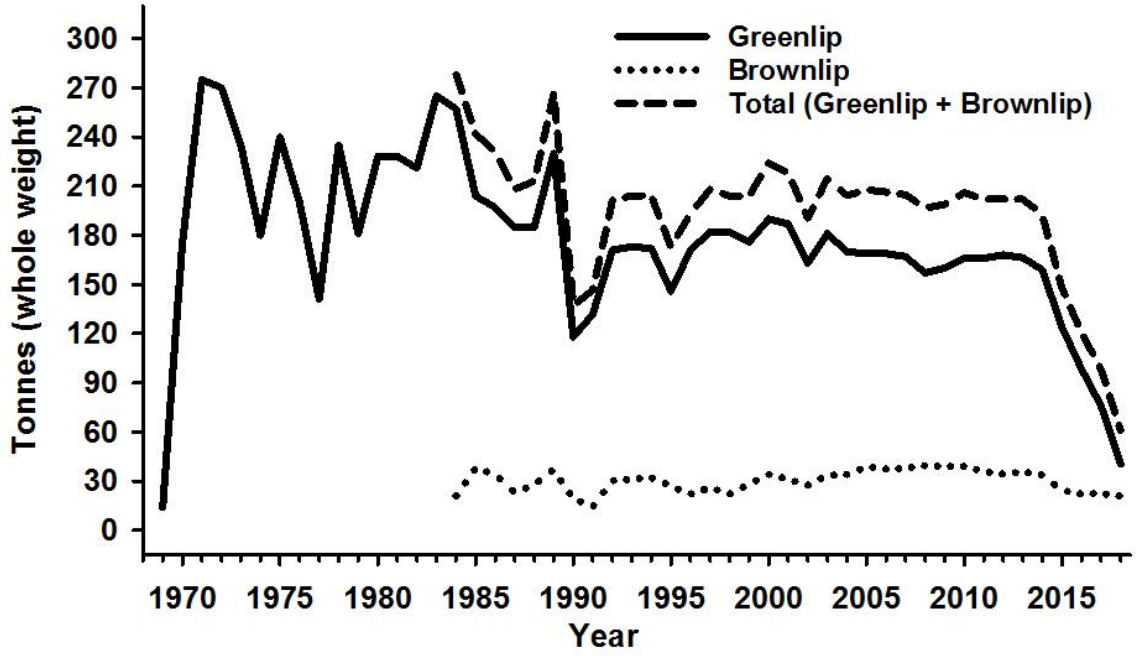


GREENLIP/BROWNLIP ABALONE FIGURE 1.
Map showing the boundaries of the management areas in the commercial Abalone Managed Fishery in Western Australia. The Greenlip/Brownlip Abalone fishery operates in Areas 1, 2, 3 and 4, other areas are associated with the Roe's Abalone fishery

GREENLIP/BROWNLIP ABALONE FIGURE 2.
Map 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 2018 the total commercial Greenlip/Brownlip abalone catch was 61 t whole weight (Greenlip 40 t and Brownlip 21 t), which was 82% of the combined TACC (74 t whole weight) and represents the lowest catch in over 40 years (Greenlip/Brownlip Abalone Figure 3). The lower catch in 2018 was due to the reduction in Greenlip abalone TACC by 68 t whole weight (24 t in Area 2 and 44 t in Area 3). The combined recreational catch of both species estimated at 8 t, which was derived from a 2007 telephone diary survey, is still considered sufficiently accurate.



GREENLIP/BROWNLIP ABALONE FIGURE 3.
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)

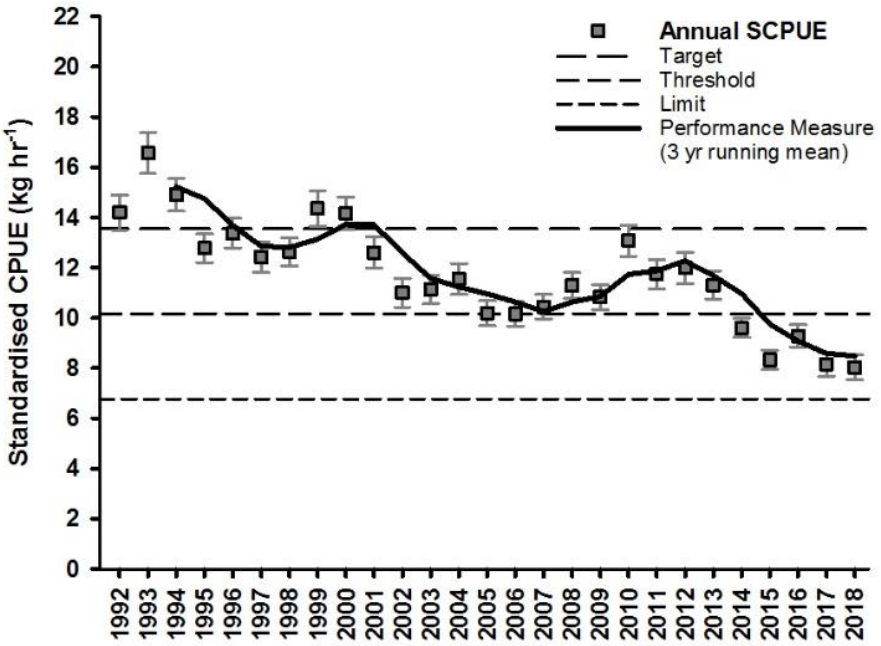
Greenlip abalone are distributed from south-west WA across southern Australia to Victoria and Tasmania. A recent genomic study suggests the existence of one single Greenlip abalone population along the WA coast but with five adaptive populations (Sandoval-Castillo *et al*. 2018). The fishery has a legal 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 has been a declining trend in annual SCPUE and PI since 2012 that in the last 2 seasons has arrested. The PI is currently below the threshold but above the limit reference level (Greenlip/Brownlip Abalone Figure 4a).

In Management Area 3 (Albany) the annual SCPUE and PI have continually declined since 2010. In 2018 both the annual SCPUE and PI are below the limit reference level. (Greenlip/Brownlip Abalone Figure 4b). Analysis of raw catch rate, average meat weight per individual and length-frequency trends also support evidence of a declining trend over recent years. Fishery-independent surveys in the major component of Area 3 (Augusta) indicate total density of Greenlip abalone at record low levels for the last 4 years, while there has been a slight increase in densities of juvenile animals (4 – 8 cm shell length) in 2018 after it was at record low levels between 2014 and 2017. A reduction in TACC has occurred in Areas 2 and 3 in response to the decline (see Harvest Strategy section).

Stock status of Greenlip abalone is considered **inadequate**.

a



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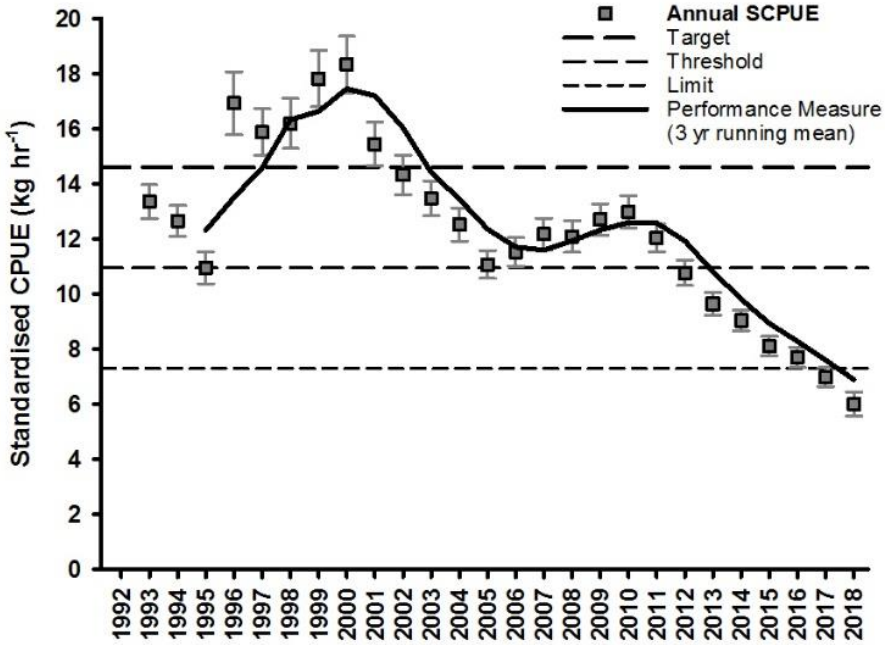

GREENLIP/BROWNLIP ABALONE FIGURE 4.
The standardised CPUE (kg.hr^{-1}) for Greenlip abalone with the performance indicator (3 year running mean) and reference levels (target, threshold and limit) in Management Area 2 (a) and Area 3 (b).

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 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 2018 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 but above the limit reference level. During the last 2 seasons the annual SCPUE has increased and the PI is now approaching the threshold 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, with a substantial increase occurring in 2018 to the high levels recorded during the 2000's above the target reference level.

The integrated length-based model was 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 ratio of spawning biomass to unfished levels in 2016 as above the target reference level. 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 21 vessels operating in the Commercial Greenlip/Brownlip Abalone Fishery, employing approximately 45 divers and deckhands. 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 16,196 recreational abalone licenses issued in 2018 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 2018 was $3 million, based on the estimated average price received by commercial fishers of $141.19/kg meat weight ($52.94/kg whole weight) for Greenlip abalone and $104.52/kg meat weight ($41.81/kg whole weight) for Brownlip abalone. Greenlip and Brownlip abalone prices increased again in 2018 and the price for Greenlip abalone has even surpassed the high prices of 10 to 15 years ago (e.g. $127/kg meat weight in 2005). **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 2019/20 season using the harvest strategy, for Greenlip abalone they are 3 t in Area 1, 24 t in Area 2 and 11 t in Area 3, while for Brownlip abalone they are 150 kg in Area 1, 12.5 t in Area 2 and 12.5 t in Area 3.

Annual Catch Tolerance Levels Commercial – Not Acceptable; Recreational – Acceptable

Commercial: 74 t (TACC) (3,440 – 5,270 fishing hours)

Recreational: Not formal

Commercial catch below TACC due to commercial industry decisions. The commercial fishing effort (2624 hours) was also below the expected range. Greenlip abalone stock indicator below threshold reference level for Area 2 and below limit reference level for Area 3. TACC reduced to 62 t for the 2019 season with Greenlip abalone TACC at 21% of long-term levels. Spatial closures in Area 3 being considered for 2019 season. Recreational catch levels are 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 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 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 (MSC Assessment)

Consultation took place with industry on relatively minor operational changes to the *Abalone Management Plan 1992* and these matters have been finalised. A Recovery Strategy for Area 3 Greenlip abalone will be progressed in 2019/20.

The commercial Greenlip/Brownlip abalone fishery has undergone full MSC assessment and achieved certification in 2017, with the 1st surveillance audit completed during 2018 (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 since 2011 needs to be investigated further. Greenlip and Brownlip abalone have been assessed as a medium-high risk to climate change effects. **High** risk.

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SOUTH COAST NEARSHORE AND ESTUARINE FINFISH RESOURCE STATUS REPORT 2019

K. Smith, R. Duffy and G. Grounds

OVERVIEW

In the South Coast Bioregion (SCB), nearshore and estuarine finfish are targeted by beach-based fishers and boat-based recreational fishers operating in shallow water. The main recreational method is line fishing. The main commercial methods are gill net, haul net and beach seine. The main commercial fisheries targeting nearshore and/or estuarine finfish in the SCB are the South Coast Estuarine Managed Fishery (SCEMF) and the South Coast Salmon Managed Fishery (SCSMF). Thirteen estuaries in the SCB are open to commercial fishing.

Fishery landings of nearshore finfish are mainly comprised of Western Australian salmon (*Arripis truttaceus*), southern school whiting (*Sillago bassensis*), Australian herring (*Arripis georgianus*) and King George whiting (*Sillaginodes punctatus*). Landings of estuarine finfish are mainly comprised of sea mullet (*Mugil cephalus*), estuary cobbler (*Cnidoglanis macrocephalus*) and black bream (*Acanthopagrus butcheri*).

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2018: 243 t	Unacceptable (SCEMF)
Recreational fishery	Total Catch 2017/18: 17–35 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Western Australian salmon	Above target	Adequate
Sea mullet (SCB)	Above threshold	Adequate
Cobbler (Wilson Inlet)	Below limit	Inadequate (under review)
Black bream	Above limit	Adequate
Ecological		
Bycatch	Low risk	Adequate
Listed Species	Negligible risk	Adequate
Habitat	Negligible risk	Adequate
Ecosystem	Low risk	Adequate
Economic (GVP $1-5 m)	Low risk	Acceptable
Social (high amenity)	Medium risk	Acceptable
Governance		Adequate
External Drivers	High risk	Adequate

CATCH AND LANDINGS

In 2018, the total commercial catch of nearshore and estuarine finfish in the SCB was 243 t, comprising 68 t from ocean waters and 175 t from estuaries (South Coast Nearshore and Estuarine Finfish Table 1). The commercial catch was taken by the SCEMF (175 t), the SCSMF (47 t) and 'open access' commercial fishers (21 t).

Since 1990 there has been a major decline in total catch in each of the main commercial 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 availability of some species.

The top 10 nearshore and estuarine species (or species groupings) in the South Coast represented 95% 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 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). No recent estimates of shore-based recreational catches are available.

SOUTH COAST NEARSHORE AND ESTUARINE FINFISH TABLE 1.
Total catches (tonnes) of finfish by commercial fisheries in nearshore and estuarine waters in the South Coast Bioregion in previous five years.

Species	Scientific name	2014	2015	2016	2017	2018
Western Australian salmon	*Arripis truttaceus*	303.4	119.3	5.0	50.4	51.5
Estuary cobbler	*Cnidoglanis macrocephalus*	57.0	53.3	70.2	60.6	37.2
Black bream	*Acanthopagrus butcheri*	31.2	29.7	71.9	76.8	50.9
Sea mullet	*Mugil cephalus*	28.0	17.7	27.8	28.0	18.0
Australian herring	*Arripis georgianus*	104.0	23.7	20.9	38.9	19.9
King George whiting	*Sllllaginodes punctatus*	13.3	22.5	17.2	8.7	11.9
Tarwhine	*Rhabdosargus sarba*	6.0	7.5	12.1	8.2	8.0
Leatherjackets	*Monocanthidae*	11.7	8.7	10.2	10.4	7.7
Southern garfish	*Hyporamphus melanochir*	6.7	7.2	6.9	4.6	4.7
Flatheads	*Platycephalidae*	3.0	5.3	6.9	7.8	6.9
Yelloweye mullet	*Aldrichetta forsteri*	5.2	4.4	3.5	5.6	4.1
Pink snapper	*Chrysophrys auratus*	2.2	4.4	10.4	3.0	2.4
Skates	*Rajiformes*	3.1	3.4	2.8	3.6	5.0
Snook	*Sphyraena novaehollandiae*	1.5	3.4	2.2	1.7	3.0
Yellowfin whiting	*Sillago schombergkii*	1.6	1.1	3.4	0.7	1.3
Other finfish		13.9	12.5	11.4	9.5	10.0
Total		591.7	323.9	282.8	318.4	242.6

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.

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 (landings in WA

were historically mainly sold as bait) (South Coast Nearshore and Estuarine Figure 1). The 2018 commercial catch was 191 t, with 72% taken by the South West Coast Salmon Managed Fishery, 25% by the SCSMF and 3% by other fisheries.

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 recent (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)

(see West Coast Nearshore and Estuarine Finfish Resource Status Report).

Sea mullet (Sustainable-Adequate)

The population structure of sea mullet in WA is unclear, due to uncertainty about the level of connectivity between Bioregions. Given this uncertainty, sea mullet within each Bioregion are currently managed as separate units. A level 3 assessment of stock status in other Bioregions is underway which may also provide more information about stock structure. Refer to the Inner Shark Bay Scalefish and West Coast Nearshore and Estuarine Finfish status reports for information about sea mullet in other Bioregions.

In the SCB, the majority (>95% p.a.) of commercial landings are taken by the SCEMF, mainly in Wilson Inlet and Oyster Harbour, although significant quantities are taken in other estuaries in some years. Since the 1970s, total commercial landings in the SCB have been relatively stable, mostly remaining between 20 and 50 t per year (range 11-92 t) (South Coast Nearshore and Estuarine Figure 2). The total SCB commercial catch in 2018 was 18.0 t. The recreational catch is estimated to be negligible.

The nominal annual catch rate trend in Oyster Harbour suggests an increase in sea mullet availability since 2000, coinciding with a period of pronounced ocean warming around south-western Australia (South Coast Nearshore and Estuarine Figure 2).

The current risk level for the SCB stock is Medium, based on all lines of evidence including trends in catch, effort and catch rates, and a vulnerability assessment (PSA). On this basis, the stock is classified as **sustainable-adequate**.

Estuarine cobbler (Inadequate - Wilson Inlet; Not assessed – other estuaries)

In WA, cobbler occurs in marine and estuarine waters but is mainly caught by commercial fishers in estuaries. Landings by recreational fishers are negligible (Smallwood and Sumner 2007, Ryan *et al.* 2019). 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).

Since 2000, 95% of commercial landings of cobbler have been caught in the SCB, with the remainder in the WCB. From 2000 to 2018, the total SCB catch ranged from 37 to 98 t (South Coast Nearshore and Estuarine Figure 3). Over this period, 79% of SCB commercial landings were taken in Wilson Inlet, with the remainder in Irwin Inlet (10%), Oyster Harbour (8%) and several other estuaries. The catch was 37 t in 2018, including 26 t from Wilson Inlet.

In Wilson Inlet, fishery catches and catch rates have been relatively stable, but annual fishery-independent surveys since 2007 indicate that juvenile recruitment (age 1+) and adult abundance have been declining. Recruitment in 2019 was the lowest on record.

A Level 4 assessment in 2018 found a High Risk to the sustainability of the Wilson Inlet stock.

On the basis of this assessment, the status of cobbler in Wilson Inlet is **depleted-inadequate**. Another Level 4 assessment is scheduled for 2019, incorporating new age structure data from fishery-independent gill netting collected in 2018.

King George whiting (Not assessed)

(see West Coast Nearshore and Estuarine Finfish Resource Status Report).

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 2018, the total SCB catch was 51 t, mainly from Beaufort Inlet (27% of landings), Stokes Inlet (23%), Wilson Inlet (20%), Jerdacuttup Lakes (10%) and Oyster Harbour (9%). Catches in Jerdacuttup Lakes are normally low, but increased in 2018 following flood events in 2016 and 2017. Catches in the other four estuaries have either remained stable (Stokes) or increased (others)

since 2000 (South Coast Nearshore and Estuarine Figure 4). 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. Black bream catches typically show large inter-annual fluctuations within each south coast estuary in response to environmental factors, particularly river flow.

The estimated boat-based recreational harvest of black bream in the South Coast was steady in 2017/18 (95% CI 1–4 t) comapred with 2015/16 (1–6 t), 2013/14 (1–3 t) and 2011/12 (3–11 t) (Ryan *et al.* 2019). 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.**

A 2002/03 survey of recreational fishing in SCB estuaries indicated that the highest recreational catches of black bream were taken in Walpole-Nornalup Inlet (Smallwood and Sumner 2007). The current stock status in Walpole-Nornalup Inlet cannot be assessed due to lack of recent data.

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**.

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 seal in the net. Fishers are able to release a seal from their seine net without injury to the animal. There have been no reports of incidental mortalities of seals 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 plans 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 and haul nets over predominantly sand and mud bottoms is unlikely to have any impact on these habitats in estuaries and nearshore waters. Similarly, the 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.

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 there is a **negligible risk** to benthic habitats.

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 2018, there were approximately 12 commercial fishers employed in the South Coast Salmon Fishery and 37 in the South Coast Estuarine Managed Fishery. 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 Fishery is an important source of fresh local fish 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 2018

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

South Coast Estuarine Managed Fishery: 200 – 500 tonnes (finfish only).

There has been a steady decline in annual finfish catch in the SCEMF since 1990. This is due to a complex suite of factors, including declining effort (mainly during the1990s), changing environmental conditions and declining availability of some species. In 2018 the total finfish catch was 175 t. This fishery has traditionally targeted finfish, but in recent years has harvested significant quantities of blue swimmer crabs (7 t in 2018), which have partly replaced finfish in the overall catch. The total catch by this fishery in 2018 is considered **inadequate**.

Australian Salmon Fisheries (all WA commercial fisheries): 0 - 1200 tonnes.

Catch was 47 t in 2018. Catches continue to be low relative to historic levels, due to low effort in response to limited market demand.

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 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 2021.

A trial of extended penning time for western Australian salmon is being undertaken in the

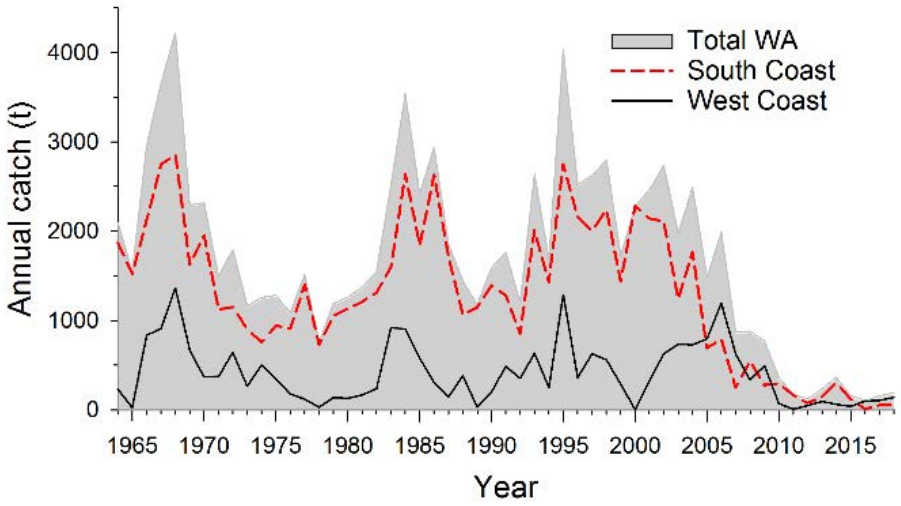
SCSMF. The trail is scheduled to run until 10 April 2020.

The Minister for Fisheries finalised the review of South Coast commercial line, fish trap and net fisheries in January 2019. The Department is currently drafting two new management plans to give effect to the outcomes of the review. This includes a management plan for a South Coast nearshore net fishery that will regulate current open-access nearshore netting activities on the South Coast.

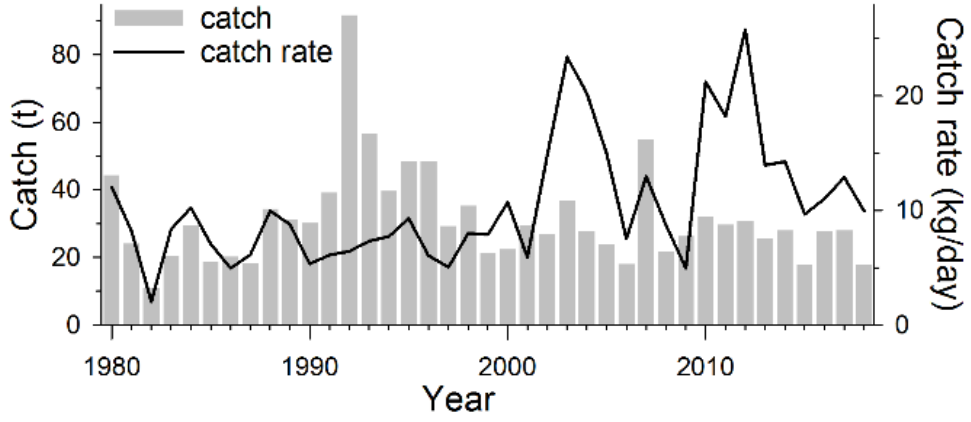
EXTERNAL DRIVERS

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 and Western Australian salmon. 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.

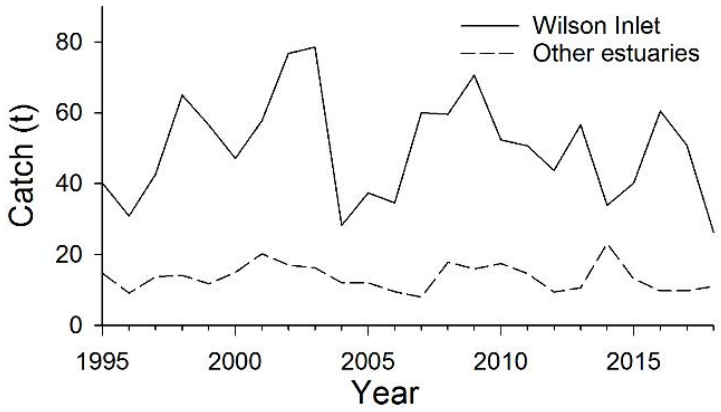
Fluctuating market demand is a significant factor affecting the annual commercial catch level of many species. On the basis of market demand and price commercial fishers sometimes elect not to capture a school of fish, or release part of their catch, when a market is not available. This is particularly relevant to western Australian salmon. **High** risk.



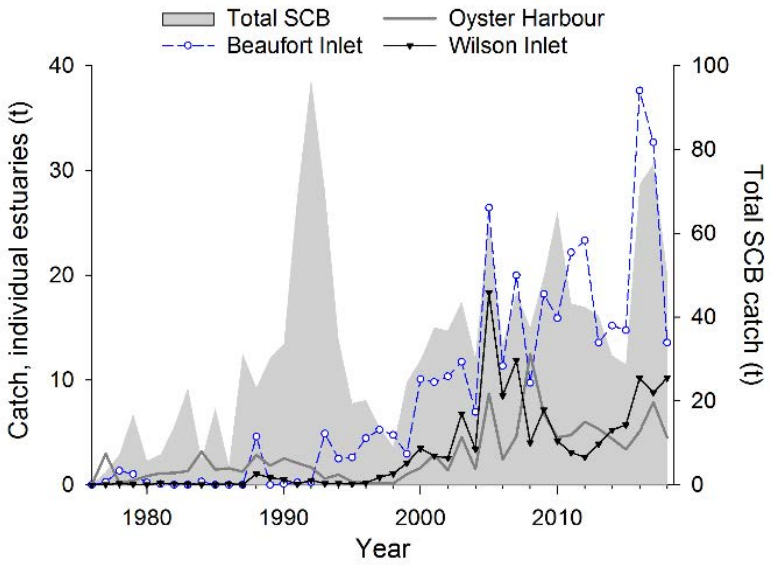
SOUTH COAST NEARSHORE AND ESTUARINE FIGURE 1.
Annual commercial catches of western Australian salmon in the South Coast Bioregion, West Coast Bioregion and statewide, 1964 to 2018.



SOUTH COAST NEARSHORE AND ESTUARINE FIGURE 2.
Sea mullet total commercial catch in the South Coast Bioregion, and nominal annual commercial catch rate in Oyster Harbour, 1980 to 2018.



SOUTH COAST NEARSHORE AND ESTUARINE FIGURE 3.
Total annual commercial catches of estuary cobbler in Wilson Inlet and other South Coast Bioregion estuaries, 1995 to 2018.



SOUTH COAST NEARSHORE AND ESTUARINE FIGURE 4.
Annual commercial catches of black bream in total South Coast Bioregion and key estuaries, 1976 to 2018.

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SOUTH COAST SMALL PELAGIC SCALEFISH RESOURCE STATUS REPORT 2019

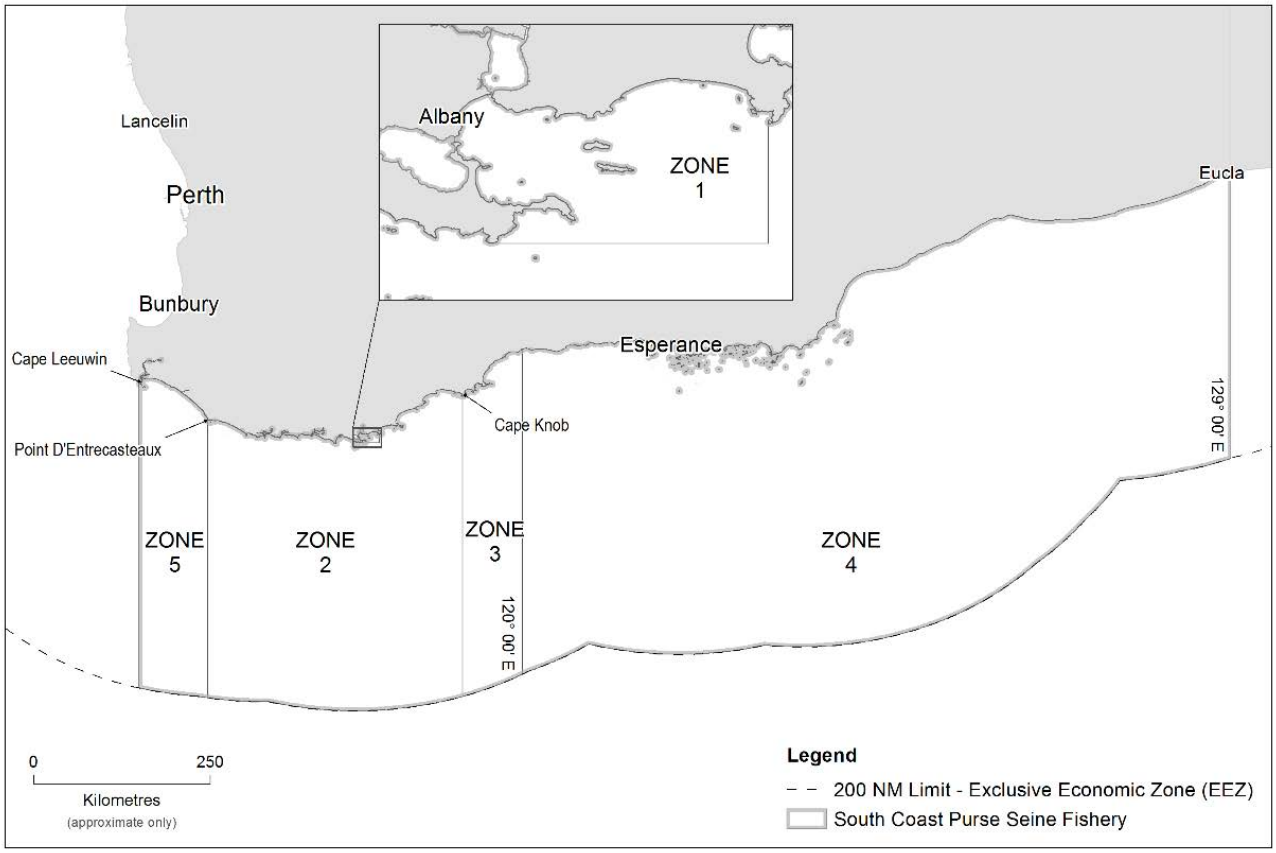
J. Norriss and G. Grounds

OVERVIEW

The five species comprising the south coast small pelagic scalefish resource are pilchards (*Sardinops sagax*), yellowtail scad (*Trachurus novaezelandiae*), Australian anchovy (*Engraulis australis*), scaly mackerel (*Sardinella lemuru*) and maray (*Etrumeus teres*). Pilchards and yellowtail scad are the indicator species and dominate 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, 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 pilchard virus devastated stocks in 1995 and 1998/99. While surveys demonstrated strong recovery by the mid-2000s, catches have remained well below the total allowable catch (TAC), which was conservatively set at 5,683 t.

SUMMARY FEATURES 2019

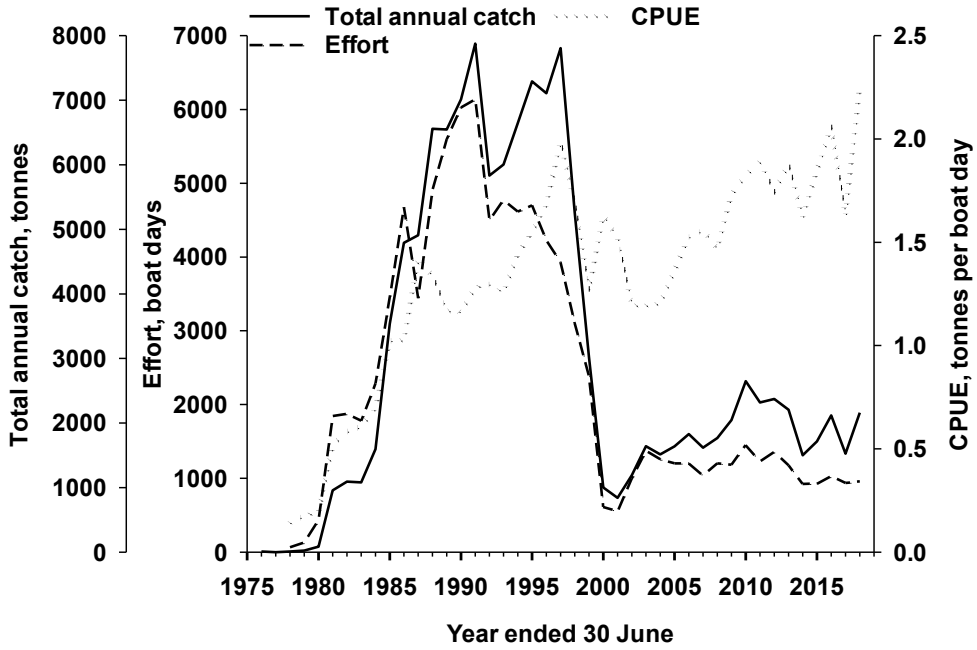
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (5,683 t)	Total Catch 2017/18: 2,168 t	Acceptable
Recreational fishery (not applicable)	Total Catch 2017/18: <1 t (boat-based only)	Acceptable
EBFM		
Indicator species		
Pilchards	Above target	Adequate
Yellowtail scad	Above target	Adequate
Ecological		
Bycatch	Negligible risk	Adequate
Listed Species	Moderate 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 boundaries of the South Coast small pelagics resource.

CATCH AND LANDINGS

The SCPSMF total catch of 2,168 t in the 2017/18 quota year included 2,161 t of pilchards (>99%), a decrease of 42% from the previous year (South Coast Small Pelagic Figure 2). The remainder of the catch was comprised entirely of yellowtail scad (7 t), the lowest for that species since 2010/11. The total catch was comprised of 1,242 t from King George Sound (zone 1), zero from the greater Albany region (zone 2) and 926 t from Bremer and Esperance (zones 3 and 4) combined (South Coast Small Pelagic Table 1). Fishing effort in the 2017/18 quota year was 960 boat days, little changed from the previous year, by 9 active vessels.



SOUTH COAST SMALL PELAGIC FIGURE 2.
Time series of total annual catch, effort and nominal catch per unit effort (CPUE) for pilchards in the SCPSMF from 1975/76 to 2017/18.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Pilchards (Sustainable-Adequate)

The pilchard is a small, low trophic level pelagic species that feeds by filtering plankton. Longevity is up to 9 years and maximum size 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 never exceeded 3,000 t since then. Since 2008/09 the nominal catch rate has remained relatively high (South Coast Small Pelagic Figure 1). The stock is therefore not considered to be recruitment overfished. Under the current level of fishing pressure, the biological stocks of pilchards are considered **sustainable-adequate**.

Yellowtail scad (Sustainable-Adequate)

Yellowtail scad is a schooling species common in temperate Australian waters. The population structure in WA is unknown. The species is known to reach a maximum age of 24 years and maximum length of about 330 mm FL.

Historically, relatively low prices have contributed to low annual catches in the SCPSMF, never exceeding 26 t since the pilchard stock recovery in the mid-2000s. The annual recreational catch has been negligible (< 1 t). This low level of fishing mortality suggests the biological stock is **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. Small quantities of fish bycatch species are sometimes captured incidentally, but this occurs infrequently and the majority are released from the net unharmed. **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. Low capture rates of dolphins, sea lions and seals, usually released unharmed, have been recorded. Bycatch of Flesh-footed Shearwaters (FFS) are often recorded. FFS opportunistically feed on fish trapped during purse seine net operations and may drown if caught in the net. Interactions with protected species are mitigated and managed through the implementation of a voluntary SCPSMF Code of Practice 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 further elevated. DPIRD observers were on board commercial vessels during the 2017, 2018 and 2019 SMPs to obtain independent estimates of the level of bycatch. For trips when the net was deployed, they recorded 30 FFS mortalities from 51 trips in 2017, 32 from 52 in 2018, and 1 from 14 in 2019. **Moderate** 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 kept 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

Pilchards are a 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 likely to be <10% of spawning biomass, and trophic modelling by the much larger South Australian pilchard fishery (Goldsworthy *et al*. 2013) indicates minor impacts on top order predators. The ecosystem impact from fishing in the SCPMF 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). Pilchards are an important bait for recreational fishers. **Low** risk.

Economic

Nine active vessels as well as local fish processing facilities in Albany, Bremer Bay and Esperance provided local employment during 2017/18. A small proportion of the catch is sold for human consumption but the large majority for bait, aquaculture feed or pet food. The estimated gross value of product (GVP) for the SCPSMF in 2017/18 was level 2 ($1-5 million). There is a **moderate** risk to this level of return due to possible management responses to seabird interactions.

GOVERNANCE SYSTEM

Harvest Strategy

The SCPSMF is managed under a constant catch harvest strategy, with catches limited to quotas (TAC) set for each management zone. Any proposed changes to the TAC 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 2017/18 quota year was only 38.1% of the total allowable catch (TAC, 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

Consultation with SCPSMF licensees on operational issues occurs on an as needs basis, and more formally via industry Management Meetings convened by the West Australian Fishing Industry Council (WAFIC) pursuant to a Service Level Agreement with the Department.

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.

The FFS bycatch observer program was repeated during the 2019 SMP. Publication of results with sustainability analysis in a scientific journal is intended, which will inform future bycatch mitigation strategies.

EXTERNAL DRIVERS

Licensed operators in the Commonwealth Small Pelagic Fishery are permitted to take pilchards in waters adjacent to the West Australian coastline but no fishing in these waters was identified in 2017/18, the last year reported for that fishery (Marton and Mobsby 2018). **Moderate** risk.

SOUTH COAST SMALL PELAGIC TABLE 1.
2017/18 catches and total allowable catches (TAC) for each of the major Management Zones of the South Coast Purse Seine Managed Fishery.

Management Zone	TAC (t)	2017/18 catch (t)	Active vessels	2017/18 catch as % of TAC
Albany (Zones 1 and 2)*	2,683	1,242	6	46.3%
Bremer Bay and Esperance (Zones 2 and 3)#	3,000	926	3	30.9%
Total for Fishery	5,683	2,167	9	38.1%

* Zero catch in zone 2.

Zones cannot be reported individually because insufficient vessels operated in 2017/18

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TEMPERATE DEMERSAL GILLNET AND DEMERSAL LONGLINE FISHERIES RESOURCE STATUS REPORT 2019

M. Braccini & N. Blay

OVERVIEW

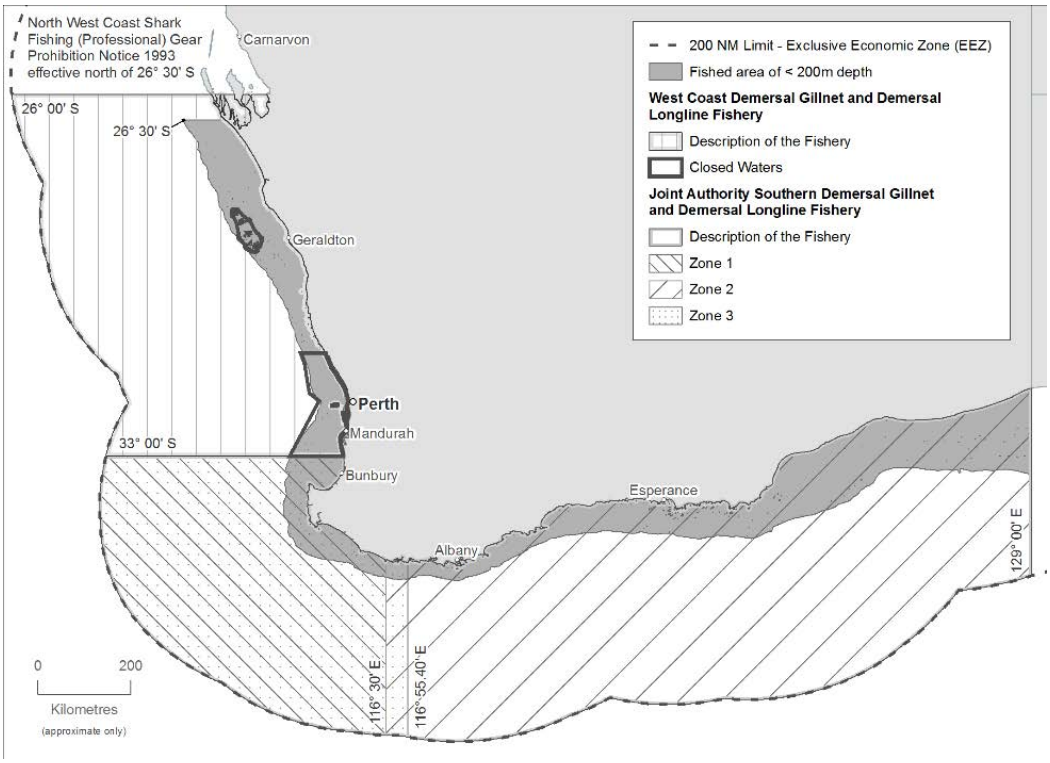
The Temperate Demersal Gillnet and Demersal Longline Fishery (TDGDLF) comprises the West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (WCDGDLF), which operates between 26° and 33° S, and the then Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (JASDGDLF)[1], which operates from 33° S to the WA/SA 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 The JASDGDLF transitioned from joint Commonwealth/State management to State only management in December 2018

SUMMARY FEATURES 2019

Asset (Allowable catch for indicator species)	Outcome	Status
Commercial fishery (725−1,095 t)	Total Catch 2017-18 Sharks and rays*: 820 t Scalefish*: 110 t	Acceptable
Recreational fishery (not defined)	Total Catch 2017/18: < 5% 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	Negligible-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

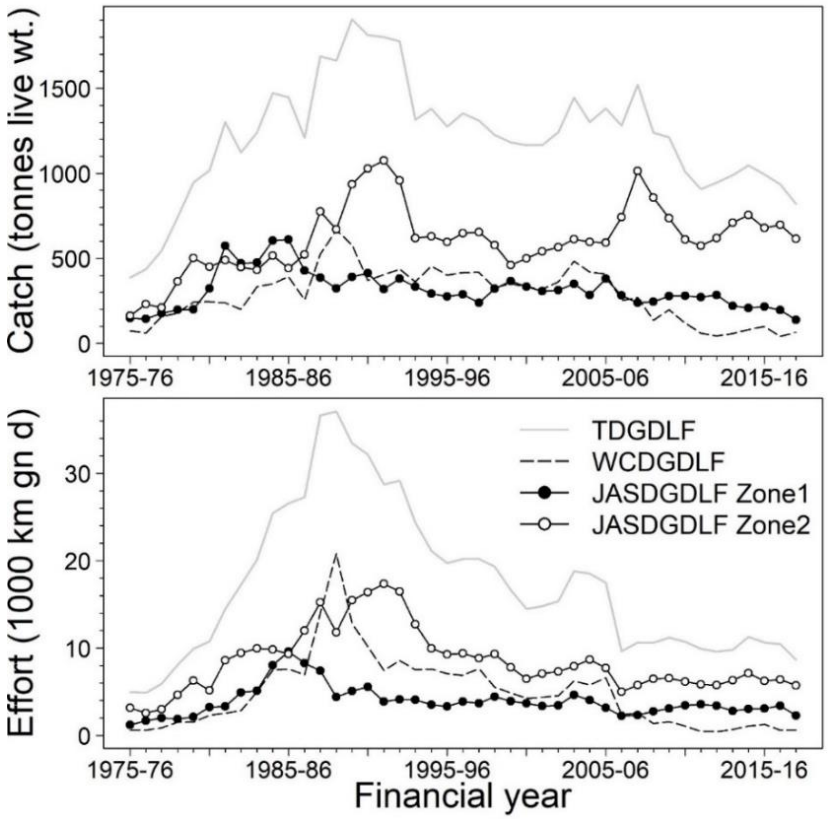
*All reported weights are live weight



TEMPERATE DEMERSAL FIGURE 1.
Map showing boundaries of the Temperate Demersal Gillnet and Demersal Longline Fishery

CATCH AND LANDINGS

For the TDGDLF, reported catches of elasmobranchs and fishing effort peaked during the late 1980s and early 1990s and have stabilised at much 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 a historic peak in catch rates in the mid/late 2000s, which coincides with the historic peak in catches, and a failure in the fitting of population dynamics models to this catch rate series. 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

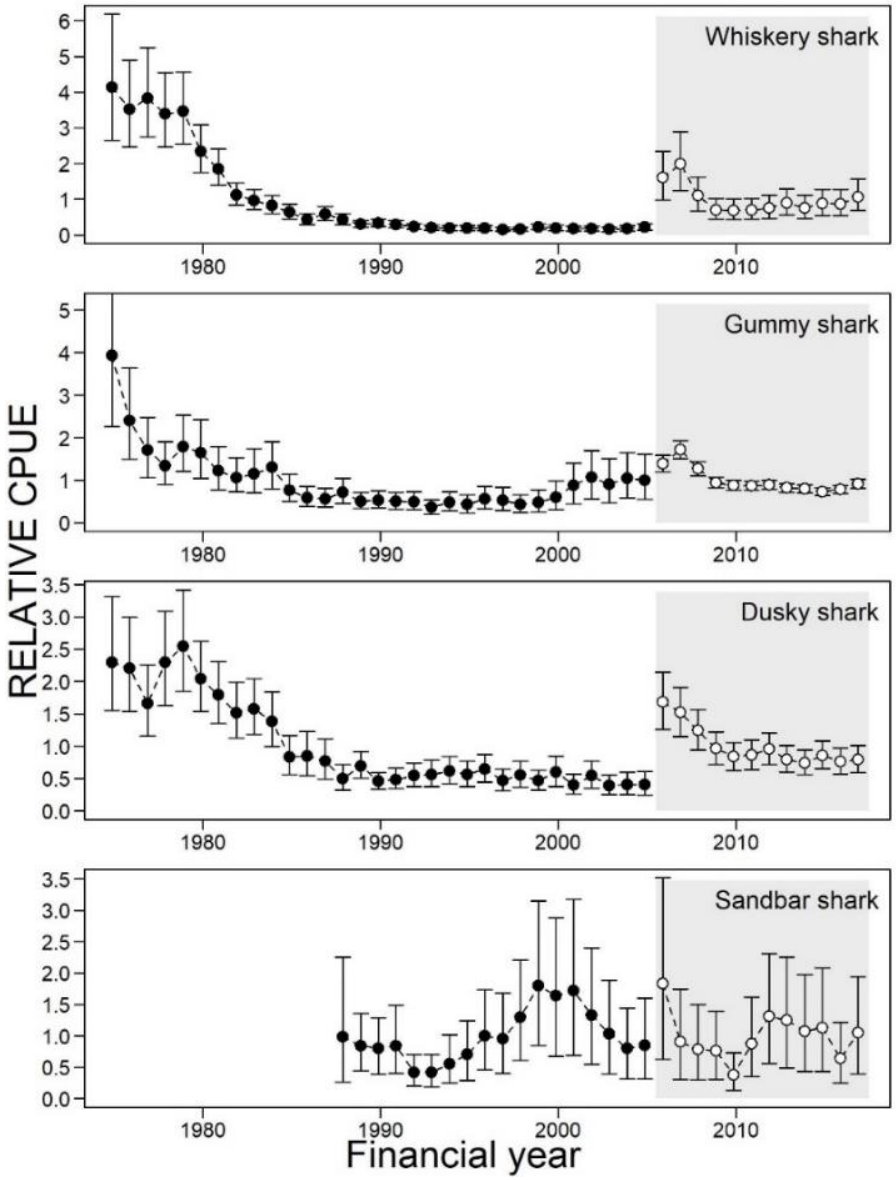
limit biomass reference points, respectively (Braccini *et al*. 2018). Hence, current management arrangements are considered suitable to allow gradual recovery of the breeding stock. On the basis of the above, the current status of dusky sharks is **sustainable-recovering.**

Whiskery shark (Sustainable - Adequate)

Significant declines in standardised catch rates in the early 1980s (Temperate Demersal Figure 2) is likely a result of changes in targeting practices (Simpfendorfer *et al*. 2000). Since 2009, standardised catch rates have remained stable. 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 been fluctuating between 2007 and 2017 (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. Based on ESD risk assessment of these finfish, all fishery impacts on stocks of bycatch species impose a **low risk** to their ongoing sustainability.

Protected Species

The TDGDLF has low interactions with listed species (McAuley & Simpfendorfer 2003).

For 2017-18, fishers reported catching and releasing 0 Australian sea lions (ASL), 1 dead muttonbird, 16 dead and 29 alive grey nurse sharks, and 2 dead and 3 alive white sharks (Appendix 2) and are therefore considered **negligible-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 therefore representing 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 49 and 63 skippers and crew were employed in the JASDGDLF and between 12 and 15 skippers and crew were employed in the WCDGDLF during 2017-18.

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 Western Australian fish and chip shop market (WCDGDLF and Zone 1 of the JASDGDLF) or sold to wholesalers in Adelaide and Melbourne (Zone 2 of the JASDGDLF). However, anecdotal evidence suggests that recent tourism expansion in the South West of the State may have resulted in a higher proportion of shark meat having been sold to restaurants and fish retailers around landing ports.

The estimated annual value (to fisheries) for 2017-18 is $2.7 million and $0.3 million for JASDGDLF and WCDGDLF, respectively (GVP level 2).

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 JASDGDLF: 84,075 km gn.hr^{-1} or 3,503 km gn.d^{-1}; Zone 2 of the JASDGDLF: 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 2017-18 effort levels were maintained within these ranges (32400 km gn.hr-1 or 2284.8 km gn.d-1 for Zones 1 & 3 of the JASDGDLF; 105800 km gn.hr-1 or 5732.3 km gn.d-1 for Zone 2 of the JASDGDLF; 17900 km gn.hr-1 or 662.9 km gn.d-1 for WCDGDLF).

Allowable Catch Tolerance Levels

The 2017-18 total catch of sharks and rays was 820 t (373 t, 200 t, 38 t, and 105 t for gummy,

dusky, sandbar and whiskery sharks, respectively), similar to previous years and within the acceptable catch ranges (725-1,095 t for the four key species and 350-450 t, 200-300 t, < 120 t and 175-225 t for gummy, dusky, sandbar and whiskery sharks, respectively). Whiskery catch was maintained below historical allowable levels due to reductions in targeted effort. 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 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 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 JASDGDLF to address potential interactions between ASL and the TDGDLF.

Furthermore, following amendments to the Offshore Constitutional Settlement (OCS) arrangements that came into place 1 December 2018, the JASDGDLF transitioned from Joint Authority to State jurisdiction. As such, management arrangements for the Southern Demersal Gillnet and Demersal Longline Fishery (SDGDLF) are now provided for under the *Southern Demersal Gillnet and Demersal Longline Managed Fishery Management Plan 2018*, which also commenced on 1 December 2018.

The development of a formal harvest strategy for the SDGDLF and catch share arrangements for the associated Commonwealth managed fishery is proposed to commence in 2019.

EXTERNAL DRIVERS

The TDGDLF key target species span multiple regional boundaries and sandbar and dusky sharks were targeted in the Northern Shark Fisheries. However, the risks to the stocks are currently low due to no fishing being undertaken in the Northern Shark Fisheries since 2008/09, low catches from other fisheries or catches from tightly-managed fisheries (gummy sharks).

Environmental drivers pose 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. **Moderate** risk.

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SOUTH COAST DEMERSAL SCALEFISH RESOURCE STATUS REPORT 2019

J. Norriss and S. Walters

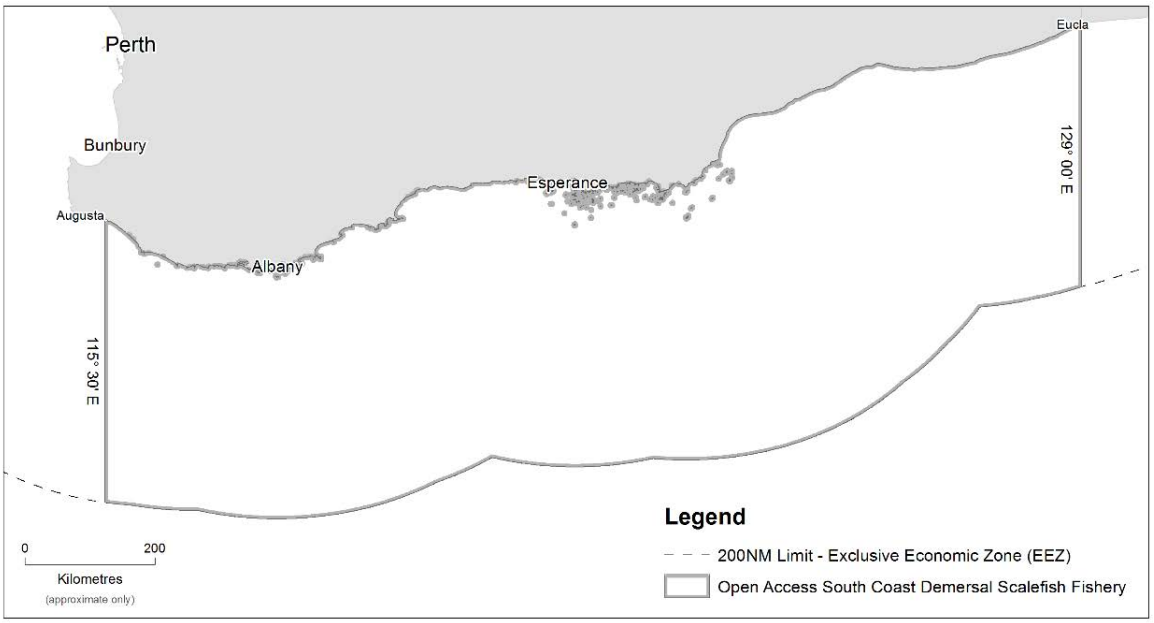
OVERVIEW

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) by predominantly demersal gillnet as part of the Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (JASDGDLMF) (see Temperate Demersal Gillnet and Demersal Longline Fisheries Resource Status Report). Recreational and charter catches are almost exclusively boat-based using hook and line.

More details of biology and assesment can be found in Norriss et al. (2016) at www.fish.wa.gov.au/Documents/research_reports/frr276.pdf.

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (not defined)	Total Catch 2017: 194 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

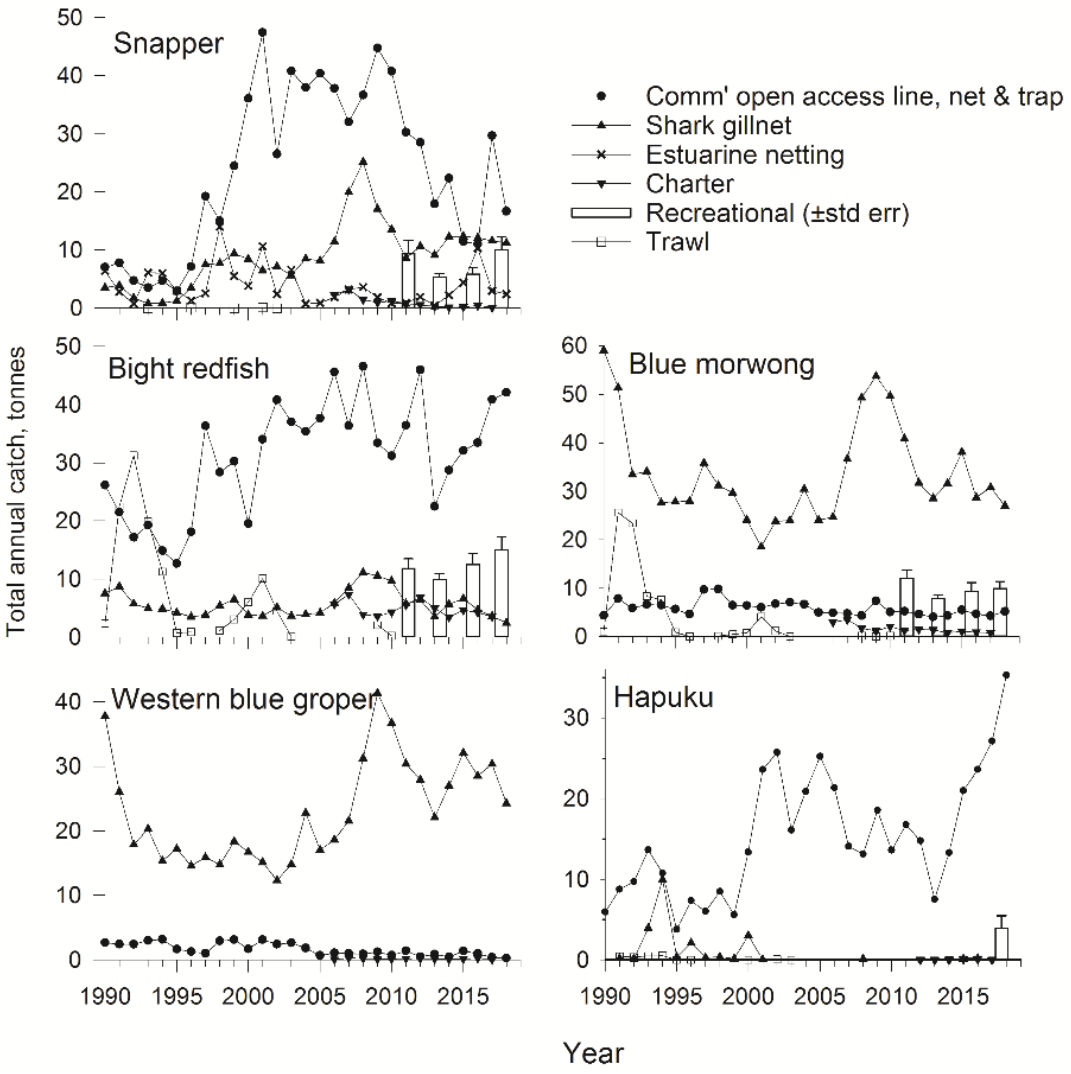


SOUTH COAST DEMERSAL FIGURE 1.
Map showing boundaries of the south coast demersal scalefish resource.

CATCH AND LANDINGS

The SCDSR total commercial catch of 194 t in 2018 was a 9% decrease from 212 t in 2017. Catches for all indicator species remain within recent historical levels except for hapuku which was highest on record for the second consecutive year (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 1990 to 2017. 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 chance of breaching the limit reference levels (1.5 and 0.20 respectively). However, any significant increase in catches beyond recent historical levels 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 slight capacity for increased catches beyond recent historical levels 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 that 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 year1 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 breeding stock was adequate, and fishing mortality sustainable, at the time the sample was collected. However, catches have increased in recent years to record highs in 2017 and 2018. The increased risk has triggered the commencement of age sampling during 2017/18 to provide an updated assessment.

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 non-retained species (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 little 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 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 2013/14 (28,277, SE=2,323), but lower than 2011/12 (40,073, SE=3,354) (Ryan *et al*. 2019). The SCDSR provides a **moderate** level social amenity to recreational fishing which is subject to a **moderate** level of risk.

Economic

In 2017 crew were employed on 63 commercial line vessels reported taking demersal scalefish, as well as employment with seafood processors in the SCB and Perth. The estimated gross value of product (GVP) for the SCDSR in 2018 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 State’s economy each year.

GOVERNANCE SYSTEM

The South Coast commercial line fishery currently operates under open-access arrangements (as opposed to a Management Plan) although this is currently under review (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 recommended catches remain within recent historical limits (Norriss *et al*. 2016).

Compliance

Fisheries and Marine Officers conduct both at-sea and on-land inspections.

Consultation

A broad consultation process is currently in progress as part of a review of management arrangements for a number of SC open access and other fishing activities (see Management Initiatives/Outlook Status below). Consultation occurs with commercial fishers and 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 Minister for Fisheries finalised the review of South Coast commercial line, fish trap and net fisheries in January 2019. The Department is currently drafting two new management plans to give effect to the outcomes from the review.

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 2017/18 were 308 t, or 39% of the Commonwealth TAC, predominantly in waters off South Australia but also from the western Great Australian Bight off the WA coast (Moore and Mobsby 2018). Preliminary results from analysis of otolith chemistry suggest that Bight redfish from the waters surrounding Albany and Esperance constitute separate stocks to those of the main South Australian fishing grounds.

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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 include:

- Increasing frequency of *El Niño*/Southern Oscillation (ENSO) events;
- More years with a weaker Leeuwin Current;
- Increase 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 (Fletcher and Santoro 2012). 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 2015/16 iSurvey of boat-based recreational fishing in WA1 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.

1Ryan 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.

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 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.

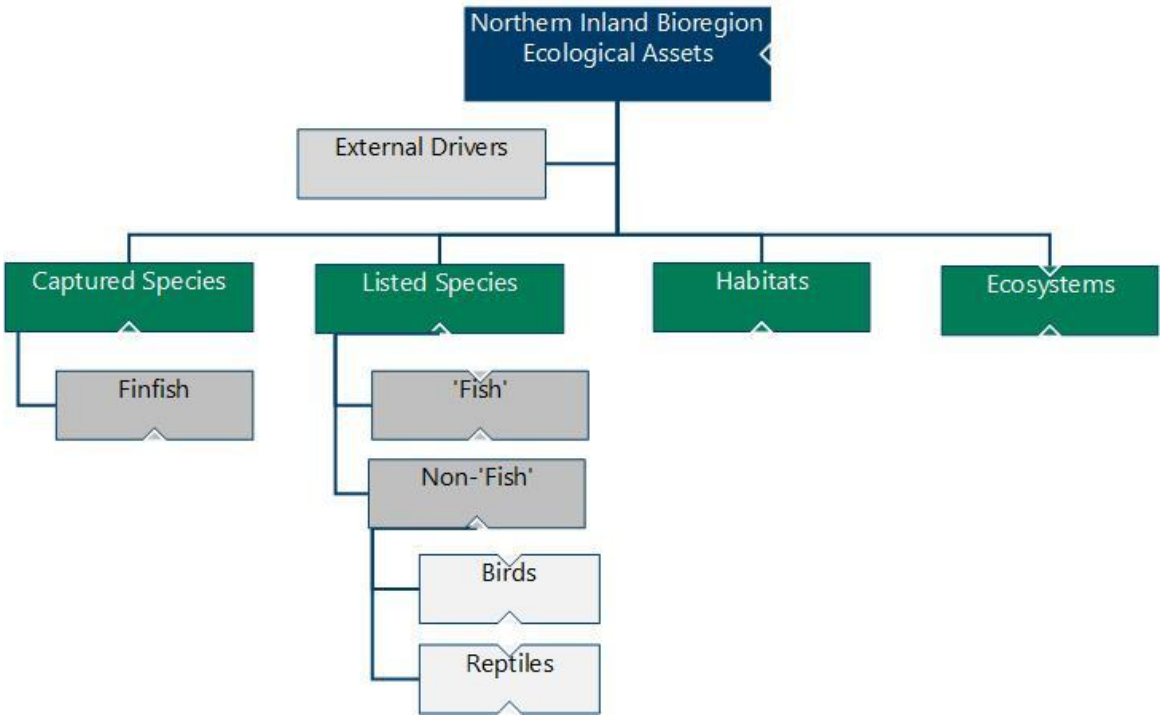
BIOREGIONAL SPECIFIC ECOSYSTEM MANAGEMENT

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 (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*). 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	MODERATE

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*). Gillnets have relatively low habitat impacts and fishers actively avoid fishing in areas where the nets may become entangled on submerged vegetation. Therefore, the Fishery is considered to be a negligible risk to the habitats of Lake Argyle. 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	NEGILGIBLE

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.

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 2019

S. Newman, G. Mitsopoulos and L. Wiberg

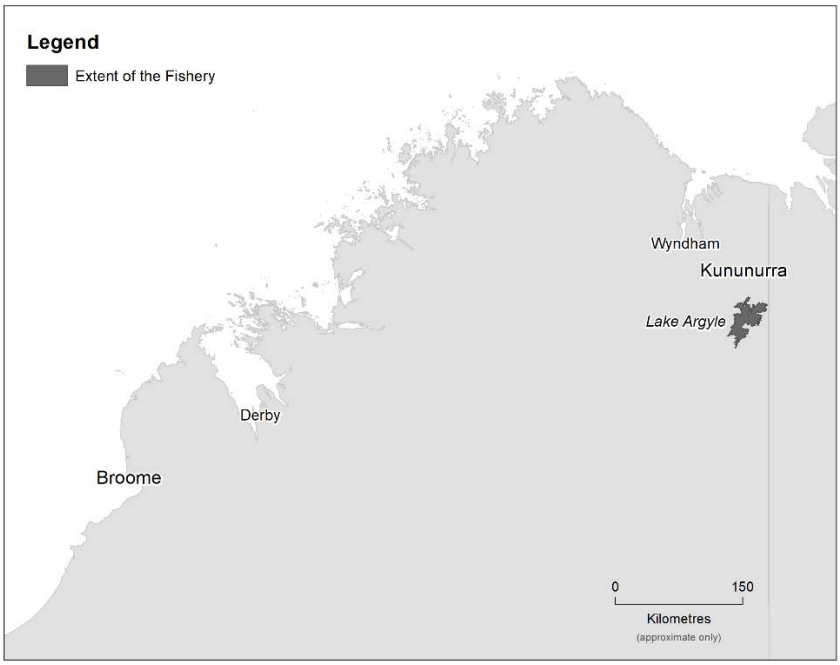
OVERVIEW

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 2019

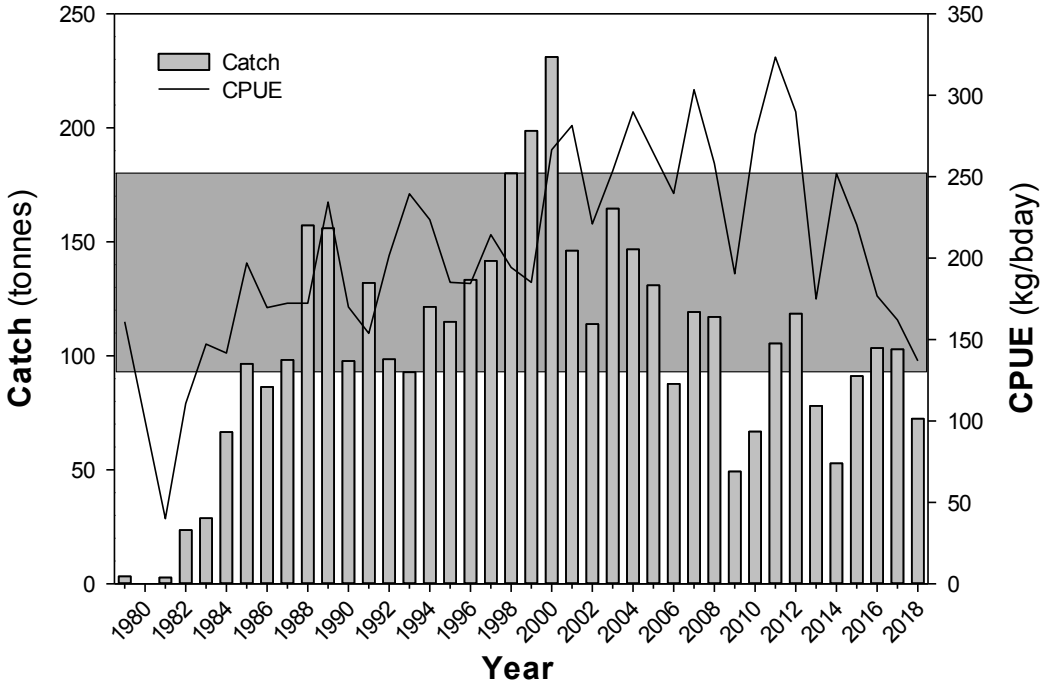
Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (93-180t)	Total Catch 2018: 72t	Acceptable
Recreational fishery (NA)	Total Catch 2018: NA	Acceptable
EBFM		
Indicator species		
Silver Cobbler	Below target commercial catch range	Adequate
Ecological		
Bycatch	Negligible Risk	Adequate
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 2008 to 2018 have fluctuated between 49 t and 119 t. In 2018, the catch of silver cobbler was 72 t.



LAKE ARGYLE SILVER COBBLER FIGURE 2.
The annual catch and catch per unit effort (CPUE, kg/block day) for silver cobbler in the Lake Argyle Silver Cobbler Fishery over the period from 1979 to 2018. The upper and lower bounds of the target commercial catch range are shown by the shaded catch area between 93 and 180 tonnes.

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 2018 is within 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 2018, four vessels fished in the LASCF, with an average crew of 2.3 people per vessel, indicating that nine 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 2018 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 2018 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 2019/20. 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 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 with 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.

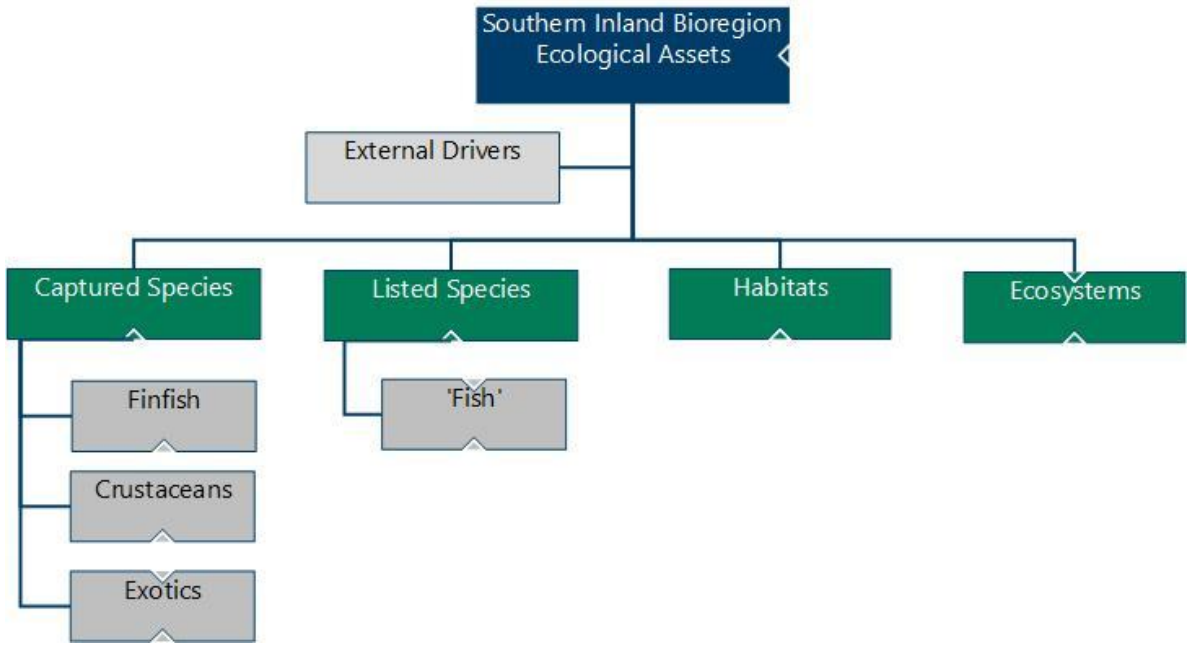
The Department works with representatives from the Department of Water and Environmental Regulation, the Department of Biodiversity, Conservation and Attraction, and other stakeholders, to facilitate information exchange, identify research projects and apply for funding to manage freshwater native fish species. This is being facilitated by the Freshwater Ecosystem Working Group which aims to coordinate a whole-of -Government approach to the management of freshwater ecosystems in the State.

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 (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 Southern Inland Bioregion are identified in Southern Inland Overview Figure 1 and their current risk status reported on in the following sections.



SOUTHERN IN LAND 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	MODERATE

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 (*C. 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 unable 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*	SIGNIFICANT (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.

Western trout minnow (*G. truttaceus*) were successfully bred in captivity by the Department. A restocking program is being developed for this species.

Hairy marron (*C. tenuimanus*) are only found in the lower reaches of Margaret River and are a totally protected species. They are threatened due to habitat loss and range loss as a result of being outcompeted by smooth marron (*C. cainii*). Some fishing is still reported despite hairy marron being totally protected.

A new recovery plan is being developed to guide hairy marron recovery activities. This includes population monitoring, control of threatening processes, a captive breeding program, and increased community awareness through a zoo display and collaboration with regional NRM groups.

Habitats and Ecosystems

Habitat / Ecosystem	Aquatic zone	Current Risk Status
Habitat	Freshwater	SIGNIFICANT(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 has been completed through a state NRM funded project that 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 potential 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.

SOUTH-WEST RECREATIONAL FRESHWATER RESOURCE STATUS REPORT 2018

R. Duffy, F. Trinnie, K. Ryan and G. Grounds

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 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery	Total Catch 2018: NA	NA
Recreational marron fishery (96,000-136,000 *marron*)	Total Catch 2018: of 59,890 (± 4,516 s.e.) marron	Acceptable
Recreational angling	Total Catch 2017/18: 85,502 fish (±10,085 s.e.)	Acceptable
EBFM		
Indicator species		
Marron	Above limit of 50,000 marron	Adequate
Trout (Rainbow & Brown)	Adequate numbers stocked	Adequate
Ecological		
Bycatch	Low 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	Adequate
Governance	Negligible Risk	Adequate
External Drivers	Significant Risk	Adequate

CATCH AND LANDINGS

Marron (*Cherax cainii*): The estimated total recreational catch for marron (by number) of 59,890 (± 4,516 s.e.) in 2018 was higher, but not significantly different to the catch in 2017 of 52,669 (± 4,801 s.e.). The average number of marron caught per fisher of 9.10 (± 0.69 s.e.) in 2018, was higher but not significantly different to 8.70 (± 0.79 s.e.) marron caught per fisher in 2017. Catch of marron from dams and rivers has remained stable, as too has the distribution of effort.

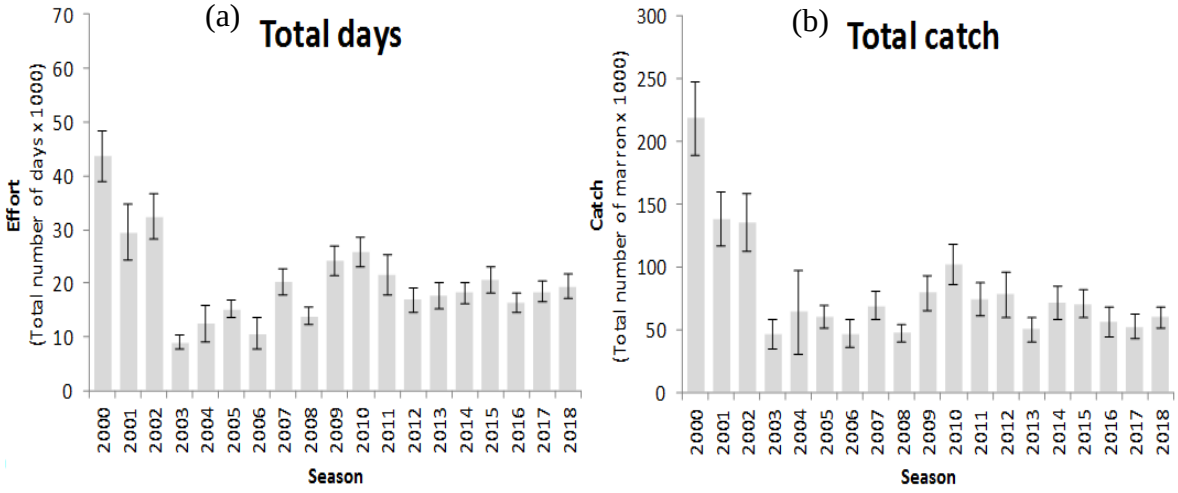
The total number of licensed fishers was 13,721 in 2018. This was ~6% higher than the total number of licensed fishers of 12,896 in 2017. The estimated total effort of 19,348 days (± 1,168 s.e.) in 2018, was higher but not significantly different to the 18,386 days (± 999 s.e.) in 2017 (Recreational Fishery Figure 1). The average number of days fished per fisher of 2.94 days (± 0.18 s.e.) in 2018, was lower but not significantly different to the 3.04 days (± 0.16 s.e.) in 2017.

More licensed marron fishers resided in the country (8,890) than the metro area (4,831). Participation rates between 2018 and 2017 remained steady, at 46% of licence holders using their licence to fish, which equates to an estimated total number of 6,578 active fishers in 2018, which was ~8% higher than the estimated 6,057 active fishers in 2017. Licence holders that reside in the country are more likely to actively participate (51%) than licence holders from the metro area (43%)

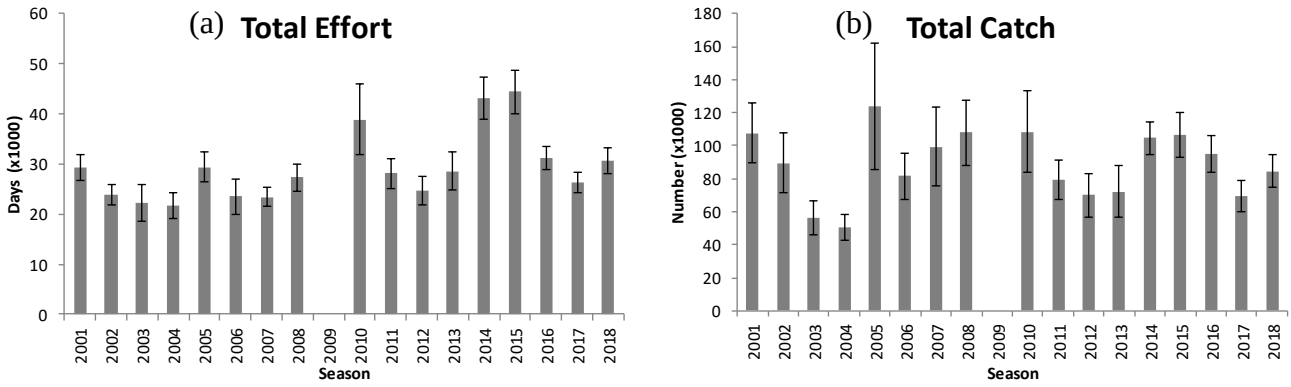
SWRFA: Children under the age of 16 are no longer required to hold a Freshwater Angling licence since March 2016. Survey design does not permit apportioning of the contribution of this age group to historical surveys. Therefore, the 2017 survey onwards, is not directly comparable to previous surveys.

The estimated total recreational catch from SWRFA across all species for was 85,502 fish (±10,085 s.e.) (by number) of which 54,187 fish (±7,650 s.e.) were kept and 30,315 fish (±4,442 s.e.) were released in 2017/18. The total estimated catch in 2017/18 was higher but not significantly different from the estimated total recreational catch (69,231 ±9,447 s.e.) in 2016/17 (Recreational Fishery Figure 2).

The estimated total number of licensed fishers was 8,918 in 2017/18. This was ~5% lower than the total number of licenced fishers of 9,378 in 2016/17. However, the total estimated fishing effort of 30,669 days (±2,610 s.e.) in 2017/18 was higher but not significantly different to the 26,258 days (±2,037 s.e.) in 2016/17. Total number of licence holder remained around the long-term average.



RECREATIONAL FISHERY FIGURE 1.
Estimated (a) total days people went marroning and (b) total number of marron caught, from 2000 to 2018 for marron licence holders in the Recreational marron fishery. 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 and (b) total number of finfish caught, from 2001 to 2018 for licence holders in the SWRFA fishery. Data was not collected in 2009.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Marron (Sustainable-Adequate)

Smooth marron (*Cherax cainii*), are the third largest crayfish in the world and endemic to Western Australia (Beatty *et al*. 2016). The Marron fishery is composed of many discrete populations (Beatty *et al* 2016) that exhibit biological and life history traits that differ among systems (Beatty *et al* 2011), including fecundity (Beatty *et al* 2016) and growth (Lawrence 2007). Refer to Southern Inland Freshwater Fishery Resource Assessment Report (RAR) (*in prep*.) for further information.

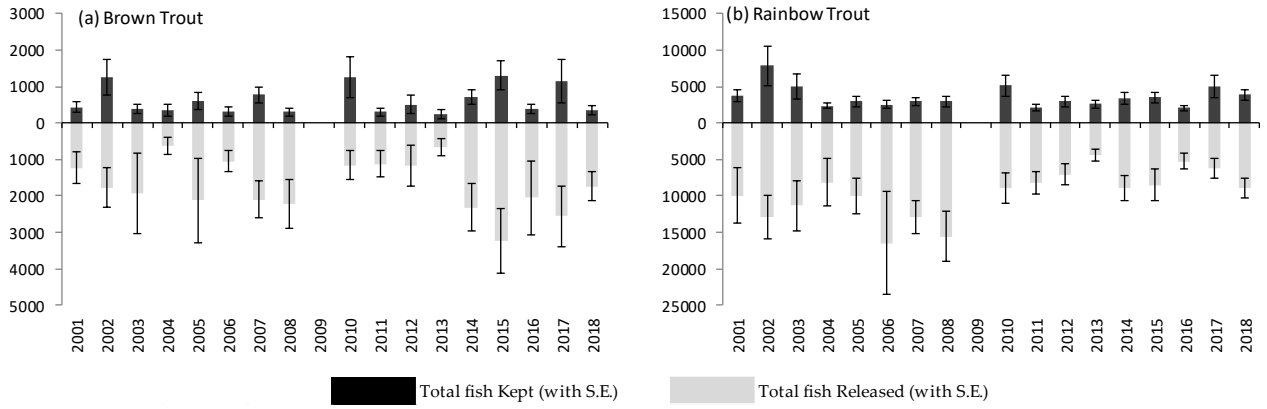
Distribution of fishing effort between dams and rivers has remained consistent with historic patterns (approximately 35% in dams and 65% in rivers). The distribution of fishing effort across particular rivers and dams is largely consistent across years, although some fluctuations occur. (Refer to RAR (*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 (a marron poaching operation was identified as operating in the Shannon River in 2017), and potentially unsustainable levels of fishing at some easily accessed and popular sites. For more information, refer to 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 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. Stocking numbers in 2017 for rainbow trout were: 600,000 fingerlings and 28,500 yearlings and ex-broodstock. Stocking numbers for brown trout were 2,300 yearlings and ex-broodstock.

The total estimated recreational catches of brown and rainbow trout in 2017/18 (2,074 (±457 se) & 12,813 (±1,843 se) respectively) were similar to brown and rainbow trout catches in 2016/17 (3,719 (±1,074 se) and 11,185 (±2,139 se) respectively) (Recreational Fishery Figure 3). For information on other freshwater fish species, refer to RAR (*in prep*.).



RECREATIONAL FISHERY FIGURE 3.
Total kept and released by species (a) Brown trout (b) Rainbow trout for 2001 to 2018 seasons.

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 little to no 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 **low** 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 transloacted 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. However, they can also provide an environmental benefit through the removal of large numbers of feral redfin perch (*Perca fluviatilis*). However, fishers can 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.

Stocking of trout has occurred in WA waters for over 100 years. To minimise adverse impacts of trout on native species, they are 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, whilst the SWRFA has an enthusiastic base of fishers and a dedicated angling group (Western Australian Trout and Freshwater Angling Association (WATFAA)), therefore the resource has high social amenity. Both fisheries attract tourists to regional areas and a FRDC project (2015-028) is underway examining the social drivers of the Marron Fishery.

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. In 2015, the drying of Cardiff Town Pool, on the south branch of the Collie River, resulted in the death of a number of large marron and gained significant media attention. The Department is investigating how these situations can be managed in the future. Social aspects are identified as having **high** amenity and a **moderate** risk.

Economic

The SWRFR is likely to support tourism to regional towns in the South-West. As this resource does not generate income, a risk score is not applicable.

GOVERNANCE SYSTEM

Harvest Strategy

The marron fishery is managed under a constant catch harvest strategy, although the Harvest strategy has not been formalised. The SWRFA fishery is based on stocking (inputs). While a stocking committee determines numbers and locations to be stocked, there is currently no formal harvest strategy for this fishery.

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. Fishery independent surveys indicate negative impacts of fishing on stocks, therefore, although catch is considered **acceptable** it should be reviewed.

SWRFA: There are no allowable catch and tolerance levels specified as trout are stocked annually.

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 the year round. The South-west freshwater angling licence allows recreational fishing south of Greenough (29°S) and above the tidal influence, including all lakes, dams, rivers and their tributaries. Anglers under the age of 16 do not require a Freshwater Angling Licence.

A licence free weekend for freshwater recreational fishing for fish Exemption was developed by the Department in September 2017 to mark the beginning of the recreational freshwater fishing season and promote recreational angling by Recfishwest. This Exemption will ran again in September 2018 in conjunction with Recfishwest's family fishing day and release of trout produced at DPIRD's Pemberton Freshwater Research Centre. The licence free Exemption includes all inland waters south of Greenough (29°S) and above the tidal influence, including all lakes, dams, rivers and their tributaries.

EXTERNAL DRIVERS

Rainfall in the south-west of Western Australia has declined by 10-15% since 1975 according to CSIRO models and it predicts an additional 7% decrease in rainfall by 2030 (CSIRO 2009). 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 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.

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STATEWIDE BIOREGION

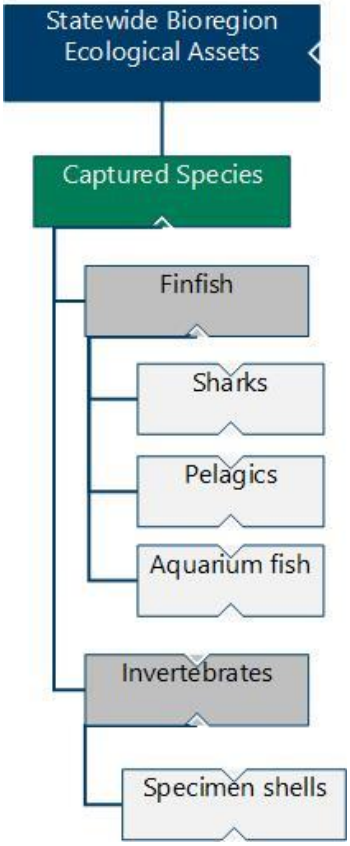
ECOSYSTEM BASED FISHERIES MANAGEMENT

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.

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. 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.



STATEWIDE ECOSYSTEM MANAGEMENT FIGURE 1
Component tree showing the Statewide ecological assets and external drivers identified and separately assessed.

Captured Species

FINFISH

Sharks (and other Elasmobranchs)

Captured Species	Aquatic zone	Ecological Risk
Sharks	South and lower west	MODERATE
	Mid West – North	MODERATE

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	LOW

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 by the Mackerel Managed Fishery (MMF) and recreational fishers. The MMF operates in the North Coast, Gascoyne Coast and West Coast Bioregions and the Spanish mackerel stock is at an acceptable level. 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	MODERATE

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 of some stocks status'.

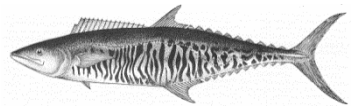
INVERTEBRATES

Captured Species	Aquatic zone	Ecological Risk
Specimen Shells	Marine	MODERATE

The level of capture is low and the management arrangements are such that these species are not considered at risk.

FISHERIES

STATEWIDE LARGE PELAGIC FINFISH RESOURCE STATUS REPORT 2018



P. Lewis and N. Blay

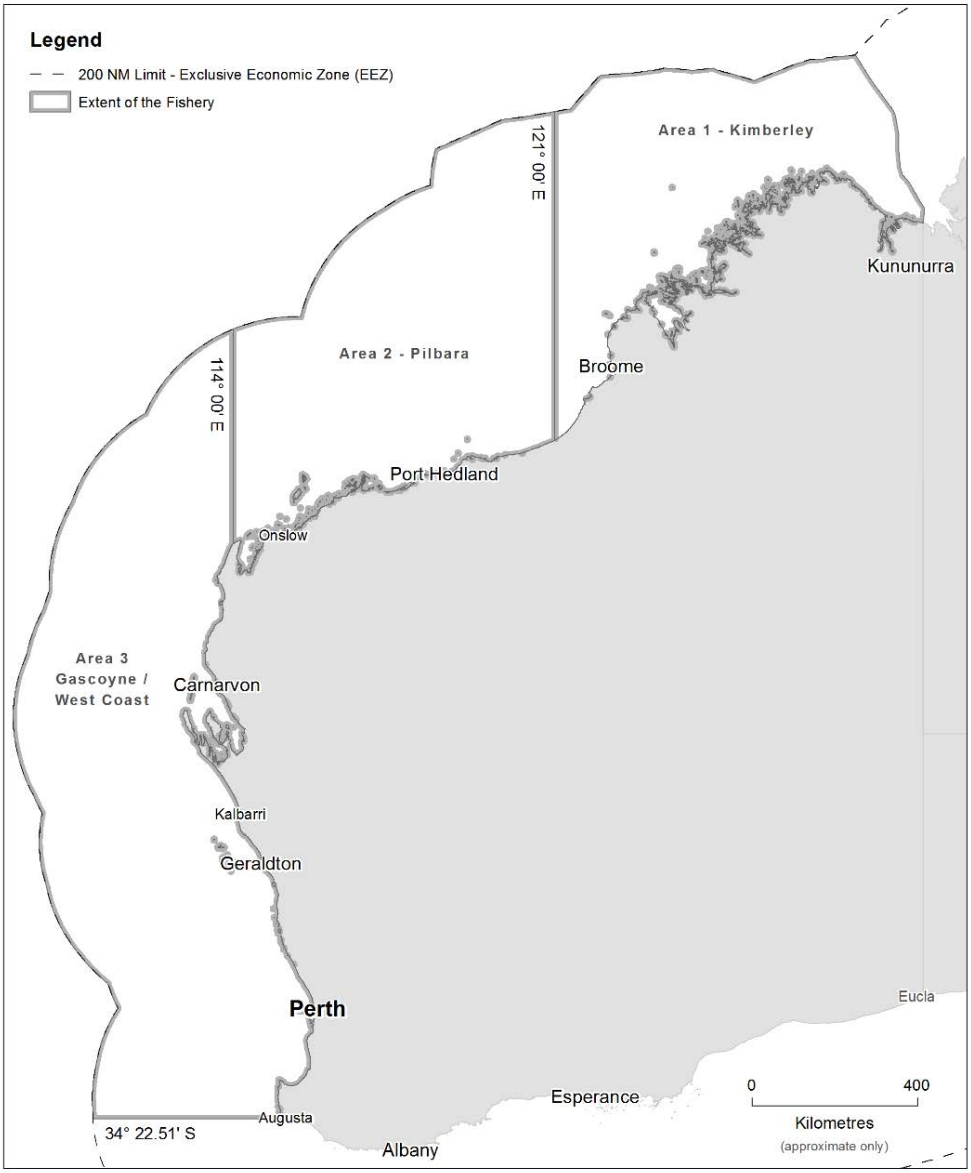
OVERVIEW

The 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 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 equal 2nd highest retained in charter/fishing tour operator catch. For most other large pelagic species, the majority of the recreational catch is released (Ryan *et al*. 2019). For further details see the Statewide Large Pelagic Scalefish Resource Assessment Report https://www.fish.wa.gov.au/Documents/resource_assessment/resource_assessment_report_019.pdf

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (Spanish mackerel 430 t, Grey mackerel 180 t)	Total catch 2018: 213 t (Spanish mackerel), 14 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 below tolerance ranges and 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 amenity)	Moderate risk	Acceptable
Governance	Stable	Acceptable
External Drivers	Moderate risk	Acceptable



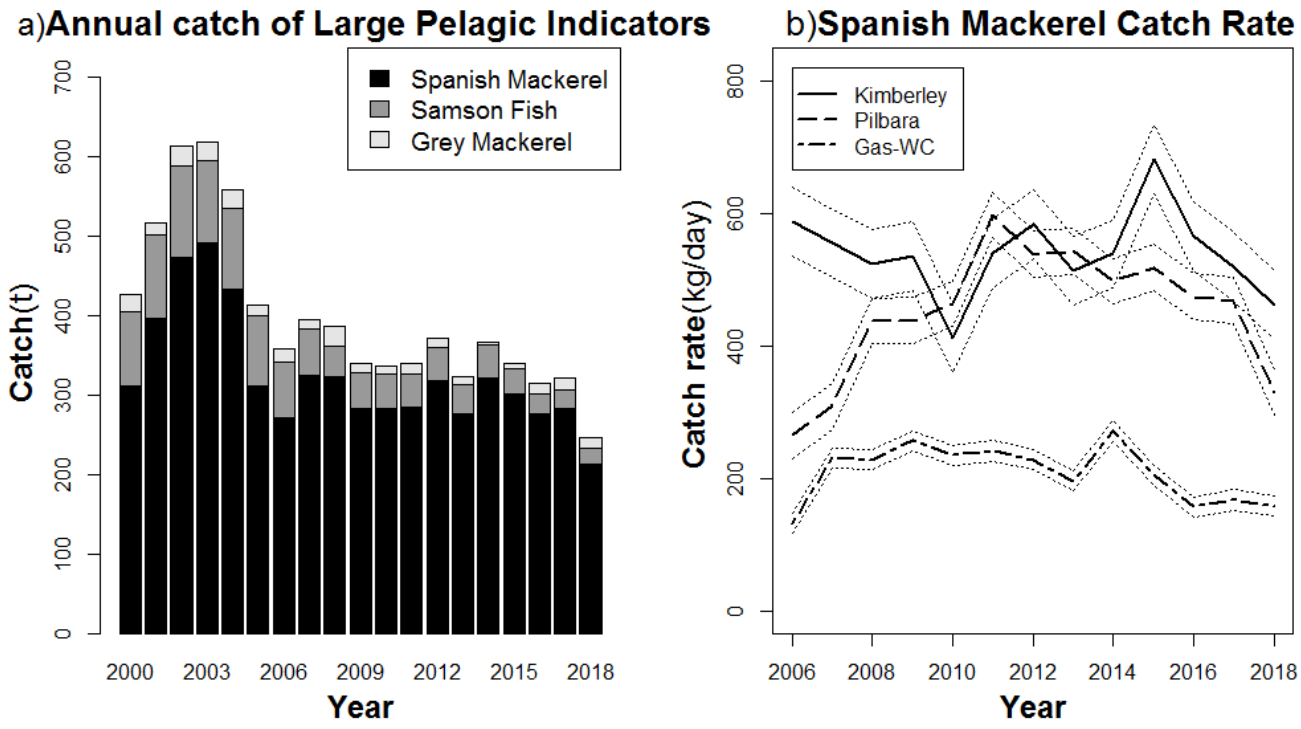
LARGE PELAGIC FINFISH FIGURE 1.
Map showing boundaries of the Mackerel Managed Fishery.

CATCH AND LANDINGS

The combined commercial landings of all Large Pelagic species in WA have ranged from 361-433 t over the past 10 years but were at a low of 293 t in 2018, with declines for many species. The main commercial catch is of Spanish mackerel by the MMF which has been 270-330 t since quotas were introduced in 2006 but in 2018 was the lowest on record at 213 t (Large Pelagic Finfish Figure 2a). The commercial catch of grey mackerel in 2018 was 14 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 t, 20 t, and 19 t, respectively, with remaining species <10 t in 2018. For the temperate large pelagic species only the combined WCB and SCB catch of 22 t for Samson fish in 2018 was > 10 t.

The fishing tour operator annual catches of the three large pelagic indicator species have been 27-54 t since 2010, with grey mackerel contributing <1 t annually.

The statewide top 10 pelagic scalefish species (or species groupings) in 2017/18 represented 85% of the total resource catch (kept by numbers). The estimated recreational harvest range for the top 10 pelagic species was steady at 104 t (95% CI 87–121 t) in 2017/18 compared with 106 t (95% CI 93–118 t) in 2015/16, but lower than 143 t (95% CI 124–163) in 2013/14 and 174 t (95% CI 154–193) in 2011/12 (Ryan *et al*. 2019). In each year a similar or higher amount of the Large Pelagic Resource was released.



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 2018 Spanish mackerel catch of 213 t (Large Pelagic Finfish Figure 2a) is the lowest on record, previously the catch and effort throughout the MMF had been relatively stable at 270-320 t following management changes in 2006. 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 1b), suggesting that the overall spawning stock may be declining. 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 marine heatwave (Pearce 2011).

The annual charter boat operators' catch of Spanish mackerel in WA has been stable at 17-37 t since 2003 with 34-61% released/discarded, 22 t was caught in 2018 with 75% taken in the NCB and 35% released.

The estimated recreational harvest range of Spanish Mackeral was steady in 2017/18 (37–58) compared with 2015/16 (35–54), and lower than 2013/14 (69–103) and 2011/12 (78–108) (Ryan *et al*. 2019). The decline in catch can be partly attributed to the 20-35% decline in recreational effort in the North and Gascoyne Coast Bioregions, 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 West Coast Bioregion was steady in 2017/18 (775, SE=233) and 2015/16 (704, SE=233), 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 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 Western Australia 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 at 3.5 to 24 t (Large Pelagic Finfish Figure 1a). In 2018 the WA catch of 14 t, was predominantly taken by two vessels (93%), 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 (SAFS 2018). The low levels of catch are likely to reflect the gear limitations (line only) and limited targeting of the species in the MMF.

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 tonne 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 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 fishing pressures.

The statewide commercial catch of Samson fish in 2018 was 22 t, which is the lowest on record and split between the WCB and SCB. Since 2008 catches have been at historically low levels of <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 Managed Fisheries (TDGDLMF). Over the past 5 years the catches of Samson fish have been 5-16 t in each of the South Coast open access line fishery, WCDSIMF, and TDGDLMF.

The annual charter boat operators' total estimated catch of Samson fish in WA for 2017 and 2018 have been the lowest on record at 6 t with 95% taken in the WCB and 62% 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 Samsonfish was steady in 2017/18 (10–17) compared with 2015/16 (11–19), 2013/14 (16–28) and 2011/12 (14–22), with similar high release rates of 74-86% (Ryan *et al*. 2019).

On the basis of the evidence provided above, 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 (2018). Thus, there is **negligible** risk to the breeding stocks of other finfish species, by fishers targeting the large pelagic 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 or ecosystem interactions.

SOCIAL AND ECONOMIC OUTCOMES

Social

Fifteen boats fished in the MMF during the 2018 season, primarily from May – November, with approximately 35-40 people were directly employed in the MMF. The estimated participation rate for recreational fishing in the population of WA is 31.1% in 2015/16 (DoF 2016). 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 North and Gascoyne Coast Bioregions (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.

The large pelagic resource provides a **moderate/high** social amenity 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 2018, the estimated value (to fishers) of the Spanish mackerel annual catch was level 2, approximately $2.0 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 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 (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 2020. This will inform the harvest strategy which will be developed for this fishery.

Annual Catch Tolerance Levels (Acceptable)

The 2018 catch is below the target commercial catch range for Spanish mackerel in the MMF of 246-430 t. In the Kimberley area the 2018 Spanish mackerel catch of 126 t is within the range (110 – 225 t) while the catches of 69 t in the Pilbara and 20 t in the GCB/WCB are below the respective tolerance ranges of 80 – 126 t and 56 – 79 t. Although the Pilbara catch is often below the tolerance range and the GCB/WCB catch has been 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 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 deemed **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

Management Meetings are held every two years 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 February 2018.

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 for a period of ten years. In 2018 an Instrument of Exemption was issued to all licence holders which provides

for operational and economic efficiencies relating to nomination requirements.

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 Spanish mackerel distribution shifted southwards (Pearce *et al*. 2011), but can be detrimental in northern parts, if coinciding with spawning season. Other external factors on the fishery include the petroleum industry restricting access to fishing grounds in some parts of the Pilbara area and the potential re-activation of the Northern Shark Fisheries.

The high proportion of released/discarded charter and recreationally caught large pelagic fish with the unknown level of mortality along with the increasing mortality of hooked and discarded large pelagic species by depredation, particularly in some areas, are factors affecting the large pelagic resource.

Finally, the past four Indian Ocean Tuna Commission (IOTC) assessments of the Spanish mackerel catch have determined the species is overfished, subject to overfishing and requires the catch of 160,000 t to be reduced by 30% (IOTC 2019). However, this outcome does not apply to the Western Australian 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 **low** risk to WA's Large Pelagic resource, with possible impacts varying among individual species.

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STATEWIDE MARINE AQUARIUM FISH AND HERMIT CRAB RESOURCES STATUS REPORT 2019

S. Newman, C. Bruce, P. Kalinowski, A. Steele and L.Wiberg

OVERVIEW

The Marine Aquarium Fish Managed Fishery (MAFMF) is able to operate in all State waters (between the Northern Territory border and South Australian border). 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. The HCF operates under Ministerial Exemptions and is currently permitted to fish Western Australian waters north of Exmouth Gulf (22°30'S).

There are no documented recreational or customary fisheries.

SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (NA)	Total Catch 2018: Fish (n) – 27,327	Acceptable
Recreational fishery (NA)	Total Catch 2018: NA	Acceptable
EBFM		
Indicator species		
Syngnathid (n) – 219; Invertebrates (n) -; 61,568; Hard coral (kg) - 5,835.57 Soft coral (kg) – 5,594.70 Living rock & Living sand (kg) - 20,595; Sponges (n) - 4,774; Algae/Seagrasses (l) – 176	Small numbers of individual species taken annually.	Adequate
Hermit crabs (n) - 62,300	Lowest level of catch in last 10 years	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

CATCH AND LANDINGS

All twelve licences were active in the MAFMF in 2018 and there were three active licences in the HCF (out of a total of five licences) during 2018. The total catch in the MAFMF in 2018 was 156,188 fishes, 32.025 t of coral, live rock & living sand and 176.02 L of marine plants and live feed. MAFMF fish catches were dominated by Vachell's Glassfish (*Ambassis vachellii*, n =4,086), scribbled angelfish (*Chaetodontoplus duboulayi*, n = 3,553), margined coralfish (*Chelmon marginalis*, n = 1,934), blue and yellow wrasse (*Anampses lennardi*, n = 1,552, wavy-lined blenny (*Entomacrodus decussatus*, n = 1,337), and Black-axil Chromis (*Chromis atripectoralis*, n = 1,301; Marine Aquarium Table 1), with more than 280 other fish taxa also reported. In addition, more than 100 invertebrate taxa were also landed in the MAFMF dominated by gastropods, crabs and anemones. The main coral species landed in 2018 were the coral-like anemones of the *Corallimorphus* genus with 2,420 kg (Marine Aquarium Fish Table 2).

The total catch in the HCF in 2018 was 62,300 Australian land hermit crabs. The catch range of Australian land hermit crabs over the last 11 years (2008-2018) is 58,643-118,203.

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 is a result 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 WTO 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

Fifteen licences were active in 2018 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 2 – 3 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 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. Catches of CITES species in 2018 were well below the WTO limits for hard corals (5,835.57 kg; a total limit of 15,000 kg for all corals (hard and soft coral combined – excluding Corallimorpharia and Zoanthidae spp) applies, with individual species-specific limits, see DPIRD 2018a), *Tridacnid* clams (382 individuals; limit of 2,400 across all species) and seahorses (*Hippocampus* spp. – 156 individuals; a total limit of 2000 across all Syngnathiformes applies); Syngnathids (total all species 219; a total limit of 2000 across all Syngnathiformes applies).

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. No threshold levels were exceeded in 2018.

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 a new 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 September 2018.

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 2018, and catches over the previous four years.

Species	Common Name	2014	2015	2016	2017	2018
Ambassis vachellii	Vachell's Glassfish		5,245	3,200	775	4,086
Chaetodontoplus duboulayi	Scribbled Angelfish	1,333	1,668	2,670	3,602	3,553
Chelmon marginalis	Margined Coralfish	1,082	827	943	1,888	1,934
Anampses lennardi	Blue and Yellow Wrasse	20	121	92	1,448	1,552
Entomacrodus decussatus	Wavy-lined Blenny	4			655	1,337
Chromis atripectoralis	Black-axil Chromis	2,778	2,400	2,106	340	1,301
Chromis viridis	Blue-green Chromis	52	108	545	120	1,279
Valenciennea puellaris	Orange-spotted Glidergoby	513	35	10	1,039	1,046
Valenciennea alleni	Allen's Glidergoby		310		647	760
Istiblennius edentulus	Rippled Blenny	350	29			574

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 2018, and catches over the previous four years.

Species	Common Name	2014	2015	2016	2017	2018
Corallimorphus spp.	Corallimorphus Coral-like Anemones	2318	2319	1708	2192.5	2420
Zoanthidae - Undifferentiated	Zoanthidae Zoanthid Anemones	1576	1976	748.5	1035.7	1273
Euphyllia ancora	Hammer Hard Coral	330.9	535.1	421.8	821	770.4
Euphyllia glabrescens	Torch Hard Coral	277.4	362.52	290.1	467.4	752.8
Order Zoantharia - undifferentiated	General Zoanthid Anemones	632	609	340	14	470
Lobophyllia spp.	Lobophyllia Hard Corals	333.5	439.82	145.4	168.9	422.6
Goniopora spp.	Goniopora Hard Corals	225.8	251.22	234.65	175.9	401
Sarcophyton spp.	Toadstool Soft Corals	448	430	455.7	456	390.5
Acropora spp.	Acropora Staghorn Hard Corals	165.6	198.37	173.2	302.8	376.8
Corallimorphidae - undifferentiated	Corallimorphidae Coral-like Anemones	30			60	362
Order Corallimorpharia - undifferentiated	General Coral-like Anemones	418	282	369	49	331.20
Trachyphyllia geoffroyi	Trachyphyllia Hard Coral	180.15	279.3	272.9	528.5	326.6
Duncanopsammia axifuga	Whisker Hard Coral	318.8	505.99	375.7	382.2	315.37
Catalaphyllia jardinei	Elegant Hard Coral	154.1	229.5	164.7	106.5	306.2
Favia spp. (Dipsastraea spp.)	Favia Hard Corals (Dipsastraea Hard Coral)	44	127	151.3	91.7	293.8
Order Alcyonacea - Undifferentiated	General Soft Coral & Sea Fans	197	712	471	286.5	223
Order Scleractinia - Undifferentiated	General Hard Corals	290	218	231	320	192
Symphyllia wilsoni	Symphyllia wilsoni Hard Coral		42.5	57	206.5	169.9
Echinophyllia spp.	Echinophyllia Hard Coral	90.9	104.2	51.2	52.3	142.1
Acanthastrea spp.	Acanthastrea Hard Corals	90.7	65.912	50.2	126.9	135.7

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STATEWIDE SPECIMEN SHELL RESOURCE STATUS REPORT 2019

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 by hand 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 and Albany.

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 31 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 trail 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 2019

Asset (Allowable catch &/or effort)	Outcome	Status
Commercial fishery (NA)	Total Catch 2018: Shells (n) – 7,628	Acceptable
Recreational fishery (NA)	Total Catch 2018: NA	Acceptable
EBFM		
Assessment Indicator		
Catch: 10,000 to 25,000 shells Catch rate: 10 – 40 shells per day	7,628 shells. 12 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

CATCH AND LANDINGS

In 2018, the total number of specimen shells collected was 7,628 distributed over 197 species. This is based on 100% of submitted catch returns. In the past 5 years, more than 450 separate species of molluscs have been collected, with an average of more than 200 species per year – the majority in low numbers per species.

There is some focus of effort on mollusc families 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 31 licences in the fishery, 20 fished in 2018. Effort in 2018 was 636 days, which was 38 fishing days less than the number of fishing days reported in 2017 (674 days). Over the past five years, there was an annual average of around 630 days fished.

INDICATOR SPECIES ASSESSMENTS AND STOCK STATUS

Statewide SSMF (Sustainable-Adequate)

During the 2018 season, the catch rate was approximately 12 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 as potentially vulnerable comprised 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 54% of the shells sighted were not harvested in 2018. The measure of the number of

shells sighted is reported correctly in about 98% 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.

Protected species

The fishery reported no interactions with listed protected species during 2018. 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 2018, around 12 licences recorded consistent activity, with around 21 people operating occasionally in the fishery. It is expected that approximately 21 people are employed regularly in this fishery.

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.

GOVERNANCE SYSTEM

The performance measures for the fishery relate to the maintenance of breeding stocks, as indicated by catch levels and catch rates. In 2018, the catch level of approximately 7,628 shells was within the range set, i.e. 10,000 – 25,000 shells and the catch rate of 12 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/Outlook Status

A review of the management arrangements for the SSMF is planned for 2019/2020.

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.

APPENDICES

APPENDIX 1

Science and Resource Assessment staff publications 2018/19

Scientific Papers

Braccini, M. & Waltrick, D. 2019. Species-specific at-vessel mortality of sharks and rays captured by demersal longlines. Marine Policy: 99: 94-98.

Braccini, M., de Lestang, S.& McAuley, R. 2018. Dusky sharks (*Carcharhinus obscurus*) undertake large-scale migrations between tropical and temperate ecosystems. Canadian Journal of Fisheries and Aquatic Sciences 75: 1525–1533.

Coulson, P.G., Norriss, J.V., Jackson, G., & Fairclough, D.V. 2019. Reproductive characteristics of the fishery important temperate demersal berycid *Centroberyx gerrardi* indicate greater reproductive output in regions of upwelling. Fisheries Management and Ecology, 26(3), 236-248. https://doi.org/10.1111/fme.12343

Crisafulli, B.M., Fairclough, D.V., Keay, I.S., Lewis, P., How, J.R., Ryan, K.L., Taylor, S.M., Wakefield, C.B. 2018. Does a spatiotemporal closure to fishing *Chrysophrys auratus* (Sparidae) spawning aggregations also protect individuals during migration? Canadian Journal of Fisheries and Aquatic Sciences 6: 1171-1185

Evans, R. D., Ryan, N. M., Travers, M. J., Feng, M., Hitchen, Y. & Kennington, W. J. 2019. A seascape genetic analysis of a stress-tolerant coral species along the Western Australian coast. *Coral Reefs* 38, 63-78.

Fletcher, W., Jackson, G., Kangas, M., Fairclough, D., Harrison, N. and Crowe, F. 2018. Rebuilding fisheries: Three multi-sectoral case studies from Western Australia. FAO Fisheries and Aquaculture Technical Paper, FAO, Rome. 630: 84-116

Gaughan, D.J., Caputi, N., Molony, B., Wise, B., Begg, G., Mayfield, S., Steer, M., Ward, T., Linnane, A., Stobart, B., Sloan, S. and Saunders T. 2019. Comments on Edgar et al. 2018 paper for south-western Australia. Aquatic Conserv: Mar Freshw Ecosyst. 2019;1–2

Harry, A.V., Butcher, P.A., Macbeth, W.G., Morgan, J.A.T., Taylor, S.M., Geraghty, P. 2019. Life history of the common blacktip shark, *Carcharhinus limbatus*, from central eastern Australia and comparative demography of a cryptic shark complex. Marine and Freshwater Research 70 (6): 834-848.

Hart, A.M., Strain, L.W.S. and Brown, J. Regulation dynamics of exploited and protected populations of *Haliotis roei*, and their response to a marine heatwave. ICES Journal of Marine Science, doi:10.1093/icesjms/fsy064.

Jones, J., DiBattista, J., Stat, M., Bunce, M., Boyce, M. C., Fairclough, D. V., Travers, M. J. & Huggett, M. J. 2018. The microbiome of the gastrointestinal tract of a range-shifting marine herbivorous fish. *Frontiers in microbiology* 9, 2000.

Junge, C., Donnellan, S.C., Huveneers, C., Bradshaw, C.J.A., Simon, A., Drew, M., Rogers, P., Johnson, G., Cliff, G., Braccini, M., McAuley, R., Duffy, C., Peddemors, V., Butcher, P., Cutmore, S.C., & B.M. Gillanders. 2019. Comparative population genomics confirms little population structure in two commercially targeted carcharhinid sharks. Marine Biology 166: 16.

Lai, E.K.M., Mueller, U., Hyndes, G.A., Ryan, K.L., 2019. Comparing estimates of catch and effort for boat-based recreational fishing from aperiodic access-point surveys. Fisheries Research. 219, 105305. https://doi.org/10.1016/j.fishres.2019.06.003

Lynch, T.P., Smallwood, C.B., Lyle, J., Williams, J., Ryan, K.L., Devine, C., Gibson, B., Jordan, A. 2019. A cross continental scale comparison of Australian offshore recreational fisheries research and its applications to Marine Park and fisheries management. ICES Journal of Marine Science. doi:10.1093/icesjms/fsz092

Stewardson, C., Andrews, J., Ashby, C., Haddon, M., Hartmann, K., Hone, P., Horvat, P., Klemke, J., Mayfield, S., Roelofs, A., Sainsbury, K., Saunders, T., Stewart, J., Nicol S. and Wise, B. (eds) 2018, *Status of Australian fish stocks reports 2018*, Fisheries Research and Development Corporation, Canberra.

Travers, M. J., Clarke, K. R., Newman, S. J., Hall, N. G. & Potter, I. C. 2018. To what extents are species richness and abundance of reef fishes along a tropical coast related to latitude and other factors? *Continental Shelf Research* 167, 99-110.

Udyawer, V., Barnes, P., Bonnet, X., Brischoux, F., Crowe-Riddell, J.M., D'Anastasi, B., Fry, B., Gillett, A., Goiran, C., Guinea, M.I., Heatwole, H., Heupel, M.R., Hourston, M., Kangas, M., Kendrick, A., Koefoed, I., Lillywhite, H., Lobo, A.S., Lukoschek, V., McAuley, R., Nitschke, C., Rasmussen, A.R., Sanders, K.L., Sheehy III, C., Shine, R., Somaweera, R., Sweet, S.S., Voris, H.K. 2018 Future Directions in the Research and Management of Marine Snakes. Front. Mar. Sci., Vol. 5 Article 309; 186 pp.| https://doi.org/10.3389/fmars.2018.00399

Underwood, J. N., Travers, M. J., Snow, M., Puotinen, M. & Gouws, G. 2019. Cryptic lineages in the Wolf **Cardinalfish** living in sympatry on remote coral atolls. *Molecular Phylogenetics and Evolution* 132, 183-193.

Wenger, A. S., Rawson, C. A., Wilson, S., Newman, S. J., Travers, M. J., Atkinson, S., Browne, N., Clarke, D., Depczynski, M. & Erftemeijer, P. L. 2018. Management strategies to minimize the dredging impacts of coastal development on fish and fisheries. *Conservation Letters* 11, e12572.

Reports

Taylor, S.M., Steffe, A.S., Lai, E.K.M, Ryan, K.L., Jackson, G. 2018. A survey of boat-based recreational fishing in inner Shark Bay 2016/17. Fisheries Research Report No. 291. Government of Western Australia. Department of Primary Industries and Regional Development.

Webster, F.J., Wise, B.S., Fletcher, W.J., and Kemps, H. 2018. Risk Assessment of the potential impacts of seismic air gun surveys on marine finfish and invertebrates in Western Australia. Fisheries Research Report No. 288 Department of Primary Industries and Regional Development, Western Australia. 42pp.

Popular Articles

Caputi, N, R. Wahle, J. Moore (2018) (Ed.) The Lobster Newsletter. 31(1). Department of Primary Industries and Regional Development, Western Australia. November 2018 http://www.fish.wa.gov.au/Documents/rock_lobster/the_lobster_newsletter/lobster_newsletter_v31_no1.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 2017/18

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			
Acanthuridae, Zanclidae	Surgeonfishes & Moorish Idols	Acanthuridae, Zanclidae - undifferentiated	5
Acropomatidae, Percichthyidae, Serranidae, Polyprionidae, Moronidae, Callanthiidae, Centrogeniidae, Ostracoberycidae	Temperate Basses & Rockcods	Percichthyidae, Serranidae - undifferentiated	68
Ariidae	Forktail Catfishes	Ariidae - undifferentiated	10
Ariidae	Silver Cobbler	Neoarius midgleyi	79
Arripidae	Australian Herring	Arripis georgianus	71
Arripidae	Western Australian Salmon	Arripis truttaceus	191
Balistidae, Monacanthidae	Triggerfishes & Leatherjackets	Balistidae, Monacanthidae - undifferentiated	30
Berycidae	Bight Redfish	Centroberyx gerrardi	56
Berycidae	Redfishes	Berycidae - undifferentiated	8
Berycidae	Yelloweye Redfish	Centroberyx australis	2
Caesiondae, Lutjanidae, Symphysanodontidae	Fusiliers, Tropical Snappers & Slopefishes	Caesionidae, Lutjanidae, Symphysanodontidae - undifferentiated	1
Carangidae	Amberjack	Seriola dumerili	12
Carangidae	Black Pomfret	Parastromateus niger	6
Carangidae	Golden Trevally	Gnathanodon speciosus	41
Carangidae	Samsonfish	Seriola hippos	21
Carangidae	Silver Trevally	Pseudocaranx georgianus spp. complex	2
Carangidae	Trevallies	Carangidae - undifferentiated	258
Carangidae	Yellowtail Kingfish	Seriola lalandi	4
Carangidae	Yellowtail Scad	Trachurus novaezelandiae	14
Centrolophidae	Blue-Eye Trevalla	Hyperoglyphe antarctica	11
Cheilodactylidae	Blue Morwong	Nemadactylus valenciennesi	35

Category Family Scientific Name	Common Name	Scientific Name	Live Weight (tonnes)
Cheilodactylidae	Morwongs	Cheilodactylidae - undifferentiated	1
Clupeidae	Australian Sardine	Sardinops sagax	2,201
Clupeidae	Perth Herring	Nematalosa vlaminghi	3
Clupeidae	Sandy Sprat	Hyperlophus vittatus	28
Clupeidae	Scaly Mackerel	Sardinella lemuru	703
Fishes (multi-family groups)	Flounders	Bothidae, Psettodidae & Pleuronectidae	2
Glaucosomatidae	Northern Pearl Perch	Glaucosoma buergeri	32
Glaucosomatidae	West Australian Dhufish	Glaucosoma hebraicum	45
Haemulidae	Grunter Breams	Haemulidae - undifferentiated	62
Haemulidae	Javelinfishes	Pomadasys spp.	32
Haemulidae	Painted Sweetlips	Diagramma labiosum	61
Hemiramphidae	Southern Garfish	Hyporhamphus melanochir	5
Labridae	Baldchin Groper	Choerodon rubescens	7
Labridae	Pigfishes	Bodianus spp.	2
Labridae	Tuskfishes	Choerodon spp.	14
Labridae	Western Blue Groper	Achoerodus gouldii	32
Labridae	Wrasses	Labridae - undifferentiated	1
Latidae	Barramundi	Lates calcarifer	55
Lethrinidae	Bluespotted Emperor	Lethrinus punctulatus	400
Lethrinidae	Drab Emperor	Lethrinus ravus	3
Lethrinidae	Grass Emperor	Lethrinus laticaudis	7
Lethrinidae	Longnose Emperor	Lethrinus olivaceus	14
Lethrinidae	Mozambique Seabream	Wattsia mossambica	4
Lethrinidae	Redspot Emperor	Lethrinus lentjan	37
Lethrinidae	Redthroat Emperor	Lethrinus miniatus	52
Lethrinidae	Robinson's Seabream	Gymnocranius grandoculis	27
Lethrinidae	Spangled Emperor	Lethrinus nebulosus	82
Lethrinidae	Yellowtail Emperor	Lethrinus atkinsoni	3
Lutjanidae	Brownstripe Snapper	Lutjanus vitta	138
Lutjanidae	Chinamanfish	Symphorus nematophorus	9
Lutjanidae	Crimson Snapper	Lutjanus erythropterus	290
Lutjanidae	Darktail Snapper	Lutjanus lemniscatus	25
Lutjanidae	Goldband Snapper	Pristipomoides multidens	801
Lutjanidae	Golden Snapper	Lutjanus johnii	2
Lutjanidae	Indonesian Snapper	Lutjanus bitaeniatus	7
Lutjanidae	Mangrove Jack	Lutjanus argentimaculatus	13
Lutjanidae	Moses' Snapper	Lutjanus russellii	53
Lutjanidae	Red Emperor	Lutjanus sebae	315
Lutjanidae	Rosy Snapper	Pristipomoides filamentosus	9
Lutjanidae	Ruby Snapper	Etelis carbunculus	7
Lutjanidae	Saddletail Snapper	Lutjanus malabaricus	290
Lutjanidae	Sharptooth Snapper	Pristipomoides typus	14
Lutjanidae	Stripey Snapper	Lutjanus carponotatus	1
Lutjanidae	Tropical Snappers	Lutjanus spp.	44
Mugilidae	Sea Mullet	Mugil cephalus	213

Category Family Scientific Name	Common Name	Scientific Name	Live Weight (tonnes)
Mugilidae	Yelloweye Mullet	Aldrichetta forsteri	18
Mullidae	Goatfishes	Mullidae - undifferentiated	30
Nemipteridae	Rainbow Monocle Bream	Scolopsis monogramma	5
Nemipteridae	Threadfin Breams	Nemipteridae - undifferentiated	168
Pentacerotidae	Boarfishes	Pentacerotidae - undifferentiated	4
Platycephalidae	Flatheads	Platycephalidae - undifferentiated	15
Plotosidae	Estuary Cobbler	Cnidoglanis macrocephalus	48
Polynemidae	King Threadfin	Polydactylus macrochir	24
Polynemidae	Threadfin Salmons	Polynemidae - undifferentiated	1
Polyprionidae	Bass Groper	Polyprion americanus	1
Polyprionidae	Hapuku	Polyprion oxygeneios	48
Pomatomidae	Tailor	Pomatomus saltatrix	10
Pricanthidae	Bigeyes	Priacanthidae - undifferentiated	34
Psettodidae	Australian Halibut	Psettodes erumei	1
Rachycentridae	Cobia	Rachycentron canadum	21
Scaridae	Parrotfishes	Scaridae - undifferentiated	7
Sciaenidae	Black Jewfish	Protonibea diacanthus	7
Sciaenidae	Mulloway	Argyrosomus japonicus	12
Scombridae	Grey Mackerel	Scomberomorus semifasciatus	18
Scombridae	Spanish Mackerel	Scomberomorus commerson	252
Scombridae	Yellowfin Tuna	Thunnus albacares	1
Scorpididae	Sea Sweep	Scorpis aequipinnis	1
Serranidae	Banded Grouper	Epinephelus amblycephalus	4
Serranidae	Barcheek Coral Trout	Plectropomus maculatus	30
Serranidae	Birdwire Rockcod	Epinephelus merra	1
Serranidae	Blackspotted Rockcod	Epinephelus malabaricus	22
Serranidae	Breaksea Cod	Epinephelides armatus	4
Serranidae	Common Coral Trout	Plectropomus leopardus	1
Serranidae	Duskytail Grouper	Epinephelus bleekeri	17
Serranidae	Eightbar Grouper	Hyporthodus octofasciatus	9
Serranidae	Goldspotted Rockcod	Epinephelus coioides	32
Serranidae	Radiant Rockcod	Epinephelus radiatus	1
Serranidae	Radiant Rockcod/Comet Grouper	Epinephelus Radiatus/Morrhua	1
Serranidae	Rankin Cod	Epinephelus multinotatus	191
Serranidae	Spotted Cod	Epinephelus Microdon/Areolatus/Bilobatus	69
Serranidae	Tomato Rockcod	Cephalopholis sonnerati	2
Siganidae	Rabbitfish	Siganus spp.	1
Sillaginidae	King George Whiting	Sillaginodes punctatus	15
Sillaginidae	Whitings	Sillaginidae - undifferentiated	58
Sillaginidae	Yellowfin Whiting	Sillago schomburgkii	99
Sparidae	Black Bream	Acanthopagrus butcheri	70
Sparidae	Frypan Bream	Argyrops spinifer	59
Sparidae	Pink Snapper	Chrysophrys auratus	207
Sparidae	Tarwhine	Rhabdosargus sarba	8
Sparidae	Western Yellowfin Bream	Acanthopagrus morrisoni	12

Category Family Scientific Name	Common Name	Scientific Name	Live Weight (tonnes)
Sphyraenidae	Pikes	Sphyraenidae - undifferentiated	5
Sphyraenidae	Snook	Sphyraena novaehollandiae	4
Terapontidae	Striped Grunters	Terapontidae - undifferentiated	3
TOTAL SCALEFISH			8,723
SHARKS & RAYS			
Carcharhinidae	Bronze Whaler	Carcharhinus brachyurus	30
Carcharhinidae	Dusky Whaler	Carcharhinus obscurus	171
Carcharhinidae	Sandbar Shark	Carcharhinus plumbeus	38
Carcharhinidae	Spinner Shark	Carcharhinus brevipinna	22
Carcharhinidae	Tiger Shark	Galeocerdo cuvier	4
Lamnidae	Shortfin Mako	Isurus oxyrinchus	1
Orectolobidae	Wobbegong	Orectolobidae - undifferentiated	20
Pristiophoridae	Common Sawshark	Pristiophorus cirratus	1
Rajidae	Skates	Rajidae, Arhynchobatidae - undifferentiated	18
Sphyrnidae	Hammerhead Sharks	Sphyrnidae - undifferentiated	31
Triakidae	Gummy Shark	Mustelus antarcticus	373
Triakidae	Whiskery Shark	Furgaleus macki	105
Trygonorrhinidae	Banjo Rays	Trygonorrhinidae - undifferentiated	1
	Other Sharks	Sharks - undifferentiated	10
TOTAL SHARKS & RAYS			825
OTHER FISH	Other Fish		99
TOTAL FISH			9,647
INVERTEBRATES			
CRABS			
Geryonidae	Crystal Crab	Chaceon bicolor	150
Hypothalassiidae	Champagne Crab	Hypothalassia spp.	13
Menippidae	Giant Crab	Pseudocarcinus gigas	9
Portunidae	Blue Swimmer Crab	Portunus armatus	618
TOTAL CRABS			790
LOBSTERS			
Palinuridae	Southern Rock Lobster	Jasus edwardsii	31
Palinuridae	Western Rock Lobster	Panulirus cygnus	6,918
Scyllaridae	Moreton Bay Bug	Thenus spp.	8
TOTAL LOBSTERS			6,957
MOLLUSCS			
Cephalopoda	Squid	Order Teuthoidea - undifferentiated	29
Haliotidae	Brownlip Abalone	Haliotis conicopora	22
Haliotidae	Greenlip Abalone	Haliotis laevigata	60
Haliotidae	Roe's Abalone	Haliotis roei	52
Octopodidae	Octopuses	Octopodidae - undifferentiated	297
Pteriidae	Silverlip Pearl Oyster	Pinctada maxima	176
Sepiidae	Cuttlefish	Sepia spp.	63
Veneridae	Ballot's Saucer Scallop	Ylistrum balloti	2,243
TOTAL MOLLUSCS			2,942
PRAWNS			

Category Family Scientific Name	Common Name	Scientific Name	Live Weight (tonnes)
Penaeidae	Banana Prawn	Penaeus merguiensis	415
Penaeidae	Blue Endeavour Prawn	Metapenaeus endeavouri	253
Penaeidae	Brown Tiger Prawn	Penaeus esculentus	765
Penaeidae	Velvet Prawn	Metapenaeopsis spp.	127
Penaeidae	Western King Prawn	Melicertus latisulcatus	946
Stomatopoda	Mantis Shrimps	Order Stomatopoda - undifferentiated	40
TOTAL PRAWNS			2,546
OTHER INVERTEBRATES	Other Invertebrates		140
TOTAL INVERTEBRATES			13,375
GRAND TOTAL			23,022

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 2017/18

Common Name	Quantity (numbers)	Weight (kg)	Volume (litres)
MARINE AQUARIUM FISH FISHERY			
Fish	25,287		
Syngnathidae (not included in Fish)	300		
Invertebrates (not including Corals)	65,883		
Hard Coral		4,625.77	
Soft Coral[1]		4,653.30	
Living Rock & Living Sand		10,840	
Sponges	3,916		
Algae/Seagrasses			218
SPECIMEN SHELL FISHERY			
Specimen Shells - Mollusca	7,948		
HERMIT CRAB FISHERY			
Land Hermit Crabs only - *Coenobita variabilis*	67,043		

1 The 'Soft coral' category for the Marine Aquarium Fish Fishery includes 3,997.3 kg of coral like anemone groups such as corallimorphs and zoanthids in the Class Anthozoa. These are not part of the annual coral TAC.

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

Category / Family	Common Name	Scientific Name	Est Kept Catch (number)	Est Kept Catch (tonnes)	Charter Kept Catch (number)	Charter Est Kept Catch (tonnes)
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
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

Category / Family	Common Name	Scientific Name	Est Kept Catch (number)	Est Kept Catch (tonnes)	Charter Kept Catch (number)	Charter Est Kept Catch (tonnes)
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
	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

Category / Family	Common Name	Scientific Name	Est Kept Catch (number)	Est Kept Catch (tonnes)	Charter Kept Catch (number)	Charter Est Kept Catch (tonnes)
	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 2017/18

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 2017/18 include abalone, barramundi, koonacs, live rock, Murray cod, mussels, western rock oysters and yellowtail kingfish.

Common name	Productive licences	Quantity	Units*	Average price/ kg or individual	Value
Marron	193	64	Tonnes	$34.08	$2,173,669
Yabbies	8	32	Tonnes	$30.80	$994,924
Silver Perch	9	26	Tonnes	$15.68	$415,373
Goldfish & Koi carp	4	69,583	No.	n/a	$231,311
Ornamental Fish	9	48,767	No.	n/a	$152,183
Ornamental Invertebrates	8	13,393	No.	n/a	$140,253
Rainbow Trout	5	4	Tonnes	$16.89	$70,039
Other Species**		2785	Tonnes	n/a	$22,465,557
Algae	< 3	**			**
Total (not including algae or pearls)					$26,643,309

* 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 2018

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 2018[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 WA Wildlife Conservation Act 1950 (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	Australian Darter	Anhinga novaehollandiae	1		
	Cormorant (Unspecified)	Phalacrocoracidae	5	7	
	Duck (Unspecified)	Anatidae	1		
	Pelican	Pelecanus conspicillatus	1		
	Shearwater (Unspecified	Procellariidae	316	37	
Fish	Syngnathids (Unspecified)	Syngnathidae	165	27	
	Manta ray	Manta birostris	4		
	Sawfish (Unspecified)	Pristidae	56	18	2
	Green Sawfish	Pristis zijsron	145	58	
	Narrow Sawfish	Anoxypristis cuspidata	41	1	
	Grey nurse Shark	Carcharias taurus	3		
Reptiles	Crocodile (Unspecified)	Crocodylidae	195	36	
	Seasnake (Unspecified)	Hydrophiinae	4628	513	
	Turtle (Unspecified)	Cheloniidae	84	1	
	Turtle, Freshwater	Chelidae	17	11	
	Green Turtle	Chelonia mydas	8		
	Loggerhead Turtle	Caretta caretta	28		
Mammals	Common Dolphin	Delphinus delphis	1		
	Dolphin (Unspecified)	Delphinidae	4	17	1

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 2017/18

This table contains the average price per kilogram paid for each marine species caught in Western Australia in 2016/17. 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	Common Name	Scientific Name	Price per Kilogram
FISH			
SCALEFISH			
Acanthuridae, Zanclidae	Surgeonfishes & Moorish Idols	Acanthuridae, Zanclidae - undifferentiated	$4.77
Acropomatidae, Percichthyidae, Serranidae, Polyprionidae, Moronidae, Callanthiidae, Centrogeniidae, Ostracoberycidae	Temperate Basses & Rockcods	Percichthyidae, Serranidae - undifferentiated	$9.94
Apistidae, Neosebastidae, Pteroidae, Scorpaenidae, Sebastidae, Setarchidae, Synanceiidae, Tetrarogidae	Scorpionfishes	Apistidae, Neosebastidae, Pteroidae, Scorpaenidae, Sebastidae, Setarchidae, Synanceiidae & Tetrarogidae - undifferentiated	$5.13
Ariidae	Forktail Catfishes	Ariidae - undifferentiated	$2.45
	Silver Cobbler	Neoarius midgleyi	$4.09
Arripidae	Australian Herring	Arripis georgianus	$2.49
	Western Australian Salmon	Arripis truttaceus	$0.92
Balistidae, Monacanthidae	Triggerfishes & Leatherjackets	Balistidae, Monacanthidae - undifferentiated	$4.22
Belonidae	Longtoms	Belonidae - undifferentiated	$1.52
Berycidae	Bight Redfish	Centroberyx gerrardi	$7.34
	Redfishes	Berycidae - undifferentiated	$7.75
	Swallowtail	Centroberyx lineatus	$4.77
	Yelloweye Redfish	Centroberyx australis	$4.41
Caesiondae, Lutjanidae, Symphysanodontidae	Fusiliers, Tropical Snappers & Slopefishes	Caesionidae, Lutjanidae, Symphysanodontidae - undifferentiated	$3.89
Carangidae	Amberjack	Seriola dumerili	$2.53
	Black Pomfret	Parastromateus niger	$7.63
	Giant Queenfish	Scomberoides commersonnianus	$3.87
	Golden Trevally	Gnathanodon speciosus	$2.98
	Samsonfish	Seriola hippos	$3.17
	Silver Trevallies	Pseudocaranx georgianus, Pseudocaranx sp. "dentex" & Pseudocaranx wrighti	$3.10
	Trevallies	Carangidae - undifferentiated	$3.82
	Turrum	Carangoides fulvoguttatus	$1.70
	Yellowtail Kingfish	Seriola lalandi	$5.53
	Yellowtail Scad	Trachurus novaezelandiae	$1.84
Centrolophidae	Blue-Eye Trevalla	Hyperoglyphe antarctica	$7.67
Cheilodactylidae	Blue Morwong	Nemadactylus valenciennesi	$3.99
	Morwongs	Cheilodactylidae - undifferentiated	$1.61
Clupeidae	Australian Sardine	Sardinops sagax	$1.03
	Blue Sprat	Spratelloides robustus	$7.65
	Perth Herring	Nematalosa vlaminghi	$4.05
	Sandy Sprat	Hyperlophus vittatus	$5.95
	Scaly Mackerel	Sardinella lemuru	$1.13

Category / Family	Common Name	Scientific Name	Price per Kilogram
Coryphaenidae	Mahi Mahi	Coryphaena hippurus	$7.11
Elopidae	Hawaiian Giant Herring	Elops hawaiensis	$4.77
Engraulidae	Australian Anchovy	Engraulis australis	$4.77
Fishes (multi-family groups)	Flounders	Bothidae, Psettodidae & Pleuronectidae	$11.08
Gempylidae	Gemfish	Rexea solandri	$2.58
Gerreidae	Common Silverbiddy	Gerres subfasciatus	$4.05
Glaucosomatidae	Northern Pearl Perch	Glaucosoma buergeri	$7.31
	West Australian Dhufish	Glaucosoma hebraicum	$14.99
Haemulidae	Grunter Breams	Haemulidae - undifferentiated	$4.96
	Javelinfishes	Pomadasys spp.	$4.58
	Painted Sweetlips	Diagramma labiosum	$4.96
Hemiramphidae	Southern Garfish	Hyporhamphus melanochir	$6.45
Labridae	Baldchin Groper	Choerodon rubescens	$12.52
	Pigfishes	Bodianus spp.	$6.81
	Tuskfishes	Choerodon spp.	$6.91
	Western Blue Groper	Achoerodus gouldii	$4.74
	Wrasses	Labridae - undifferentiated	$4.00
Latidae	Barramundi	Lates calcarifer	$7.62
Lethrinidae	Bluespotted Emperor	Lethrinus punctulatus	$4.24
	Drab Emperor	Lethrinus ravus	$4.46
	Emperors	Lethrinidae - undifferentiated	$5.14
	Grass Emperor	Lethrinus laticaudis	$6.82
	Longnose Emperor	Lethrinus olivaceus	$5.82
	Mozambique Seabream	Wattsia mossambica	$6.49
	Redspot Emperor	Lethrinus lentjan	$5.01
	Redthroat Emperor	Lethrinus miniatus	$7.18
	Robinson's Seabream	Gymnocranius grandoculis	$5.13
	Seabreams	Gymnocranius spp.	$3.45
	Spangled Emperor	Lethrinus nebulosus	$5.82
	Spotcheek Emperor	Lethrinus rubrioperculatus	$4.42
	Yellowtail Emperor	Lethrinus atkinsoni	$4.66
Lobotidae	Tripletail	Lobotes surinamensis	$4.77
Lutjanidae	Brownstripe Snapper	Lutjanus vitta	$3.83
	Chinamanfish	Symphorus nematophorus	$5.55
	Crimson Snapper	Lutjanus erythropterus	$5.22
	Darktail Snapper	Lutjanus lemniscatus	$5.43
	Fiveline Snapper	Lutjanus quinquelineatus	$3.83
	Goldband Snapper	Pristipomoides multidens	$9.03
	Golden Snapper	Lutjanus johnii	$6.30
	Indonesian Snapper	Lutjanus bitaeniatus	$3.89
	King Snappers	Pristipomoides spp.	$8.50
	Mangrove Jack	Lutjanus argentimaculatus	$5.81
	Maori Snapper	Lutjanus rivulatus	$4.77
	Moses' Snapper	Lutjanus russellii	$5.01
	Red Emperor	Lutjanus sebae	$11.41
	Rosy Snapper	Pristipomoides filamentosus	$9.31

Category / Family	Common Name	Scientific Name	Price per Kilogram
	Ruby Snapper	Etelis carbunculus	$7.61
	Saddletail Snapper	Lutjanus malabaricus	$5.48
	Sharptooth Snapper	Pristipomoides typus	$8.19
	Stripey Snapper	Lutjanus carponotatus	$3.83
	Tang's Snapper	Lipocheilus carnolabrum	$6.32
	Tropical Snappers	Lutjanus spp.	$3.83
Mugilidae	Mullets	Mugilidae - undifferentiated	$4.25
	Sea Mullet	Mugil cephalus	$2.41
	Yelloweye Mullet	Aldrichetta forsteri	$1.40
Mullidae	Goatfishes	Mullidae - undifferentiated	$3.95
Nemipteridae	Rainbow Monocle Bream	Scolopsis monogramma	$1.81
	Threadfin Breams	Nemipteridae - undifferentiated	$4.07
Neosebastidae	Bighead Gurnard Perch	Neosebastes pandus	$3.60
Ophidiidae	Pink Ling	Genypterus blacodes	$6.72
Oplegnathidae	Knifejaw	Oplegnathus woodwardi	$2.03
Pentacerotidae	Boarfishes	Pentacerotidae - undifferentiated	$4.05
Platycephalidae	Flatheads	Platycephalidae - undifferentiated	$4.51
	Rock Flathead	Platycephalus laevigatus	$7.39
Plotosidae	Estuary Cobbler	Cnidoglanis macrocephalus	$3.57
Polynemidae	Blue Threadfin	Eleutheronema tetradactylum	$4.77
	King Threadfin	Polydactylus macrochir	$12.34
	Threadfin Salmons	Polynemidae - undifferentiated	$8.32
Polyprionidae	Bass Groper	Polyprion americanus	$8.94
	Hapuku	Polyprion oxygeneios	$7.63
Pomatomidae	Tailor	Pomatomus saltatrix	$4.68
Pricanthidae	Bigeyes	Priacanthidae - undifferentiated	$3.80
Psettodidae	Australian Halibut	Psettodes erumei	$8.32
Rachycentridae	Cobia	Rachycentron canadum	$4.48
Scaridae	Parrotfishes	Scaridae - undifferentiated	$6.66
Scatophagidae	Striped Scat	Selenotoca multifasciata	$4.77
Sciaenidae	Black Jewfish	Protonibea diacanthus	$5.81
	Mulloway	Argyrosomus japonicas	$5.19
Scombridae	Australian Bonito	Sarda australia	$15.89
	Bigeye Tuna	Thunnus obesus	$10.15
	Blue Mackerel	Scomber australasicus	$17.40
	Grey Mackerel	Scomberomorus semifasciatus	$7.28
	Longtail Tuna	Thunnus tonggol	$3.60
	Mackerels	Scombridae spp. (tribes Scomberomorini & Scombrini)	
	Shark Mackerel	Grammatorcynus bicarinatus	$5.53
	Skipjack Tuna	Katsuwonus pelamis	$9.44
	Spanish Mackerel	Scomberomorus commerson	$9.80
	Spotted Mackerel	Scomberomorus munroi	$10.76
	Tunas	Scombridae spp. (tribes Sardini & Thunnini)	$3.44
	Wahoo	Acanthocybium solandri	$3.13
	Yellowfin Tuna	Thunnus albacares	$10.64
Scorpididae	Banded Sweep	Scorpis georgiana	$1.11

Category / Family	Common Name	Scientific Name	Price per Kilogram
	Sea Sweep	Scorpis aequipinnis	$1.99
Serranidae	Banded Grouper	Epinephelus amblycephalus	$9.94
	Barcheek Coral Trout	Plectropomus maculatus	$14.29
	Birdwire Rockcod	Epinephelus merra	$9.94
	Blackspotted Rockcod	Epinephelus malabaricus	$7.08
	Breaksea Cod	Epinephelides armatus	$11.14
	Chinaman Rockcod	Epinephelus rivulatus	$5.91
	Common Coral Trout	Plectropomus leopardus	$14.29
	Coral Rockcod	Cephalopholis miniata	$9.94
	Coral Trout	Plectropomus spp. & Variola spp.	$14.29
	Duskytail Grouper	Epinephelus bleekeri	$7.06
	Eightbar Grouper	Hyporthodus octofasciatus	$8.25
	Flowery Rockcod	Epinephelus fuscoguttatus	$5.98
	Goldspotted Rockcod	Epinephelus coioides	$6.74
	Harlequin Fish	Othos dentex	$4.77
	Radiant Rockcod	Epinephelus radiatus	$7.65
	Radiant Rockcod/Comet Grouper	Epinephelus Radiatus/Morrhua	$7.65
	Rankin Cod	Epinephelus multinotatus	$8.11
	Spotted Cod	Epinephelus Microdon/Areolatus/Bilobatus	$5.98
	Striped Grouper	Epinephelus latifasciatus	$9.94
	Tomato Rockcod	Cephalopholis sonnerati	$7.50
	Yellowedge Coronation Trout	Variola louti	$9.94
	Yellowspotted Rockcod	Epinephelus areolatus	$5.98
Siganidae	Goldlined Rabbitfish	Siganus lineatus	$4.77
	Rabbitfish	Siganus spp.	$4.77
Sillaginidae	Goldenline Whiting	Sillago analis	$4.77
	King George Whiting	Sillaginodes punctata	$12.88
	Whitings	Sillaginidae - undifferentiated	$9.67
	Yellowfin Whiting	Sillago schomburgkii	$4.00
Sparidae	Black Bream	Acanthopagrus butcheri	$5.68
	Breams	Sparidae - undifferentiated	
	Frypan Bream	Argyrops spinifer	$5.40
	Pink Snapper	Chrysophrys auratus	$8.12
	Tarwhine	Rhabdosargus sarba	$4.21
	Western Yellowfin Bream	Acanthopagrus morrisoni	$4.83
	Yellowback Bream	Dentex spariformis	$5.44
Sphyraenidae	Pikes	Sphyraenidae - undifferentiated	$2.88
	Snook	Sphyraena novaehollandiae	$4.64
Terapontidae	Striped Grunters	Terapontidae - undifferentiated	$1.26
	Yellowtail Grunter	Amniataba caudavittata	$4.77
Zeidae	John Dory	Zeus faber	$5.84
SHARKS & RAYS			
Carcharhinidae	Bronze Whaler	Carcharhinus brachyurus	$2.37
	Dusky Whaler	Carcharhinus obscurus	$4.37
	Sandbar Shark	Carcharhinus plumbeus	$3.66
	Spinner Shark	Carcharhinus brevipinna	$1.36

Category / Family	Common Name	Scientific Name	Price per Kilogram
	Tiger Shark	Galeocerdo cuvier	$0.71
Hexanchidae	Sevengill Sharks	Heptranchias spp.	$2.21
Lamnidae	Shortfin Mako	Isurus oxyrinchus	$0.88
Orectolobidae	Wobbegong	Orectolobidae - undifferentiated	$1.23
Pristiophoridae	Common Sawshark	Pristiophorus cirratus	$0.71
Rajidae	Skates	Rajidae, Arhynchobatidae - undifferentiated	$4.39
Rhinobatidae	Guitarfishes	Rhinobatidae - undifferentiated	$0.77
Sphyrnidae	Hammerhead Sharks	Sphyrnidae - undifferentiated	$1.11
Triakidae	Gummy Shark	Mustelus antarcticus	$4.62
	Pencil Shark	Hypogaleus hyugaensis	$1.32
	School Shark	Galeorhinus galeus	$4.77
	Whiskery Shark	Furgaleus macki	$3.94
	Shark Fins		$10.14
	Other Sharks	Sharks - undifferentiated	$2.21
OTHER FISH			
	Other Fish		$4.77
INVERTEBRATES			
CRABS			
Geryonidae	Crystal Crab	Chaceon bicolor	$41.04
Hypothalassiidae	Champagne Crab	Hypothalassia spp.	$10.82
Menippidae	Giant Crab	Pseudocarcinus gigas	$39.20
Portunidae	Blue Swimmer Crab	Portunus armatus	$6.16
	Brown Mud Crab	Scylla olivacea	$25.34
	Green Mud Crab	Scylla serrata	$25.34
LOBSTERS			
Palinuridae	Southern Rock Lobster	Jasus edwardsii	$60.00
	Western Rock Lobster	Panulirus cygnus	$63.06
Scyllaridae	Bug	Ibacus & Thenus spp.	$12.90
MOLLUSCS			
Cephalopoda	Squid	Order Teuthoidea - undifferentiated	$15.67
Haliotidae	Brownlip Abalone	Haliotis rubra conicopora	$41.81
	Greenlip Abalone	Haliotis laevigata	$52.94
	Roe's Abalone	Haliotis roei	$25.41
Octopodidae	Octopuses	Octopodidae - undifferentiated	$10.48
Sepiidae	Cuttlefish	Sepia spp.	$5.97
Veneridae	Ballot's Saucer Scallop	Amusium balloti	$5.86
PRAWNS			
Penaeidae	Banana Prawn	Penaeus merguiensis	$13.29
	Black Tiger Prawn	Penaeus monodon	$24.51
	Blue Endeavour Prawn	Metapenaeus endeavouri	$10.59
	Brown Tiger Prawn	Penaeus esculentus	$15.87
	Velvet Prawn	Metapenaeopsis spp.	$4.61
	Western King Prawn	Melicertus latisulcatus	$15.02
Stomatopoda	Mantis Shrimps	Order Stomatopoda - undifferentiated	$4.71
SEA CUCUMBERS			
Holothuriidae	Sandfish (Sea Cucumber)	Holothuria scabra	$4.25

APPENDIX 3

INDIAN OCEAN TERRITORIES RESOURCE STATUS REPORT 2019

S. Newman, L. Bellchambers, C. Skepper, S. Evans and P. Kalinowski

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 now has the management responsibilities for the marine territorial waters of the Indian Ocean Territories (IOTs) on behalf of the Commonwealth Department of Infrastructure, Regional Development and Cities (DIRDC). 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 DIRDC, 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 DIRDC 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.

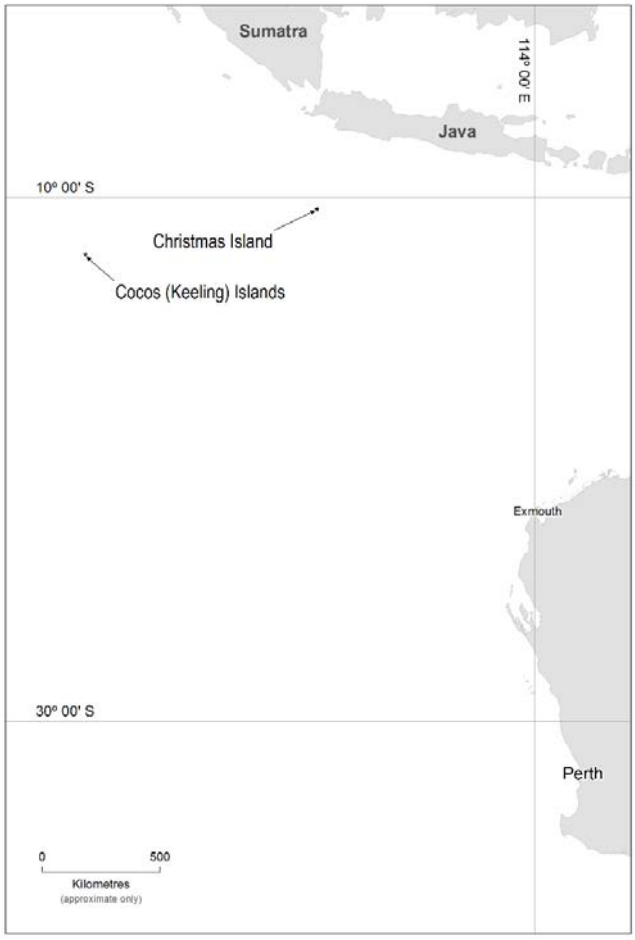
The Cocos (Keeling) Islands Marine Aquarium Fish Fishery (CKIMAFF) primarily targets the endemic Cocos Angelfish or Yellowheaded Angelfish (*Centropyge joculator*), and to a lesser extent the lemonpeel angelfish (*Centropyge flavissima*).

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).

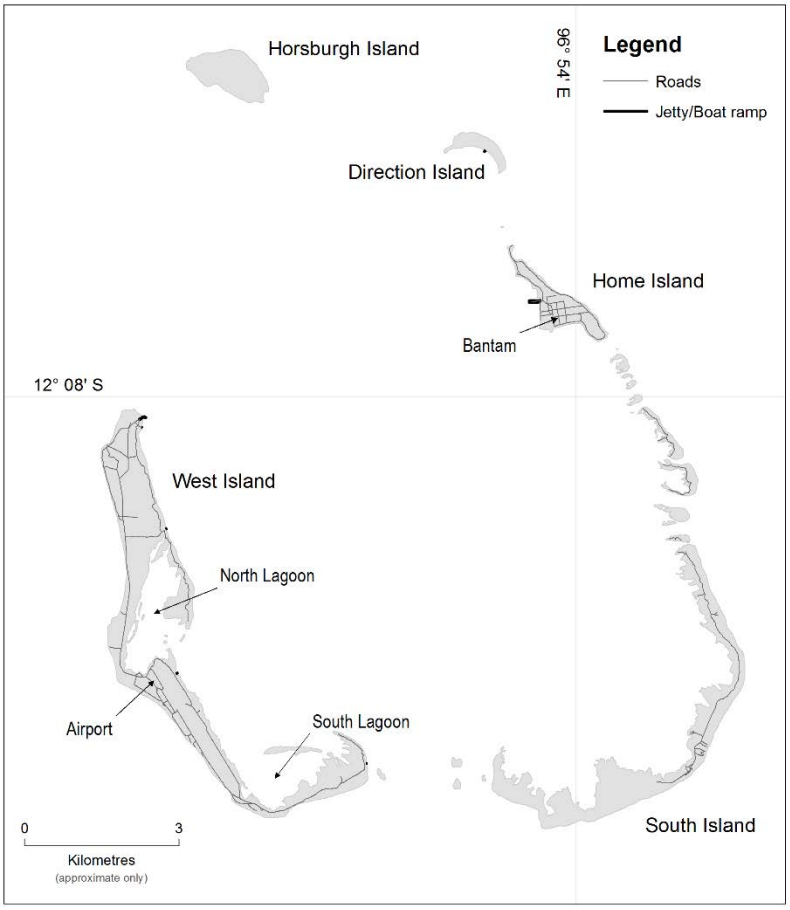
SUMMARY FEATURES 2019

Asset (Allowable catch &/or effort)	Outcome	Status
CILF (NA) CKIMAFF (NA)	Total Catch 2018: Not reportable* Total Catch 2018: Not reportable*	Acceptable Acceptable
Recreational fishery (NA)	Total Catch 2018: 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

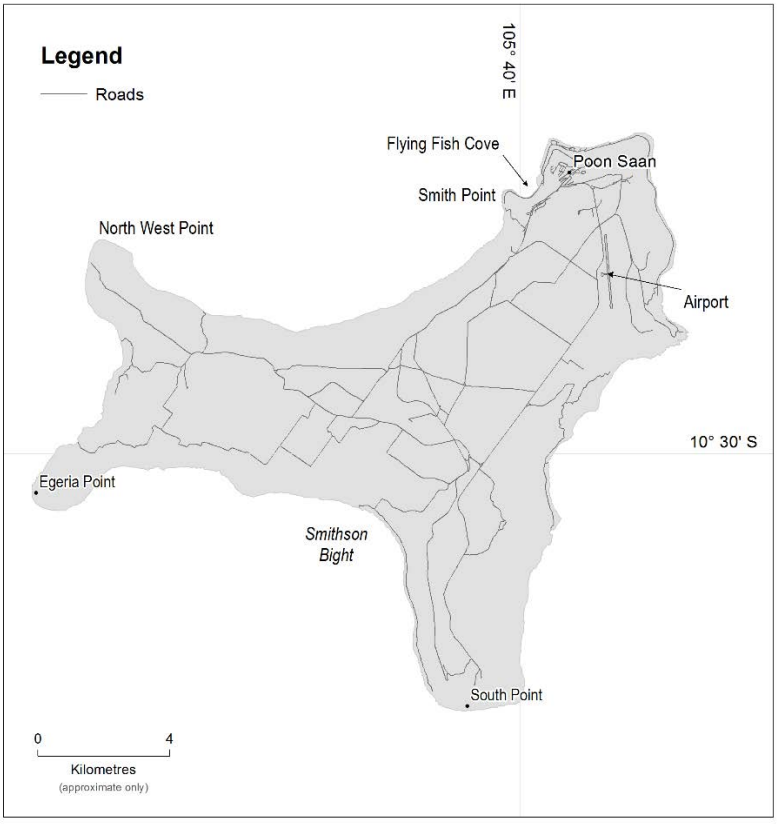
* Activities in these fisheries involved less than three licence holders in 2017 and cannot be reported for confidentially reasons.



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 99% of the total reported catch in 2018. Wahoo (*Acanthocybium solandri*) is the main target species of the CILF, comprising 84% of the total reported catch in 2018. 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.) and these species comprised ~1% of the total reported catch in 2018. 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 2018. 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 2018.

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 2018 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 the first 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.

Cocos-Malay Cultural Fishing arrangements and a Commercial Fishing policy have also been finalised during 2017/18.

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.

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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 2017/18 season or the calendar year 2018 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 2017/18 or 2018	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 below limit in Area 3.
	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 12 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 80–127 diver days; total catch 12 t	Acceptable	
	Roe's abalone Area 7 (spawning stock)	Effort range 175–215 diver days; total catch 24 t	Acceptable	Total catch indicator set annually by stock prediction model.
	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 2018, 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 Current accreditation: August 2017 Expiry date: May 2025	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 2017/18 or 2018	Comment
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 2018.
	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 within 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 have been reviewed as part of Harvest Strategy (in 2017). Further reductions in quota and spatial closures to be implemented in 2018.
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 2017/18 or 2018	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 below acceptable range for first time, likely due to operator change and environmental conditions. 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 40–220 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 high rainfall catch range.
	Brown tiger prawn (spawning stock)	Acceptable catch ranges of Nickol Bay 2–40 t and Onslow 10–120 t	Acceptable	
	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 2017/18 or 2018	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 450 tonnes was set in 2016/17 of which 98% was achieved. The commercial catch rate was well above the target.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2017/18 or 2018	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 1,100–1,600 t, given no change in effort	Acceptable	
	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 2018 season, 87 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 271 t (meat weight) was set in 2017/18 and 88% 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 2019 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 and four turtles were reported caught and returned alive.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2017/18 or 2018	Comment
Fishery: South Coast Crustacean *Approval type:* Wildlife Trade Operation Exemption Initial accreditation: September 2004 Current accreditation: August 2017 Expiry date: July 2020	Southern rock lobster (spawning stock)	Catch to remain between 50 to 80 tonnes	Acceptable	Catch of southern rock lobster below acceptable range. However, southern rock lobster stock indicator (cpue) is above the threshold reference levels in Zones 3&4 (Esperance and Bight).
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 sharks is evident and sandbar sharks is now likely. Stock assessments completed late 2017.Resource Assessment Report published September 2019.
	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. Review of the Gillnet Exclusion Zones is to align with the WTO cycle, the next being August 2021. 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 details	Issue/species	Performance measure/Condition	Current performance in 2017/18 or 2018	Comment
Fishery: West Coast Rock Lobster *Approval Type*: Wildlife Trade Operation Exemption Initial accreditation: August 2002 Current accreditation: May 2018 Expiry date: May 2025	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
	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 (spawning stock)	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 (spawning stock)	The fishery is quota based with catches limited to 154 t of crystal crab per season	Acceptable	TAC achieved with effort within acceptable range. The standardised catch rate of retained legal crabs is within the acceptable range.

APPENDIX 5

Science and Resource 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, University of Mar del Plata, Argentina, supervises Marcelo Perez – ‘Movement patterns of *Mustelus schmitti* in the coastal Bonaerense ecosystem based on the use of conventional mark recapture. Implications for management and sustainable exploitation’.
	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, University of Cologne, Cologne, Germany, supervises Sarah Jakobs – “Acoustic and conventional tagging support the growth patterns of grey nurse sharks and reveal their large-scale displacements in the west coast of Australia”.
Peter Coulson	Adjunct Senior Lecturer, Murdoch University.
	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"
	Masters co-supervision, Casper Avenant, Edith Cowan University, Dietary comparison of the tropical herbivore *Siganus fuscescens* and a range of temperate seagrass-associated omnivorous fishes
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.”
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 co-supervision, Murdoch University, Theodore Campbell – “Dietary composition of the Blue Swimmer Crab, *Portunus armatus*, and life history characteristics of related species.”
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 Associate Professor – Marine Ecology Group, School of Plant Biology, University of Western Australia.
	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, Alissa Tate “Assessing variability in standardised harvest rates from shore-based recreational fishing surveys”. Masters, 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, Matthew Navarro “Evaluating the impacts of implementing marine protected areas on Western Australian marine recreators using integrated bio-economic modelling”. PhD, The University of Western Australia.
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	Adjunct Senior Lecturer, Marine Ecology Group, School of Plant Biology, University of Western Australia.
	Honorary Research Fellow, Victoria University of Wellington, New Zealand.
	Adjunct Senior Lecturer, Curtin University of Technology.
	Masters co-supervision, Curtin University of Technology, supervises Claire Wellington – ‘Description and comparison of demersal fish ecology of the continental slope of Western Australia’.
	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’.
	Masters co-supervision, Victorian University of Wellington New Zealand, supervises Natalie Stewart – ‘The population structure of Polyprionidae from Australia and New Zealand’.
Brent Wise	Adjunct Associate Professor, School of Engineering, Faculty of Health, Engineering and Science, Edith Cowan University.

GLOSSARY OF ACRONYMS

AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AIMWTMF	Abrolhos Islands and Mid-West Trawl Managed Fishery
ASL	Australian sea lion
BPMF	Broome Prawn Managed Fishery
BRD	Bycatch Reduction Device
BRUVS	Baited Remote Underwater Video System
CAES	Catch and Effort Statistics
CDR	Catch and disposal record
CI/CKI	Christmas Island and Cocos (Keeling) Island
CILF	Christmas Island Line Fishery
CKIMAFF	Cocos (Keeling) Islands Marine Aquarium Fish Fishery
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSLPF	Cockburn Sound (Line and Pot) Managed Fishery
CW	Carapace Width
DFAC	Developing Fisheries Assessment Committee
EBFM	Ecosystem Based Fisheries Management
ECU	Edith Cowan University
EPBC	(Commonwealth Government) Environment Protection and Biodiversity Conservation (Act 1999)
ERLF	Esperance Rock Lobster Managed Fishery
ESD	Ecologically Sustainable Development
ETP	Endangered, Threatened and Protected
FED	Fish escapement device
FHPA	Fish Habitat Protection Area
FMO	Fisheries and Marine Officer
FRDC	Fisheries Research and Development Corporation
FRMA	Fish Resources Management Act
FRR	Fisheries Research Report
GAB	Great Australian Bight
GDSF	Gascoyne Demersal Scalefish Managed Fishery
HMAS	Her Majesty's Australian Ship
IBSS	Independent Breeding Stock Survey
IFM	Integrated Fisheries Management
IMCRA	Interim Marine and Coastal Regionalisation for Australia
IMP	Introduced Marine Pests
IMS	Introduced Marine Species
ISO	International Organisation for Standardisation
ITQ	Individually Transferable Quota
IUCN	International Union for the Conservation of Nature
IVR	Integrated Voice Response
JANSF	Joint Authority Northern Shark Fishery
JASDGDLF	Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery
KGBF	Kimberley Gillnet and Barramundi Managed Fishery
KPMF	Kimberley Prawn Managed Fishery
LASCF	Lake Argyle Silver Cobbler Fishery
MAF	Marine Aquarium Fish Managed Fishery
MBP	Marine Bioregional Plan
MFL	Managed Fishery Licence
MLL	Minimum Legal Length
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
NDSF	Northern Demersal Scalefish Managed Fishery
NPF	Northern Prawn Fishery
NRM	Natural Resource Management
NTAC	Notional Target Total Allowable Catch
OCL	Orbital Carapace Length
OPMF	Onslow Prawn Managed Fishery
PFRC	Pemberton Freshwater Research Centre
RAP	Research Angler Program
RAR	Resource Assessment Report
RCL	Rostrum Carapace Length
RFBL	Recreational Fishing from Boat Licence
RFFSS	Recreational Freshwater Fisheries Stakeholder Subcommittee
RRAMF	Ranked Risk Assessment of Multiple Fisheries
SBBSMNF	Shark Bay Beach Seine and Mesh Net Managed Fishery
SBCIMF	Shark Bay Crab Interim Managed Fishery
SBSF	Shark Bay Snapper Managed Fishery
SCRIP	Strategic Criteria for Rural Investments in Productivity
SCTF	South Coast Trawl Fishery
SDGDLF	Southern Demersal Gillnet and Demersal Longline Managed Fishery
SFD	Standard Fishing Day
SIEV	Suspected Illegal Entry Vessel
SLED	Sea Lion Exclusion Device
SMFG	Size Management Fish Ground
SSF	Specimen Shell Managed Fishery
SWCC	South West Catchment Council
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
TPSA	Tiger Prawn Spawning Area
UWA	University of Western Australia
VFAS	Voluntary Fisheries Adjustment Schemes
VMS	Vessel Monitoring System
WAFIC	Western Australian Fishing Industry Council
WAFMRL	Western Australian Fisheries and Marine Research Laboratories
WAMSI	Western Australian Marine Science Institute
WANCSF	Western Australian North Coast Shark Fishery
WCB	West Coast Bioregion
WCDGDLF	West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery
WCDSF	West Coast Demersal Scalefish Fishery
WCDSIMF	West Coast Demersal Scalefish (Interim) Managed Fishery
WCEF	West Coast Estuarine Managed Fishery
WCRLF	West Coast Rock Lobster Managed Fishery
WDWTF	Western Deepwater Trawl Fishery
WTO	Wildlife Trade Operation

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