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Research, Monitoring, Assessment and Development Plan 2015 – 2020



Government of **Western Australia**
Department of **Fisheries**

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Introduction

Background

The 2015 Research, Monitoring, Assessment and Development Plan (RMAD Plan) for the Department of Fisheries outlines the current and proposed data collection and analysis activities over the next five years designed to assist the Department meet the objectives of the Fish Resources Management Act (1994). The scope of this plan and the title reflects that a large proportion of the activities undertaken for management are monitoring and assessment of these data rather than new research. This distinction in terminology is consistent with the approved National RD&E framework (CoA, 2010).

The 2015 RMAD Plan specifically outlines those activities currently planned or already identified that will directly contribute to the effective management of the aquatic resources of Western Australia through the management of each of these resources and their associated fisheries and aquaculture sectors. It also covers the RMAD activities needed to assist the Department manage other areas of responsibility such as biosecurity and shark hazards. Given this strong management focus, each section not only documents the research, monitoring and assessment activities to be completed directly by Departmental staff but it also covers any relevant activities being undertaken by other agencies of direct relevance to a particular fishery/sector/asset or management issue.

The dynamic nature of aquatic resource management it is expected that this plan be updated prior to the end of the five year period based on changes to agency priorities and risks to the resources and sectors. This plan should be read in conjunction with the most recent Status Reports on the Fisheries and Aquatic Resources of Western Australia where comprehensive analyses of the current status of each of WA's fisheries and other aquatic resources (assets) are described. The activities presented within the RMAD are consistent with those documented within FishPlan and BioPlan etc. which summarise all the activities undertaken by all Divisions of the Department associated with the management of each resource (Fig. 1).

The RMAD plan is generated from an aquatic resource management perspective and therefore may not cover all research and development activities required to assist the commercial operations of a fishery. The Department acknowledges that such priorities are best determined and managed directly by industry, therefore activities such as marketing are not covered in a comprehensive fashion. Similarly, the plan does not document all marine related research being undertaken in WA especially where this is focused on the discovery of new scientific knowledge with no direct linkage to management.

The focus for the monitoring, assessment or research activities currently being undertaken within each of the sectors documented in this plan have been the result of deliberations and discussions by internal Departmental committees and, in many cases, with direct input from relevant industry/sector bodies. Thus, where specific industry/advisory group research plans exist, or where issues have been raised by industry at Annual Management Meetings, this information will have been utilised.

Given the diverse levels of risk and differing relative community values associated with each of the various resources, assets and sectors covered by the Department, there are large difference in the level of research, monitoring and assessment activities planned among the different fisheries and ecosystems. These differences also reflect differential levels of

ongoing information required to enable each of the current management processes to operate effectively and generate acceptable, cost effective outcomes.

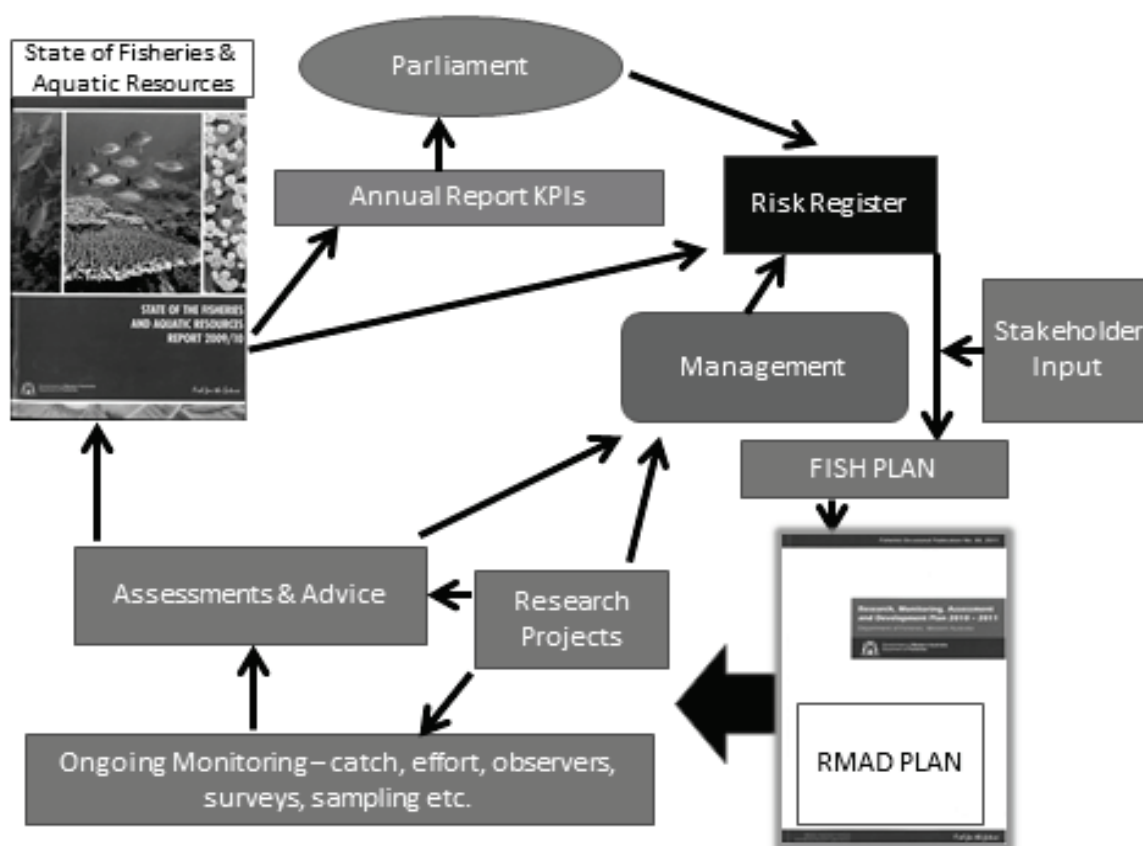


FIGURE 1.

An outline of the current planning cycle used for determining research, monitoring and assessment activities.

To determine priorities, the Department now applies formal risk assessment and risk management techniques to each of the ecological, social and economic assets within each bioregion, using the Ecosystem Based Fisheries Management (EBFM) Framework (Fletcher *et al.*, 2010, 2012). This RMAD Plan has therefore been based on the updated risk profiles across the range of objectives listed within the FRMA and summarised as the Department's KPI's to Parliament and presented within the Annual Report which should ensure that resources are directed to those areas with the highest overall community priority. The risk values are as outlined in the current *Status Reports of the Fisheries and Aquatic Resources of Western Australia 2013/14* (DoF, 2014). The internal and external consultation framework with WAFIC and RecFishWest forms the basis for finalising priorities for both FishPlan and BioPlan and therefore for future editions of the RMAD Plan.

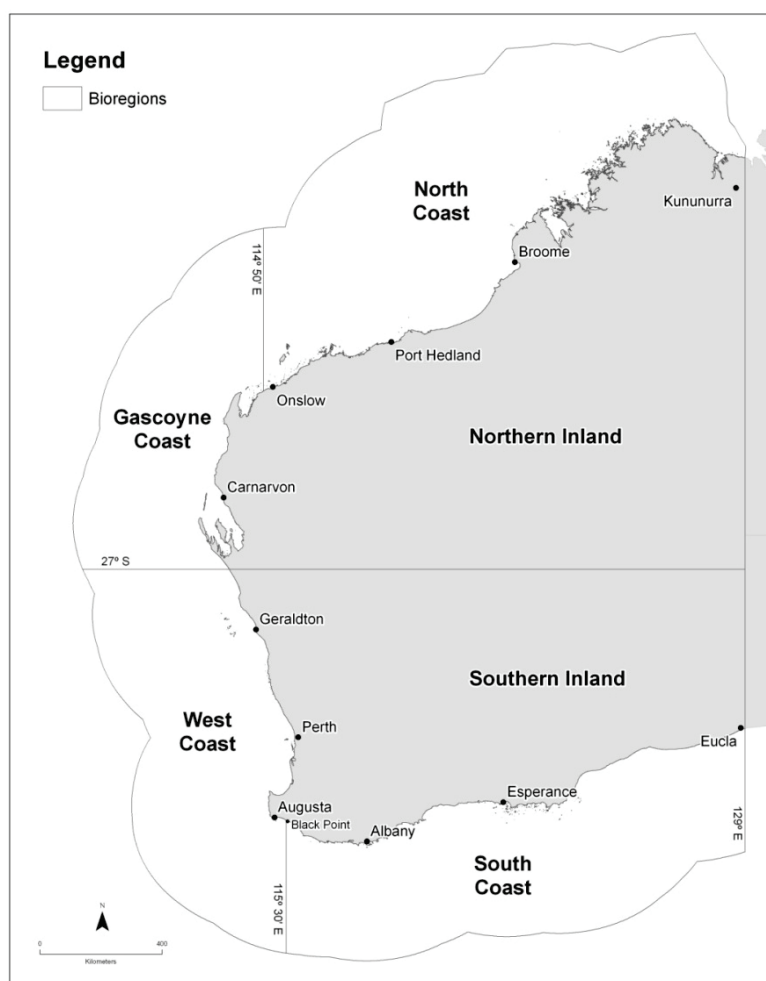


FIGURE 2.

Map of Western Australia showing the general boundaries of the bioregions referred to throughout this document.

Potential uses of the plan

Internal

Having a consolidated document that outlines the agreed research, assessment and monitoring requirements for each aquatic resource asset and sector within WA is essential for internal Departmental purposes. Most of the activities (about 80%) outlined in the plan are ongoing monitoring or assessment activities, not new 'research' projects and the frequency and timing of monitoring programs needs to align so that the resulting stock assessments can be scheduled to align with management reviews. This optimises the use of limited capacity in areas such as stock assessment and simulation modelling.

The RMAD plan provides the mechanism to identify and track any major gaps in knowledge, resources and expertise which assists capacity planning, future funding applications and planning in a broader context. The introductory section includes an outline from the Department's perspective, of what new or additional research, assessment or monitoring initiatives will be needed for the management of Western Australia's aquatic resources in the coming few years. This section also contains the consolidated list of projects and activities planned to assist manage the recreational sector. In recognition of the large number of collaborative projects that are underway, recently funded or proposed in WA, there is a list of the collaborative projects which will be used in management considerations.

External

For the fishery and resource level sections, each of the reports identifies what needs to be done, but also summarises what has already been done. This should minimise the development of unnecessary research proposals by other groups for issues already adequately covered by previous research or for issues where no management risks have been identified. To assist with this, the current risk levels for each of the bioregional resource assets relevant to each report are reported.

This plan will assist in a number of other ways:

- Having a consolidated research plan for each fishery achieves one of the requirements of the Marine Stewardship (MSC) criteria.
- Each of the commercial and recreational sectors can use this document to facilitate their own discussions and formulation of their short and long term research priorities which they can then feed up through their relevant sector/peak body;
- Individual fishers can examine and compare the research that is occurring, or is proposed, in their fishery/sector. This knowledge may help increase the level of input received by the peak and sector bodies and therefore result in higher quality community and industry feedback;
- Other research institutes (e.g. WAMSI) and universities can use the plan to assist in developing possible new projects to address the major research issues that have been identified;
- National research co-ordinating bodies such as the AFMF (including the RD&E framework) and major funding agencies such as the Fisheries Research and Development Corporation (FRDC), can use this information to assist in the future planning of national priorities and sub-program development;
- The general public and conservation groups will have the opportunity to comment upon the monitoring, assessment and research which is proposed or underway, in one of their areas of great general interest, fisheries and aquatic resources.

Description of the report structure

The EBFM based framework identifies and assesses aquatic resources (assets) at a bioregional level, but for practical purposes many of the individual reports in this plan remain at the fishery or activity level. There are separate reports for each of the main wild-capture fisheries and each of the main aquaculture industries. Many of these reports do, however, report on all the activities associated with the management of specific ecological assets (e.g. West Coast Demersal Finfish) and therefore cover activities related to all the commercial and recreational sectors that access the resource.

Within each bioregion there are also reports that outline the activities examining broader ecosystem and biodiversity issues and some that cover State-wide issues. Given the overlapping nature of issues, when a project is dealing with more than one level of asset or more than one objective, the project can be repeated in more than one report to make each report self-contained.

Each of the reports has a brief overview of the sector/issue/resource asset being addressed plus a short summary description of previous relevant research or monitoring, including a list of recent publications. The current risk levels associated with the resource assets being addressed and therefore the focus of research are updated each edition.

Following these background descriptions, most reports have a detailed matrix that is divided into a number of categories (based on EBFM/ESD principles) to clearly detail proposed activities. The categories used are:

- Retained/Key Species Stock Analysis (biology, stock assessment, fishery monitoring)
- Habitat and Ecosystem (bycatch, protected species interactions, habitat impacts, ecosystem effects and the environment)
- Management Analysis (Socio-economic surveys, Resource Access issues, Compliance Research, Management strategy evaluation)
- Industry Development (Production technology, post-Harvest, Marketing, OHS) that the Department is directly engaged (i.e. it does not cover activities undertaken by Industry)

Within the matrix each report documents:

- research topics already completed to at least a sufficient level for management,
- research/monitoring activities currently underway and the time frame for completion,
- topics for which proposals have been submitted but not yet confirmed,
- risk issues that have been identified by management which may require research/monitoring but are to yet be addressed,
- Comments concerning each of the issues relevant to the section (e.g. identifying any EPBC requirements) are also recorded.

The most common shorthand assessments of activities are listed below:

Complete – Activity/project is complete, no additional activities needs to be done.

Ongoing – Monitoring or assessment activity is continuing and occurs annually

Periodic – Monitoring or assessment activity occurs at regular intervals, but not annually.

Underway – A short term project has commenced and will continue for a defined period

Proposed – Research is proposed but unfunded

Not Needed – Risk level is too low to warrant dedicated research or monitoring activities.

References

- DoF (2014) Status Reports on the Fisheries and Aquatic Resources of Western Australia 2013/14. Department of Fisheries, Western Australia. November 2014.
- Fletcher, W.J., Gaughan, D.J., Metcalfe, S.J. and J. Shaw (2012). Using a regional level, risk based framework to cost effectively implement Ecosystem Based Fisheries Management (EBFM). In: *Global Progress on Ecosystem-Based Fisheries Management*, edited by Gordon H. Kruse, Howard I. Browman, Kevern L. Cochrane, Diana Evans, Glen S. Jamieson, Pat A. Livingston, Doug Woodby, and Chang Ik Zhang,. Pp 129-146 Alaska Sea Grant College Program doi:10.4027/gpebfm.2012.07
- Commonwealth of Australia (2010) Working Together: the National Fishing and Aquaculture RD&E Strategy 2010. Fisheries Research and Development Corporation for the Strategy Working Group

Fletcher, W.J., Shaw, J., Metcalf, S.J. & Gaughan, D.J. (2010). An ecosystem based fisheries management framework: the efficient, regional-level planning tool for management agencies. *Marine Policy* 34:1226-1238

Indicative priorities for new research and development projects 2015

The following list of topics summarises the areas where new research or development requirements have been identified that are likely to be useful for resource management purposes and for which obtaining additional or external funding will be required, or a significant shift in the allocation of internal funds will be needed. This list does not include studies that have been underway for more than a year; it also does not cover minor changes or planned shifts in ongoing monitoring projects.

The topics have been annotated to indicate where the research initiative is already:

* part funded, ** fully funded, # funding proposal pending.

If no annotation is provided it indicates that no funding has yet been found and no project proposal development has been initiated.

While this list will contain topics that are in the R&D priorities generated by the WA FRAB, in some cases there may be additions or omissions given the different scope of the Department's RMAD Plan requirements compared to the largely FRDC based scope of the WA FRAB list of priorities.

To assist in the use of this document, there is a distinction made between those issues that have more recently been identified from those where a project has identified problems and the funding status has changed. *These items are indicated by being in italics.*

Statewide

Developing ongoing ecosystem, habitat and bycatch monitoring protocols and systems

Fishery independent survey and monitoring

Supporting MSC pre-assessments and full assessments

Developing mechanisms for cost effective monitoring of shore- and boat-based recreational fishing at a Statewide level

*Understanding environmental effects (and effect of climate change) on recruitment and other biological parameters for key indicator stocks***

Understanding community preferences and expected outcomes for the use and access to WA's aquatic resources

Evaluating the relationship between the phytoplankton productivity and fish stocks#

Development and extension of a cost-effective monitoring tool to support early detection of marine pests high risk locations**

Delimiting surveys for introduced marine pest species identified during routine surveillance **

Development of emergency response capacity to ensure containment of introduced marine pest species**

Reducing biosecurity risks posed by overseas vessels**

Reducing biosecurity risks posed by recreational vessels and marinas**

Development of a national marine biosecurity research science network

Molecular tool development to increase capacity for early detection and understand likely origin of marine pest species detected in WA**.

Development of diagnostic methods to diagnose and manage Oyster Oedema Disease (OOD) in Pearl Oysters**

Development of improved fish health molecular diagnostic methods**

New research and monitoring initiatives required to support progression of fisheries through MSC certification

Development of a statewide management tool to identify and map high value marine assets#

Development of monitoring tools to facilitate better assessment of condition of key ecosystems*

Develop cost efficient fishery independent surveys that can be completed at the bioregional level to inform on stock status of target species and non-target species and community structure especially required with the continued decline in the numbers of commercial fishers in many areas,

Given the likely changes in climatic conditions and other environmental drivers, determine whether there are key habitats within each bioregion that drive fisheries production and, where relevant, develop cost effective methods to monitor changes to these habitats (collection of empirical data).

Determine the short and long term impacts of seismic surveys on fish assemblages.

Appropriately dealing with TEP's, bycatch, CITES etc. issues in a cost effective manner including generating population estimates and effective stock structure for each of the main TEPS species at the population, state or regional level.

Developing emergent fisheries and better utilisation of bycatch etc.

Improved understanding of emerging diseases for both aquaculture and wild capture fish stocks

Improved monitoring methods for biosecurity

Developing techniques to enable production of new species for aquaculture

Determining the potential for restocking, ranching, artificial habitats to increase fisheries production.

Understanding the cumulative impacts of coastal habitats on fish production

Develop methods to measure the condition of individuals (both wild caught and aquaculture) – what is healthy versus unhealthy prior to any specific disease gaining hold.

Determining appropriate aquaculture engineering to meet Australian conditions.

What is the value of citizen science?

Examining the value of increased use of social and economic sciences plus marketing strategies to change public attitudes towards fisheries to enable ongoing access

West Coast

*Improved robustness for fishing efficiency for modelling rock lobster egg production.***

Developing indicators of natural and anthropogenic pressures on critical marine habitats at the Abrolhos Islands*

*Developing cost effective rock lobster habitat mapping methods***

- Determining the relationship between algal habitats and juvenile lobster recruitment and potential impacts of range contraction #
- Minimising the level of interactions between migrating whales and fisheries**
- Ageing of rock lobster and deep sea crabs in WA*
- Development of an Ecological Risk Assessment for the Abrolhos Islands**
- Habitat mapping of Pelsaert and Easter Island groups at the Abrolhos Islands**
- Collection of baseline data to support the Mid-West Aquaculture Development Zone environmental impact assessment**.
- Investigating the cause of declines in crab numbers in Cockburn Sound

Gascoyne

- Developing ongoing ecosystem, habitat and bycatch monitoring programs for Shark Bay and Exmouth Gulf trawl fisheries.
- Assessing whether restocking of scallop populations is viable in the recovery of the stocks*
- Economic assessment of the Shark Bay prawn fishery*

North Coast

- Investigating the long term recovery of demersal fish stocks and their associated habitats in the North West Shelf region.#
- Investigating cause of OOD in pearl oysters**
- Estimating the rate and effect of shark depredation in commercial and recreational fisheries#*

South Coast

- Supporting the development of management plans for open access South Coast fisheries (demersal scalefish and other resources in the wetline and other sectors)

Inland

- Eradication of feral fish species using a risk-based approach
- Prioritisation of fresh water bodies and species for feral fish management**
- Development of breeding programs for endangered fish species to support restocking**
- Development of tools to increase capacity for production of triploid trout
- Development of tools to support development of a captive bred population of hairy marron to prevent extinction**
- Development of DNA technology to improve surveillance for the presence of non-native fish*

Aquaculture

- Development of scallop hatchery technology to support restocking of impacted stocks*

Collaborative Projects 2014/15

To improve the effective utilisation of research expertise and enhance the outcomes generated for management and the community in general, many projects now involve more than one agency. The proportion of collaborative projects undertaken to meet Departmental objectives has increased dramatically in the last decade since the formation of the WA Marine Science Institution (WAMSI). The Department is a supporter of collaborative projects where there are clear benefits either in terms of efficiency or where the scope and comprehensiveness of the problem requires a broader range of expertise.

The following is the current list of collaborative projects listed within this RMAD Plan for which the Department is directly involved (i.e. has a formal and active involvement in at least one of the collection, analysis or interpretation of data) either as the lead agency (i.e. Principal Investigator) or as a formal co-investigator or even as a participant.

Project Title	Lead Agency	Collaborators
STATEWIDE		
Determination of catch and effort by boat-based recreational fishers	DoF	ECU
Development of stable positive control material and development of internal controls for molecular tests for detection of important endemic and exotic pathogens.	CSIRO	DoF
Development of cutting edge tools to support rapid detection and management of marine pests in Western Australia	DoF	UWA, Chevron
Population dynamics of the Asian green mussel (<i>Perna viridis</i>) and its potential to establish in Western Australia	DoF	UWA, Chevron
Ecological impact of <i>Didemnum perlucidum</i>	DoF	UWA, Plymouth Marine Labs
Management implications of climate change on fisheries in WA	DoF	CSIRO
Redmap	DoF	IMAS, WAM, DPaW, UWA
WEST COAST		
Decision-support tools for economic optimization of western rock lobster fishery	DoF	WRLC
Identifying factors affecting the low western rock lobster puerulus settlement in recent years.	DoF	CSIRO
Predicting the impact of shifting recreational fishing effort toward inshore species	Murdoch Univ	DoF, RFW
Southwest Artificial Reef Trial monitoring	DoF	RFW, MU, UWA
FRDC project Habitat enhancement structures in WAs	RFW	MU, DoF
The development of techniques for the collection of fertilised eggs from Cockburn Sound snapper spawning aggregations and culture of snapper juveniles to release for enhancement	Challenger Institute	Murdoch Uni DoF
Developing a Citizen Science Culture among WA Recreational Fishers	InfoFish (Qld)	RFW, DoF
Population ecology and genetic diversity of endemic tuskfishes in Western Australia: an investigation of biogeography and evolution	UWA	DoF, JCU, AIMS
Tropicalisation of reef fish communities in the Metropolitan region, with a focus on the waters around Rottnest Island	UWA	DoF
Recovering a collapsed abalone stock through translocation	DoF	Flinders University (SA)
Development of an industry-based habitat mapping/monitoring system – POTBot (FRDC)	DoF	CSIRO Sydney University

Project Title	Lead Agency	Collaborators
Crustacean ageing project	Southern Cross University	DoF WA TAFI SARDI NWS DoF DPIF NT James Cook Uni.
An industry based mark recapture program to provide stock assessment inputs for the wrfl following introduction of quota management	DoF	WRLC
Determining the dynamics of WA squid populations through research and recreational fishing	Murdoch Uni	DoF, RFW
Cost benefit analysis of mitigation measures to reduce interactions between commercial fishing gear and whales	DoF	Murdoch Uni Antarctic Div DPAW WAFIC, WRLC
Mitigation measures to reduce entanglements of migrating whales with commercial fishing gear	DoF	Murdoch Uni Antarctic Div DPAW WAFIC, WRLC, JASCO, Curtin Uni, MABS
GASCOYNE		
Developing ongoing ecosystem, habitat and bycatch monitoring programs for Shark Bay and Exmouth Gulf trawl fisheries.	DoF	UWA Industry
Assessing whether restocking of scallop populations is viable in the recovery of the stocks*	DoF	Industry
Economic assessment of the Shark Bay prawn fishery*	DoF	UWA Industry UTAS
Blue swimmer crab stock assessment	DoF	UTAS
NORTH COAST		
Identifying the cause of Oyster Oedema Disease (OOD) in pearl oysters (<i>Pinctada maxima</i>), and developing diagnostic tests for OOD	Macquarie Uni	DoF NZ DPI
Optimising the management of tropical reef fish through the development of indigenous scientific capability	NT	DoF, UQ, QDAFF, CDU
Behavioral and biological response of fish assemblages in northern Australia to seismic survey signals	Curtin	DoF, UTas
Connectivity and stock structure of reef species between WA, IOTs and the Indo-Pacific	Univ. Hawaii	DoF, JCU, UWA, Curtin
Pilbara trawl fishery independent monitoring of ETP Interactions	DoF	Industry, WAFIC
Demography of epinephelids	DoF	Curtin, JCU
Kimberley Ecological Connectivity	WAMSI	DoF, AIMS, DPaW, UWA, WAM, WHOI
Revolutionising fish ageing	QDAFF	DoF, NT, SARDI
Establishing baselines and assessing vulnerability of commercially harvested corals across northern Australia	DoF	JCU, NT, QDAFF
IOT monitoring and assessment	DoF	Curtin
Acoustic assessment of habitat and abundance in the Northern Demersal Scalefish Fishery (FRDC)	Curtin	DoF
Propagation and sea-based growout of sea cucumber stocks in the Northern Territory	Tasmanian Seafood	Darwin Aquaculture Centre, Flinders University, DoF
SOUTH COAST		
Bioeconomic evaluation of commercial scale stock enhancement in abalone	DoF	Flinders University (SA) .

Project Title	Lead Agency	Collaborators
Spatiotemporal finfish composition and abundance in Walpole Nornalup inlet MPA	DoF	Murdoch Uni
Investigating critical biological issues for commercial greenlip abalone sea ranching in Flinders Bay, Western Australia	Curtin University	UWA, DoF
Determining and delivering critical scientific advice to fishery managers for the sustainable management of the recreationally and commercially important South Coast Demersal Scalefish Resource (incl. assessment Bight redfish in WCB).	DoF	NRM, Murdoch Uni
INLAND		
Developing native fish research and policy strategies	DoF	DoW DEC
Conserving FW fish in southwest WA	DoF	UWA, Murdoch, Blackwood Basin Group, Denmark Environment Centre, SWCC, SCNRM, DoW, DPaW
Development of eDNA as a cost effective surveillance method for freshwater pest fish	DoF	ECU, Curtin Uni

Recreational Fishing Related Projects 2014/15

The following is the current list of projects listed within this RMAD Plan for which there is a direct application to the management of recreational fisheries. The activities listed below are presented in a collated form at a much greater degree than in the fishery level reports.

Project Title	Lead Agency	Collaborators
STATEWIDE		
Estimation of catch and effort by recreational boat-based fishers	DoF	ECU, RecFishWest
Monitoring of catch and effort by Charter recreational fishers	DoF	Charter boat sector
Monitoring of catch and effort of boat-based recreational fishing in State water MPAs	DoF	DPaW
Remote camera monitoring of recreational fishing activity	DoF	
Ongoing development of survey methods to cost effectively measure participation, catch, social and economic data by recreational fishers	DoF	
Understanding environmental effects (and effect of climate change) on recruitment and other biological parameters for key recreational species	DoF	CSIRO
Investigation of fisheries independent monitoring (e.g. BRUVs) and enhancement devices	DoF	Murdoch, Curtin, RecFishWest
WEST COAST		
Estimation of recreational catch for the Perth metropolitan Roe's abalone	DoF	
Monitoring and assessment of Perth metropolitan Roe's abalone	DoF	
Monitoring and assessment of Cockburn Sound blue swimmer crab	DoF	
Monitoring and assessment of Peel Harvey blue swimmer crab	DoF	
Monitoring of South West blue swimmer crab stocks	DoF	RecFishWest
Dynamics of WA squid populations	Murdoch	DoF, RecFishWest
Estimation of recreational catch for the West Coast rock lobster	DoF	
Monitoring and assessment of western rock lobster	DoF	
Monitoring catch and effort for the Perth metropolitan shore-based recreational fishery"	DoF	
Long term beach seining & angling projects (RAP) to monitor some key species (whiting, tailor, herring, mullet)	DoF	
Monitoring and assessment of indicator species for nearshore and estuarine finfish	DoF	
Monitoring and assessment of artificial reefs	DoF	Murdoch, RecFishWest
Monitoring and assessment of indicator species for demersal finfish	DoF	
GASCOYNE		
Monitoring and assessment of Shark Bay blue swimmer crab	DoF	
Egg production estimates and assessment of pink snapper spawning stock in each of the Shark Bay Gulf stocks	DoF	
Monitoring and assessment of demersal finfish indicator species	DoF	
Monitoring and assessment of nearshore finfish indicator species	DoF	

Project Title	Lead Agency	Collaborators
NORTH COAST		
Monitoring of mud crab stocks	DoF	
Monitoring and assessment of demersal finfish indicator species	DoF	
Monitoring and assessment of nearshore finfish indicator species	DoF	
SOUTH COAST		
Monitoring and assessment of brown and greenlip abalone	DoF	
Monitoring and assessment of southern and western rock lobster	DoF	
Monitoring and assessment of demersal finfish indicator species	DoF	
Monitoring of trends in juvenile recruitment of nearshore finfish	DoF	
Monitoring and assessment of nearshore and estuarine finfish indicator species	DoF	
INLAND		
Annual stocking of trout fingerlings	DoF	
Estimation of catch and effort for the south-west freshwater angling licensed fishery	DoF	
Estimation of catch and effort for the marron licensed fishery.	DoF	
Fishery independent surveys of marron stocks	DoF	

Statewide

Statewide – Recreational Fishing and Community Surveys

Description and Scope of Issues

Recreational fishing is a popular activity in Western Australia, providing significant economic and social benefits to the State's population. An estimated 30% of Western Australians have participated in recreational fishing each year during this decade, which is above the national average. The need for information on recreational fishing activities in Western Australia has increased over the past decade due to rising public expectations about natural resource management and this trend will continue over coming years to meet the requirements of the new Aquatic Resources and Management Act (ARMA) and other Government initiatives (e.g. Marine Stewardship Council; MSC).

The ongoing monitoring of recreational catches at an appropriate level of robustness, precision and frequency is needed (1) to facilitate stock assessments used for the management of those fish stocks resources where recreational fishing constitutes an important proportion of the total catch and especially for those fisheries that intend to formally meet the requirements of the MSC; (2) where these data are needed as inputs to determine and manage sectoral allocations (i.e. between recreational, commercial and indigenous sectors) that occur either through Integrated Fisheries Management (IFM) and, in future, through implementation of the ARMA and; (3) to determine whether the current set of management arrangements are being successful in ensuring that catches from each sector are in accord with acceptable catch ranges as outlined in the new harvest strategy policy.

Relevant Resource Assets and Risks from Fishery

Refer to assets and risks within the bioregion summaries.

Summary of historical research completed

Obtaining suitable recreational data in Western Australia is particularly challenging because of the State's large coastline (20,781 km) and rapid regional development, which is changing the distribution and intensity of recreational fishing activity. Recreational fishers in WA may use multiple access points and platforms for fishing – this includes from boats operated from harbours, marinas and private moorings and, from the shore on piers, jetties, breakwaters and beaches. Their nature ranges from avid fishers to infrequent participants and may include WA residents plus both inter-state and overseas visitors. Until recently, recreational fishers in WA only needed a licence to specifically fish for rock lobster, abalone and marron or to participate in freshwater angling and netting. The Recreational Fishing from Boat Licence (RFBL) was introduced in March 2010, there is currently no licence covering general shore-based recreational fishing activities.

The Department has a relatively long history of undertaking surveys to estimate recreational catch and effort in Western Australia (e.g. Marron recreational surveys 1971 to present, Rock Lobster recreational surveys 1987 to present; boat based recreational fishing in 1996/97). The methods used for these estimates have ranged from on-site creel, aerial and camera, and off-site phone, mail and logbook surveys using both licences and 'white pages' as sampling

frames. Each of these methods have differing costs and are subject to a number of different factors that may introduce bias into the resulting estimates of catch and effort. Consequently, accurately and precisely estimating the total catch taken by recreational fishers can be logistically difficult and potentially costly, with no single survey method capable of properly achieving these requirements at all spatial and temporal scales for all fisheries.

Surveys of recreational fishers require customised designs that reflect the specific management objectives, the spatial and temporal scales of fishing activities, the number of participants (level of fishing effort), the number and types of target species (single or multiple), the levels of access to the resource (boat- or shore-based), the availability of a sampling frame and the constraints on resources (people, equipment and operating) available to conduct the survey. These factors affect what type of sampling is considered appropriate to give suitably accurate and precise estimates of the recreational catch and effort needed to meet the management requirements and the importance to the recreational sector. In addition to the sampling designs used for the surveys, evaluating what estimates of recreational catch can be generated also requires consideration of the levels of bias and uncertainty. To address these issues and develop more accurate and cost effective approaches, an international expert workshop was held in 2010 that compared and discussed the benefits and limitations of each of the various survey methodologies used in Western Australia and also elsewhere in the world (Wise and Fletcher, 2013)¹. The suite of recreational survey methods that are now currently used in Western Australia have each been informed by the outcomes of this expert consultation.

Current Research Focus

The Department currently has been conducting a range of surveys of recreational fishing to support management outcomes involving stock status assessments and harvest strategies of a variety of WA's recreational fisheries. Some surveys are ongoing and some surveys have been done once or irregularly to meet specific objectives. The results of these recreational surveys are now also being used for MSC certification and to monitor resource allocations established under IFM and the soon to be passed ARMA.

Proposed or Possible Research Initiatives

The history, proposed future timetables and methodologies for each of the recreational survey are outlined below.

State-wide surveys (boat- and shore-based)

History: Since 2011

Species/Suite: Offshore and inshore demersal, nearshore estuarine and pelagic finfish and invertebrate species including rock lobster

Regions: All four marine bioregions

IFM Allocations: Demersal West Coast Scale Fish Fishery, Demersal Gascoyne Scale Fish Fishery, Blue Swimmer Crabs – Peel Harvey, Western Rock Lobster

Other: MSC Certification

Method: Phone-diary based on Recreational Fishing from Boat Licence

¹ Wise, B.S. & Fletcher, W.J. (2013) Determination of cost effective techniques to monitor recreational catch and effort in Western Australian demersal finfish fisheries. Final report FRDC project 2005/034 *Fisheries Research Report No. 245. Department of Fisheries, Western Australia, 162pp.*

The 2015/16 state-wide survey of boat-based recreational fishing will build on the 2011/12 and 2013/14 boat-based surveys with the inclusion of shore-based and inter-state fishing activity for boat-based fishers (RFBL holders). A phone survey based on the Telstra White Pages will also provide the necessary benchmark data to provide proportional estimates of catch and effort by shore-based fishers. In addition the state-wide survey will be expanded to collect fishing data on western rock lobster from fishers that hold both a RFBL and rock lobster licence and also those fishers that only hold a rock lobster licence (see rock lobster surveys below). This approach is likely to provide the most robust estimates of the shore-based catch and will also align with the development of a national perspective of recreational fishing, which is under consideration in the ABARES project aiming to develop a Framework for a National Recreational Fishing Survey.

Biological surveys

History: Since 2011

Species/Suite: Offshore, inshore, nearshore, estuarine demersal and pelagic finfish and invertebrate species

Regions: All four bioregions

Allocations: Demersal West Coast Scalefish Fishery 64% Commercial and 36% Recreational (2013), Demersal Gascoyne Scale Fish Fishery, Blue Swimmer Crabs – Peel Harvey.

Method: Onsite Creel Survey based on key boat ramps

In parallel to state-wide surveys, there is a need to collect length and weight data to convert estimates of recreational catch by number to catch by weight. An important consideration will be the capture of length and weight data for both boat and shore-based species.

Rock lobster Surveys

History: Since 1987

Species/Suite: Rock Lobster species: Western Rock Lobster (*Panulirus cygnus*), Southern Rock Lobster (*Jasus edwardsii*) and Tropical Lobsters (*Panulirus ornatus* and *P. versicolour*).

Regions: All four bioregions

Allocations: Western Rock Lobster 95% Commercial and 5% Recreational

Method: Mail Survey and phone diary survey based on the Rock Lobster recreational licence

There is an ongoing need to collect catch and effort data for western rock lobster for determination of sustainability and resource allocation for IFM allocations and MSC certification. While mail surveys are inexpensive they are inherently biased, consequently evaluating estimates of recreational catch requires consideration of bias and uncertainty, therefore, supplementary phone-diary surveys have been conducted in 2000/01, 2001/02, and annually from 2004/05–2008/09 to assess the accuracy of estimates from the mail survey. The next state-wide survey in addition to surveying those fishers that hold both a RFBL and a rock lobster licence to also survey using an additional sampling frame that includes fishers that only have a rock lobster licence. This will provide estimates of recreational rock lobster catch to can be used to more regularly adjust for biases in estimates from the more cost effective mail survey.

Abalone Surveys

History: Since 1990

Species/Suite: Roe's abalone (*Haliotis roei*), Brownlip abalone (*Haliotis rubra conicopora*) and Greenlip abalone (*Haliotis laevigata*)

IFM Allocations: Roe's abalone 36t Commercial and 40t Recreational

Method: Field survey, phone diary survey based on the Abalone recreational licence

There is an ongoing need to collect estimates of recreational catch for Roe's abalone in the Perth metropolitan zone for determination of sustainability and for IFM allocations and proposed MSC certification. The field-based survey will continue; however, it may become necessary at some time to run a concurrent survey of abalone licence holders to estimate the recreational catch and effort of Roe's, Greenlip and Brownlip abalone across the entire fishing region.

Marron, Freshwater angling and Netting surveys

History: Since 2000

Species/Suite: Marron (*Cherax cainii*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), freshwater cobbler (*Tandanus bostocki*) and redfin perch (*Perca fluviatilis*)

IFM Allocations: NA

Method: Phone recall surveys based on the respective recreational licence

Marron and freshwater species are targeted by recreational fishers across a wide geographical range in south-western Australia. This area is considered to be a biodiversity hotspot and potentially threatened by climate change and environmental degradation, such as increased water temperatures and salinity. Inexpensive phone-recall surveys utilise the marron and freshwater angling recreational fishing licences as a sampling frame to contact fishers. A similar approach will be adopted for collecting limited information on recreational net fishing to aid MSC certification for species which are captured using recreational nets.

Metropolitan surveys (shore-based)

History: Since 2004

Species/Suite: Herring, Whiting,

Allocations: NA

Method: Roving survey based on key metropolitan shore-based fishing platforms.

Recent assessments indicate that the recreational fishing pressure applied to nearshore finfish species particularly for Australian herring, southern garfish needed to be reduced. Shore-based fishers were estimated to take >50% or more of the recreational catch of each of these nearshore species in 2000/01. A roving survey in the Perth metropolitan area was initiated in response to the limited amount of contemporary data available for shore-based recreational fishing. Roving creel surveys of shore-based recreational fishing have been conducted from February to June in 2014 and 2015.

Community and Stakeholder surveys

History: Since 1994

Species/Suite: NA

IFM Allocations: NA

Method: Phone recall survey based on white pages and selected stakeholders

The Community and Stakeholder surveys contribute to the Department's KPIs and provide state-wide estimates of participation of recreational fishing.

Research Angler Programme

History: Since 2004

Species/Suite: Offshore, inshore, nearshore, estuarine demersal and pelagic finfish and invertebrate species

IFM Allocations: NA

Method: logbook based on volunteers

The Research Angler Programme provides the opportunity for recreational fishers to volunteer their fishing information to the department. This includes information on estuarine and marine finfish and crab catches as well as catches taken within marine parks.

Remote video camera surveys (Peel Harvey)

History: Since 2014

Species/Suite: Boat based fisheries and suites

Allocations: NA

Method: Cameras at key boat ramps

Remote video camera monitoring has been used in many locations for the boat based surveys since 2010. There is a need for on-going prioritisation of camera locations required by the Departments Research and Regional Services Divisions. Development of more efficient extraction methods will reduce the cost of data extraction and will identify potential savings that could be used to supplement additional cameras.

Abrolhos surveys

History: New

Species/Suite: Offshore and inshore demersal finfish species in Abrolhos

IFM Allocations: West Coast Demersal

Method: Phone recall survey based on vessel notification database

Recreational fishing at the Houtman Abrolhos Islands is highly valued and popular but difficult to survey using normal techniques. It is proposed to conduct a small survey using the vessel notification database in 2017/18 and repeat the survey as required.

Peel-Harvey surveys

History: New

Species/Suite: Blue Swimmer Crab (*Portunus armatus*)

IFM Allocations: Under consideration

Method: Camera; Roving creel survey at key shore locations

Blue Swimmer Crab is the largest catch by species by recreational boat-based fishers, however the shore-based catch is not well known and activities occur on a 24 hour cycle.

With on-site surveys mostly limited to daylight hours, remote camera monitoring in this fishery will provide an understanding of 24/7 shore-based activity. It is proposed to continue to obtain estimates of the boat-based recreational from the state-wide survey with surveys aimed at estimating the shore-based recreational catch may occur if funding becomes available.

Inner Shark Bay surveys

History: Since 1998

Species/Suite: Offshore, inshore, nearshore, estuarine demersal and pelagic finfish and invertebrate species, including snapper (*Chrysophrys auratus*)

IFM Allocations: NA

Method: Bus route survey at key boat ramps

Snapper in the Eastern Gulf, Denham Sound and Freycinet Estuary have been a major attraction for recreational fishers since the 1960s. While the state-wide survey of boat-based recreational fishing will provide ongoing catch estimates for Shark Bay, it may become necessary to consider extending the bus-route surveys if fine-scale catch estimates for snapper for each of the three discrete snapper stocks (Eastern Gulf, Denham Sound, Freycinet Estuary) are still needed. Ideally, this survey would also coincide with the boat-based recreational fishing survey which provides broader scale catch estimates and includes boats that do not launch from public ramps.

Priority Setting Process and Review Timeline

A ten year plan (2015-2025) has been developed and outlines the current and likely future priorities for the collection of recreational catch and effort data for each of WA's recreational fisheries. Based on these priorities it outlines the proposed timetable, methodologies and approximate costs involved for each of the surveys specifically designed to obtain these data at a suitable level of accuracy and precision for each fishery for use within their current management systems, or those that are expected to be in place in the coming decade. Justifications for the current and proposed set of survey designs and their individual methodologies are also provided.

Key to symbols in the matrix/summary tables:

- Indicates that the activity is funded and planned to occur.
- Indicates that the activity is part of a proposal but is not yet funded.

Statewide – Recreational Fishing and Community Surveys Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of indicator species (Growth, Reproduction, Diet, Natural Mortality)							
1.2 Other Biology							
1.3 Stock Assessment							
1.4 Fishery Monitoring							
Statewide surveys (boat-based)	Ongoing		■		■		Biennial phone-diary survey

Statewide – Recreational Fishing and Community Surveys Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Statewide surveys (shore-based)	Ongoing				■		Phone-diary survey based on boat licences
Biological Surveys	Ongoing		■		■		Boat ramp sampling
Rock lobster mail survey	Ongoing	■	■	■	■	■	
Abalone metro field survey	Ongoing	■	■	■	■	■	
Rock lobster and Abalone surveys	Ongoing		■		■		Phone-diary survey
Marron, Freshwater angling and Netting surveys	Ongoing	■	■	■	■	■	Mail survey
Metropolitan surveys (shore-based)	Ongoing	■	■	■	■		Roving creel survey
Abrolhos surveys	Ongoing			■		■	Phone recall
Research Angler Program (Finfish)	Ongoing	■	■	■	■	■	Volunteer logbook
Peel Harvey survey (remote camera)	Ongoing	■	■	■	○	○	
Peel Harvey survey (shore-based)	Proposed		○	○	○	○	Camera based
Shark Bay survey	Proposed				○		Bus route survey
2. Habitat & Ecosystem							
2.1 Bycatch	Ongoing		■		■		Released species
2.2 Listed Species	Ongoing		■		■		Released species
2.3 Habitat							
2.4 Ecosystem/Environment							
2.5 Oceanography							
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)	Ongoing	■	■	■	■	■	Annual analysis of sectoral shares
3.3 Compliance Research							
Remote camera surveys	Ongoing	■	■	■	■	■	
3.4 Management Systems							
Community surveys	Ongoing	■	■	■	■	■	Used in Annual Report
Stakeholder surveys	Ongoing	■		■		■	Used in Annual Report
4. Industry Development							
4.1 Production Technology							
4.2 Post Harvest							
4.3 Marketing							
5. Stakeholder Consultation and Reviews							
Annual Management Meeting							
MSC							
Other - RecFishWest and WAFIC	Ongoing	■	■	■	■	■	10 Year Plan approved

Statewide – Biosecurity (Diseases and Aquatic Health)

Description and Scope of Issues

Australia's fisheries and aquaculture are the fastest growing primary industry sectors in terms of both job creation and average growth in production. In addition there is a growing recreational involvement in fishing. Western Australia is fortunate to have an aquatic animal sector relatively free from many diseases that cause significant economic impact elsewhere in the world and in the eastern states. Increasingly, disease is becoming a trade issue. The Department has responsibility under the *Fish Resources Management Act 1994* for the control of exotic and endemic aquatic animal diseases in the State. Protecting the disease status of the state and the aquatic industries within the state requires that there is ongoing surveillance and monitoring for endemic and exotic diseases, the regulation and certification of production, imports and exports, and the capacity to detect and respond to diseases as they occur.

Relevant Resource Assets and Risks from all Activities

Statewide – Diseases and Pests

High Risk

Summary of Historical Research Completed

The Fish Health Unit was formed in 1988 following an outbreak of disease in the state trout hatchery. The unit, from its inception, has been co-located within the Animal Health Laboratory of the Department of Agriculture and Food, bringing economies of scale through sharing of equipment and personnel. The unit has provided a disease diagnostic service to the seafood industries; has undertaken disease surveillance for key fisheries, including trout; dhufish; pearl oysters; prawns; yabbys, rock lobsters; mulloway, ornamental fish, barramundi and yellow-tail kingfish. In addition, protocols for high health hatchery status have been developed and adopted by key industries.

Current Research Focus

The Fish Health Unit of the Department of Fisheries is accredited to ISO 17025 and provides a diagnostic service to the fishing and aquaculture industry in Western Australia, investigates 'fish kills', contributes to policy advice developed by the Department, carries out research on diseases of aquatic organisms, and has a minor extension role. Greater emphasis has been placed on staff visiting aquaculture farms to encourage sustainable farming practices. Key activities are as follows:

- Undertakes diagnostic services for industry
- The provision of export health certificates for marron.
- The provision of mollusc and finfish translocation certificates.
- Centre for receipt of notifiable diseases. Recent detection of notifiable pathogens included iridoviruses associated with imported ornamental fish.
- Provides technical advice to the Department on diseases of concern, including risk assessments where required.
- Investigation of disease in pearl oysters (*Pinctada maxima*) through an FRDC-funded project (2013/002) to identify the cause of Oyster Oedema Disease (OOD) in pearl oysters, and developing diagnostic tests for OOD.

- Investigation of disease in prawns through the FRDC Project 2011/005 to examine WA prawn samples for virus. This project aims to identify emerging pathogens of potential significance to both wild fisheries and any potential developing prawn aquaculture industry.
- In collaboration with staff from the Department of Water (DoW) and the Water and Rivers Commission, investigates reports of ‘fish kills’ throughout the State.
- Assist with a range of national committees including the national Subcommittee on Aquatic Animal Health, the national Laboratories for Emergency Animal Disease Diagnosis and Response and the Aquatic Animal Health Subcommittee of the Fisheries Research Development Corporation. The federal government departments Biosecurity Australia and Department of Agriculture Fisheries and Forestry frequently also seek the expertise of the Fish Health Unit.
- Provide a regional resource centre for aquatic animal health within the Network of Aquaculture Centres (NACA) in the Asia-Pacific.

Priority Setting Process and Review Timeline

Meetings between the Department of Fisheries and ACWA.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

Statewide – Biosecurity Diseases and Aquatic Health Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Habitat & Ecosystem							
1.1 Biology							
OOD research	Underway	■	■				Funded
Characterise native viruses in prawns	Underway	■					Funded
1.2 Listed Species							NA
1.3 Habitat							NA
1.4 Ecosystem/Environment							NA
1.5 Oceanography							NA
1.6 Other impacts on ecosystems							
1.7 Monitoring							
Translocation certification	Ongoing	■	■	■	■	■	Fee per service basis
Fish kill investigations	Ongoing	■	■	■	■	■	In conjunction with DoW
Disease surveillance and monitoring	Ongoing	■	■	■	■	■	National reporting requirement
2. Management Analysis							
National coordination	Ongoing	■	■	■	■	■	
3. Industry Development							
3.1 Production Technology							
Diagnostic services	Ongoing	■	■	■	■	■	Fee per service basis

Statewide – Biosecurity Diseases and Aquatic Health Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
3.2 Post Harvest							
Provision of export certifications	Ongoing	■	■	■	■	■	Fee per service basis
3.3 Marketing							NA
4. Stakeholder Consultation and Reviews							
ACWA	Ongoing	■	■	■	■	■	
5 Yearly Research Review Strategy	Proposed		○				

Statewide – Biosecurity (Pest Incursions)

Description and Scope of Issues

As an island nation, Australia derives many social, cultural, environmental and economic benefits from its marine environment. Its coast is home to some of the most unique and biodiverse hotspots on the planet, containing iconic regions such as the Ningaloo and Great Barrier Reef systems, the Kimberley coast, the Great Australian Bight and cooler southern marine ecosystems. These systems provide the basis for highly productive fisheries recruitment and ecosystem services. The country's economy is also highly dependent on maritime transport, with 99% of Australia's imports and exports being carried by sea (Bureau of Infrastructure, Transport and Regional Economics 2013). International maritime trade was calculated to be worth \$418.4 billion in 2011/12, exporting 973.2 million tonnes and importing 94.9 million tonnes of freight (Bureau of Infrastructure, Transport and Regional Economics 2013).

Australia as a signatory to the Convention on Biological Diversity, approved by Council Decision 93/626/EEC¹, is bound by the provisions of Article 8(h) of that Convention. According to those provisions, all parties shall, as far as possible and as appropriate, 'prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species'.

Invasive marine pests are marine plants or animals that have been, or have the potential to be, introduced outside their natural range to marine waters (of Australia) by human activities. The impacts of introduced marine pests (IMP) are wide and varied. They can lead to a loss of diversity in local species and negatively affect amenity and recreational activities and reduce the fuel efficiency for all vessel types (hull fouling organisms). With increasing human population, associated travel, transport and trade, the pressure on marine biosecurity resources and the risk of introducing new IMP is likely to grow (Convention on Biological Diversity 2005).

In 2005, most Australian governments, signed an intergovernmental agreement establishing arrangements for dealing with biosecurity risks to the marine environment. A key output was

¹ Council decision of 25 October 1993 concerning the conclusion of the Convention on Biological Diversity (OJ L 309, 13.12.1993, p. 1).

the *Intergovernmental Agreement on a National System for the Prevention and Management of Marine Pest Incursions*.

To improve Australia's ability to rapidly detect and deal with IMP incursions, the National System for the Prevention of Marine Pest Incursions (National System) was developed. One of the key initiatives within the National System is a network of standardised monitoring regimes at high-risk port locations around Australia. This framework identified 55 target marine pest species and 18 high-risk locations throughout Australia as priorities for monitoring.

Within WA, the Department of Fisheries is the lead agency for developing and implementing the necessary management arrangements and activities to, where possible, reduce the risk of introduction and translocation of aquatic pest animals and plants as well as animal and plant pathogens and diseases. These obligations also extend to the Indian Ocean Territories through contract agreements with the Federal government.

There are three overarching functions associated with the management of aquatic biosecurity:

- **Prevention** to reduce the risk of introduction of non-indigenous aquatic organisms into WA and to manage the translocation of non-indigenous aquatic organisms within WA using a risk based approach;
- **Emergency Response Management** (preparedness and response) to provide a co-ordinated emergency response to new incursions of non-indigenous aquatic organisms; and
- **On-going, Risk Based Management** to control introduced aquatic organisms already within WA.

Relevant Resource Assets and Risks from all Activities

Statewide Diseases and Pests

High Risk

Summary of historical research completed

In 2008 a literature review was conducted to collate existing knowledge on introduced marine species relevant to WA. At that time approximately 60 introduced marine species were identified in WA waters. That report served as the basis for a popular publication outlining the natural values of the WA marine environment, the threat presented by introduced marine species, and what we can do about it.

At the same period three WA ports were identified on the by the National System as ports at high risk for introductions. These included Port Hedland, Dampier and Fremantle. These high risk sites were based primarily on vessel numbers and amount of ballast discharged. A more recent analysis on the likelihood of marine pest introduction by Bridgwood and McDonald (2014) examined the likelihood of marine pest introduction across the state. Based on this analysis a review of the previously nationally identified high risk sites is advised.

Across the state nationally approved marine pest monitoring designs have been developed and implemented for six WA ports, including Port Hedland, Dampier, Fremantle, Garden Island, Geraldton and Christmas Island ports. Ongoing marine pest monitoring is underway at Port Hedland, Dampier and Fremantle and Garden Island ports. Marine pest monitoring at Geraldton and Christmas Island does not occur on a regular basis.

Surveillance in response to detection

In 2011 the Department were alerted to the presence of the ascidian *Didemnum perlucidum* in our waters. The initial detection of this species triggered further investigation by the Department's Biosecurity Research Group who have since found the species to be present in many ports and marinas from Esperance to Broome.

The Biosecurity Research Group has developed identification capabilities for this species based on characterisation of its DNA. Work is ongoing to understand the generic relationship of *D. perlucidum* populations found throughout WA with those from overseas likely to represent potential sources of introduction of this species.

Crab condos

Baited crab traps have been used in many decapod sampling regimes around the world and specifically target larger predatory/scavenger crustaceans.

Following on from the *Charybdis japonica* incursion and trapping program, a research project examining the behaviours of crabs towards different traps was developed. This study is ongoing and examines crab behaviour towards different trap types and the presence of other crabs in the traps. Outcomes from this study will help direct future crab trapping programs.

Indian Ocean Territories 2012/13

The Biosecurity Research Group has recently concluded two projects in the Indian Ocean Territories.

- As part of the ongoing biennial project the Biosecurity Research Group completed a large-scale marine pest monitoring program in Christmas Island port in late 2012.
- The Biosecurity Research Group have conducted an analysis of vessels entering Christmas Island. This research provided an analysis of the likelihood of a potential marine pest introduction to Christmas Island based on the above data that will inform management and policy.

Current Research and Monitoring Focus

Recreational vessel study

WA has a very high ownership of recreational vessels (90,000 registered vessels and growing; Department of Transport 2012). However, very little is known about the risk associated with recreational vessels for the introduction and translocation of marine pests along our coast line. The Biosecurity Research Group has commenced a study of recreational vessels from marinas all over the State. This has three main components - firstly a survey of vessel owners examining vessel use and maintenance practices. Secondly an examination of vessels for the presence of known IMPs and an assessment of the degree and type of fouling from different areas on a vessels hull and finally an examination of marinas to see how fouling present on structures correlates with that found on vessels. This information will be combined to allow for predictions in vessel mediated translocation of IMPs which will inform management strategies.

Vessel wrapping

Preventative measures such as maintenance of a clean vessel hull is widely acknowledged as more effective in curtailing invasions of marine pests than are eradication or control

measures. The Biosecurity Research Group has completed a trial to ascertain the efficacy of wrapping small recreational vessel hulls and pylons in eliminating/killing biofouling. The use of wrapping is being explored for larger vessels with collaboration from the Biosecurity Compliance group.

Other current research activities include:

- Establishing national marine pest science network to prioritise and direct marine pest research of national and state importance – WA leading this network;
- Determining relative likelihood of marine pest introduction and establishment in WA waters;
- Prioritising target species for monitoring;
- Evaluating and improving methods (including molecular) for detecting, monitoring and controlling invasive species incursions;
- Undertaking research into the growth and physiology of high risk marine pests, e.g. Asian green mussel; and
- Ongoing cost-effective monitoring of high risk locations throughout the state.

Recent Publications

Bridgwood, S.D., Muñoz, J., McDonald, J.I. (2014) Catch me if you can! The story of a colonial ascidian's takeover bid in Western Australia. *BioInvasions Records* 3(4): 217-223
doi: <http://dx.doi.org/10.3391/bir.2014.3.4.02>

McDonald, J., Bridgwood, S., Hourston, M. (2015). Likelihood of Marine Pest Introduction to the Indian Ocean Territories. Fisheries Research Report No. 264. Department of Fisheries, Western Australia. 40pp.

Bridgwood, S.D., McDonald, J.I. (2014). A likelihood analysis of the introduction of marine pests to Western Australian ports via commercial vessels. Fisheries Research Report No. 259. Department of Fisheries, Western Australia. 212 pp.

McDonald, J.I., Wilkens, S. L., Stanley J.A., Jeffs, A.G. (2014). Vessel generator noise as a settlement cue for marine biofouling species. *Biofouling: The Journal of Bioadhesion and Biofilm Research* 30(6): 741-749.

Muñoz, J., McDonald, J. (2014). Potential eradication and control methods for the management of the ascidian *Didemnum perlucidum* in Western Australia. Fisheries Research Report No. 252. Department of Fisheries, Western Australia. 40 pp.

Duffy, R., Snow, M., Bird, C. (2013). The convict cichlid *Amatitlania nigrofasciata* (Cichlidae): first record of this non-native species in Western Australian waterbodies. *Records of the Western Australian Museum* 28 (1): 7-12.

Priority Setting Process and Review Timeline

Meetings between the Department of Fisheries and stakeholders at annual biosecurity planning and review workshops. Departmental engagement with National representation bodies (eg Marine Pest Sectoral Committee).

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

Statewide – Biosecurity Pest Incursions Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Habitat & Ecosystem							
1.1 Biology							NA
Introduced marine pests - biology	Ongoing	■	■				Undertake growth and physiology studies on high risk pests
1.2 Listed Species							NA
1.3 Habitat							NA
1.4 Ecosystem/Environment							NA
1.5 Oceanography							NA
1.6 Other impacts on ecosystems							
Introduced marine pests	Ongoing	■	■				Determine relative risk of marine pest introduction and likelihood of establishment in WA waters and prioritise target list
1.7 Monitoring							
Port monitoring	Ongoing	■	■				Conduct cost-effective surveillance for marine pests at high risk locations
Introduced marine pests	Ongoing	■	■				Evaluate and improve methods (including molecular) for detecting, monitoring and controlling invasive species incursions
2. Management Analysis							
National coordination and leadership	Ongoing	■	■				
3. Stakeholder Consultation and Reviews							
Stakeholder engagement	Ongoing	■	■	■	■	■	Annual biosecurity planning and review workshop. Marine Pest Sectoral Committee
Bioplan	Ongoing	■	■	■	■	■	

Statewide– Biosecurity (Freshwater Pest Incursions)

Description and Scope of Issues

Alongside marine biosecurity, freshwater biosecurity is also fast becoming a significant issue for Western Australia. Non-native species introduced into the State for a variety of ornamental, aquaculture and aquaponics purposes have the potential to find their way into our freshwater lakes and rivers. These fish are generally highly adaptable and able to tolerate a wide range of environmental parameters. Many of these species can establish in the wider freshwater environment of WA, and can also spread to estuarine and marine environments. Their impacts can include outcompeting our already threatened native fish species, the introduction of associated new diseases, reduction in water quality through environmental degradation and habitat modification, and genetic interference with native species through hybridisation. From a national perspective, the risk posed particularly by ornamental fish species has long been recognised. In the 2005 Commonwealth of Australia document entitled “A Strategic Approach to the Management of Ornamental Fish in Australia” it is stated that “34 exotic freshwater species have established populations in Australia; the pathway for 22 of these species is thought to have been the ornamental fish industry”.

Within Western Australia, The Department of Fisheries is the lead agency to develop and implement the necessary education, research, management and compliance activities to, where possible, reduce the risk of establishment of non-native freshwater fish species. The focus of research in this area is around the overarching functions associated with aquatic biosecurity:

Prevention to reduce the risk of introduction and establishment of non-native fish in Western Australia using a risk based approach. This includes maintenance of adequate surveillance activity to identify incursions of new high risk species at high risk locations to maximise chances of early management control.

Emergency Response Management (preparedness and response) to provide a coordinated emergency response to new incursions of non-native freshwater fish species.

On-going Risk Based Management to control the distribution of introduced freshwater fish already within Western Australia

Resource Assets and Risks from all Activities

Statewide Diseases and Pests

High Risk

Summary of historical research completed

Since 2009 the Department has maintained a state-wide database to document the distribution of both native and non-native freshwater fish. Sources of data provided to the Department for management purposes include universities and research institutes, public reports, the environmental consultancy sector, the water resource management industry, other government departments (e.g. Department of Water) and the Department’s own surveillance program.

In 2009, Department of Fisheries supported a pilot survey by a UWA student of 29 waterbodies in the metro area. This showed an alarming decline in endemic species, with most water bodies containing either no fish or feral species. Based upon this evidence, in 2010 the Department obtained State NRM funding to undertake a survey of native and

introduced species in 113 natural waterbodies on the Swan Coastal Plain. This survey found that 25% no longer contained any fish. Of those that did contain fish few contained only native species (12%), while the majority contained either both non-native and native fish species (45%) or non-native species only (42%).

During 2012 the Freshwater Biosecurity Research Unit was formed to undertake comprehensive surveys, respond to pest species reports and undertake control measures of introduced freshwater species where required. The survey work in 2012-2013 was concentrated in the Perth-metro region (Swan/Canning coastal plain). This area has been identified as high risk due to previous pest fish detections, the large urban population and the extensive lake and drainage systems connected to the Swan/Canning Rivers. As of February 2015, the Department is aware of 26 species of non-native finfish that have been released into the WA freshwater environment, with 16 of these thought to have originated from the ornamental fish industry. Of the permanent waterbodies sampled (176 in 2013), native species were found to be present in only 42 sites (24%). Far less waterbodies were found to contain *only* native freshwater species (2%); other sites contained introduced and native species or only introduced species.

Using a risk-based approach the Department has implemented control activities for a number of the non-native fish detections targeted at controlling species that pose a significant risk to the states high value assets, including Murray cod, eel-tailed catfish, cichlid and live-bearing ornamental species. Further detail of these activities may be found in the Department's Status reports of the fisheries and aquatic resources of Western Australia 2013/14

Current Research Focus

- Develop cost effective and sensitive surveillance tools to detect presence of non-native fish and verify their eradication (eDNA)
- Further understand and assess the relative risk posed by different species of non-native fish
- Develop practical management tools to eradicate and/or manage the spread of non-native fish.
- Develop emergency response procedures and capability

Priority Setting Process and Review Timeline

Meetings between the Department of Fisheries and other Government management agencies at regular Freshwater Ecosystem Working Group Meetings. Engagement with stakeholders through a biennial Freshwater Fish research and management conference.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

O Indicates that the activity is part of a proposal but is not yet funded.

Statewide Biosecurity FW Pest Incursions Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Habitat & Ecosystem							
1.1 Biology							
Review the biology and potential impact of pest species to support a risk-based approach to non-native fish management	Ongoing	■	■	■	■	■	Determine relative risks of freshwater fish species and high risk locations
1.2 Listed Species							NA
1.3 Habitat							NA
1.4 Ecosystem/Environment							NA
1.5 Oceanography							NA
1.6 Impacts on ecosystems							
Non-Native fish distribution surveillance and monitoring	Ongoing	■	■	■	■	■	Maintain baseline surveillance using a risk basis.
1.7 Monitoring							
Native Fish Database	Ongoing	■	■	■	■	■	Management of Freshwater Fish database for monitoring non-native fish distribution and spread.
Evaluate methods for non-native fish detection, monitoring and control	Ongoing	■	■	■	■	■	Including development of emergency response capacity
2. Management Analysis							
Community involvement	Proposed	○	○	○	○	○	Involving community & school groups in non-native fish management and reporting
3. Stakeholder Consultation and Reviews							
Stakeholder engagement	Ongoing	■	■	■	■	■	
Biennial Freshwater Fish Conference	proposed		○		○		

Statewide – Specimen Shell Managed Fishery

Description and Scope of Issues

The Specimen Shell Managed Fishery (SSF) is based on the collection of individual shells for the purposes of display, collection, cataloguing, classification and sale.

Up to 550 different shellfish species are collected by hand by a small group of divers operating from small boats in shallow coastal waters. While the fishery covers the entire WA coastline, there is some concentration of effort in areas adjacent to population centres such as metropolitan Perth, Bunbury, Albany and Port Hedland.

Relevant Resource Assets and Risks from Fishery

Statewide Nearshore Molluscs

Low Risk

Summary of historical research completed

Ponder and Grayson (1998¹) 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 WA were identified by Ponder and Grayson as potentially vulnerable comprised 6 cowries and 2 volutes (*Amoria* spp.).

Current Research Focus

Current fishery-dependent data collection systems monitor the catch (species-specific), effort and catch rates for the fishery. Fishers within the SSF provide monthly returns under the statutory catch and effort system (CAES). These returns contain information on catch (species, numbers and spatial area), and days and hours fished by month and year.

In August 2004, fishers commenced reporting using 10 x 10 nautical mile (nm) grids rather than 60 x 60 nm grids, providing a finer spatial scale to the data collected. At the same time, they began collecting additional information on sightings of the 8 mollusc species identified as potentially ‘vulnerable.’ These data are used as the basis to provide research advice for fisheries management

Priority Setting Process and Review Timeline

Meetings between the Department of Fisheries and Industry.

Annual reviews of data occur in June.

Given the small amount of activity no matrix is provided.

¹ Ponder, W.F., Grayson, J.E. (1998). The Australian marine molluscs considered to be potentially vulnerable to the shell trade. A report prepared for Environment Australia.

Statewide – Marine Aquarium Fish

Description and Scope of Issues

The Marine Aquarium Fish Managed Fishery (MAF) targets more than 250 species of fish under the management plan. Other management arrangements authorise fishers to take coral, live rock, algae, seagrass and invertebrates. It is primarily a dive-based fishery that uses hand-held nets to capture the desired target species from boats up to 8 m in length. While the MAF operates throughout all Western Australian waters, catches are relatively low in volume due to the special handling requirements of live fish. Fishing operations are heavily weather-dependent due to the small vessels used. In addition, human constraints (i.e. physiological effects of compression) limit the amount of effort exerted in the fishery, the depth of water and the offshore extent where collections can occur.

Relevant Resource Assets and Risks from Fishery

Statewide Aquarium fish

Low Risk

Summary of historical research completed

Due to resourcing constraints the marine aquarium fish fishery is only assessed by compilation of catch data from the fishery in the form of the statutory monthly catch and effort returns.

Current Research Focus

Information provided by the fishery in the form of statutory monthly catch and effort returns is used as the basis to provide research advice for fisheries management. Current research is focused on undertaking risk assessments across the suite of taxa landed in order to maintain WTO certifications. Research to establish baselines for exploited coral species is underway.

Priority Setting Process

Initial assessments were made through internal departmental meetings and forums discussing the history of research in the fishery, research activities that have been completed, current research as well as research and development gaps. Research issues have been discussed at annual industry consultation meetings once a year. Additional research needs have also been highlighted through the ESD assessment process.

Review Timeline

This fishery is of low priority relative to other fisheries in the State and is only reviewed when resources permit

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Given the small amount of activity no matrix is provided.

Statewide – Aquaculture

Description and Scope of Issues

The aquaculture industry in WA is growing and diversifying and there are positive signs growth will continue. The total gross value of production for WA commercial fisheries and aquaculture production in 2012-13 was \$427 million, with aquaculture (including the pearling industry) contributing approximately \$96 million (equal to 22 per cent of total production). Based on the silver-lipped pearl oyster (*Pinctada maxima*), the pearling industry remains a strong performer in WA but other sectors have continued to expand based on a range of species and production environments. Since 2007, production has shown strong growth as finfish aquaculture, in particular, has increased. The production of cultured abalone is also growing substantially. There is also a well established and highly valuable algae industry in WA.

The Government has committed to a number of measures aimed to support the continued development of aquaculture in WA. These include the establishment of investment-ready aquaculture zones in the Kimberley and Mid-West, commitment to third party assessment of fisheries and aquaculture in WA and for the development of finfish aquaculture pilot studies supported by Royalties for Regions.

Future growth is likely to be driven in marine species groups such as algae, prawns, finfish and abalone while, in the pearling sector, market improvement will see it continuing to be a strong performer. Other sectors, which include species groups such as mussels, marron and other fresh water species, also contribute to the diversity of WA aquaculture. Various emerging sectors with capacity for growth include species such as coral, live rock, octopus and artemia; and new species groups such as kelp and seaweeds may emerge.

Research relevant to Aquaculture is undertaken across the Department of Fisheries Research Division, but is a primary focus of the Biodiversity and Biosecurity Branch which includes research teams dedicated to Aquaculture, Fish Health and Biosecurity. This report covers the activities of the marine aquaculture group whose focus is on working alongside industry to identify and develop new species and aquaculture opportunities. The Department has limited involvement in freshwater aquaculture research and development though it does support local growers through production and supply of trout through its Pemberton hatchery facility.

Summary of historical research completed

Whilst many areas of aquaculture research represent long term strategic investment in capacity building (e.g. development of fish health and disease diagnostic expertise) other areas of aquaculture research have by necessity been more opportunistic, dependent on external and industry funding, and aligned to the specific and current ambitions of sectors of the aquaculture industry (e.g. development of specific projects aimed at refining culture techniques of new species). Whilst the Department remains committed to maintaining its core investment in aquaculture expertise and research capacity, significant new projects of this nature have historically been dependent on a level of external funding support. These trends are expected to continue as pressure on funding increases, new technologies and species-based sectors emerge and industry and associated investment diversifies.

Previous projects have included development of a large scale production system for the commercial culture of artemia using *Dunaliella salina* algae (FRDC project 2004/238) and a project aimed at commercial development of octopus aquaculture. Both of these project

resulted from approaches to the Department from industry sectors and were collaborative projects involving co-investment.

Current Research Focus

Work with industry to:

- Identify and exploit new funding opportunities to undertake new projects aimed at developing practical culture techniques for species suited to aquaculture in Western Australia.
- Identify opportunities and technology to support development of a multi-species mollusc hatchery to support growth in both existing and emerging sectors such as mussels, pearl oysters, edible oysters and scallops.

Maintain commercial supply of an automated microdiet (AMD) feeding system for aquaculture hatcheries developed as a result of previous FRDC-funded R&D activity. Funds from this activity are re-invested in the Departments aquaculture research program.

Support the establishment of aquaculture zones through:

- Undertaking baseline environmental assessment work required for zone pre-approval.
- Conducting risk assessment (social, biological and economic) of future activity likely to be undertaken in zones as required for the Public

Priority Setting Process and Review Timeline

Department of Fisheries meeting and consultation with stakeholders. Identification of opportunistic funding.

Given the small amount of activity no matrix is provided.

West Coast Bioregion

West Coast – Biodiversity & Ecosystem Issues

Description and Scope of Issues

The West Coast Bioregion is characterised by exposed sandy beaches and limestone reef systems which create surface reef lines often about 5 km off the coast. Sea floors further offshore on the continental shelf are typically coarse sand interspersed with low limestone reef associated with old shorelines. There are few areas of sheltered water, the exceptions being the offshore Houtman Abrolhos Islands and some small inshore islands of the mid-west coast, as well as Rottnest and Garden Islands off the Perth metropolitan region. The major significant marine embayments are Cockburn Sound and Geographe Bay. Beyond Cape Naturaliste the coastline changes from limestone to predominantly granite and becomes more exposed to the influences of the Southern Ocean. There are four significant estuarine systems, the Swan/Canning, Peel/Harvey and Leschenault estuaries and Hardy Inlet (Blackwood estuary), all of which are permanently open to the sea and form an extension of the marine environment.

Relevant Resource Assets and Risks from all Activities

West Coast Benthic Habitats – Estuarine	Significant Risk (non-fishing)
West Coast Benthic Habitats – Nearshore	Low Risk
West Coast Benthic Habitats – Inshore Demersal	Low Risk
West Coast Benthic Habitats – Offshore	Low Risk
West Coast Listed Species – Non-fish	Low Risk
West Coast Listed Species – Non-fish (mammals)	Moderate Risk
West Coast Listed Species – Fish	Low Risk
West Coast Ecosystem Abrolhos Islands – Marine	Moderate Risk
West Coast Ecosystem Central West – Marine	Moderate Risk
West Coast Ecosystem Central West – Estuarine	Significant Risk (non-fishing)
West Coast Ecosystem Leeuwin-Naturaliste – Marine	Low Risk
West Coast Ecosystem Leeuwin-Naturaliste – Estuarine	High Risk (non-fishing)
West Coast External Drivers – Climate	Moderate Risk

Summary of historical research completed

Bycatch: The Department of Fisheries conducted a study of the potential impacts on bycatch species and the benthic habitat of this region in the South West Trawl in the early 1990s and found minimal impact. Research to mitigate interactions is developing such as the implementation of Sea Lions Exclusion Devices (SLEDs) in 2006 and current studies into humpback whale interaction in the Western Rock Lobster fishery. Recently completed WAMSI project 4.4.1 established a risk analysis of interaction rates between the collective

fisheries and bycatch to identify which species, species groups or fisheries require more detailed assessment.

Marine Ecology and Monitoring: A long-term monitoring program to compare fish, rock lobster and sessile benthic communities inside and outside sanctuary zones of the NRM Swan region has been completed for the Swan Catchment Council (now Perth Region NRM). Marine Futures (NHT) funded, the project collected baseline scientific data to develop marine resource indicators for marine habitats, biodiversity and human use patterns in SW Australia. The Strategic Research Fund for the Marine Environment (SRFME) undertook studies on several ecosystem topics in this Bioregion including pelagic productivity cycles of oceanic waters, coastal and shelf biogeochemical modeling, and benthic ecosystem dynamics (algae, invertebrates and fish communities) in shallow (<20 m depth) waters. Focus areas for community ecology in this Bioregion included Jurien Bay and Geographe Bay. Recently completed WAMSI projects have seen a substantial program of work on biodiversity and community structure on the West Coast including the Swan, Peel-Harvey and Leschenault estuaries – WAMSI 4.2.

Current Research Focus

A number of research activities are underway within this Bioregion such as;

- Interaction rates with endangered, threatened and protected species (ETPS) are now recorded on daily logbooks and Catch And Effort Statistics (CAES) forms.
- The physical impact of fishing with lobster pots on coral communities at the Houtman Abrolhos Islands is being monitored. Information on a number of environmental variables is also being collected as part of this project to assess the impact of natural and anthropogenic effects on the marine ecosystem of the Houtman Abrolhos Islands.
- Research into the interaction of humpback whales with the western rock lobster fishery is underway.
- Broad and fine scale habitat mapping/modelling work is continuing throughout the Bioregion, notably off shore Jurien and the Houtman Abrolhos Islands.
- Development of a designated aquaculture development zone in the Mid-West – within the waters of the Houtman Abrolhos Islands Fish Habitat Protection Area, and associated baseline data collection.
- Western rock lobster ecosystem – focusing on determining the ecosystem effects of removing lobster from the ecosystem in this Bioregion by comparing areas open and closed to western rock lobster fishing.
- Development and implementation of monitoring programmes for the Ngari-Capes marine park.
- Assessing and monitoring the implementation of artificial reefs in the Bioregion.

There are also numerous other projects occurring within this Bioregion led by other agencies or institutes that the Department of Fisheries is aware of.

Priority Setting Process

The Department has developed a risk assessment process for the West Coast Bioregion under its processes of considering Ecosystem Based Fisheries Management as a management goal.

Review Timeline

The projects falling into this RMAD summary are varied and generally related to specific fisheries or management requirements. Review timeline are as required for fishery reporting or through peer reviewed reports or publications.

Recent Publications

Bellchambers L.M., Evans S.N. and Meeuwig J.J. (2013). Assessing the effectiveness of two methods of habitat characterisation for understanding species habitat relationships, using the western rock lobster (*Panulirus cygnus* George). *Fisheries Research*. 139 5-10.

Speed C.W., Babcock R.C., Bancroft K.P., Beckley L.E., Bellchambers L.M., Depczynski M.R., Field S.N., Friedman K.J., Gilmour J.P., Heyward A.J., Hobbs J.P., Kobryn H.T., Moore J.A.Y., Nutt C.D., Shedrawi G., Simpson C.J., Thompson D.P., Wilson S.K. (2013). Dynamic stability of West Australian coral reefs. *PLoS ONE* 8(7): e69863. doi: 10.1371/journal.pone.0069863

Bellchambers L.M., Mantel P., Chandrapavan A., Pember M.B., Evans S.E. (2012). Western Rock Lobster Ecology - The State of Knowledge Marine Stewardship Council - Principle 2: Maintenance of Ecosystem. Fisheries Research Report 236. Department of Fisheries Western Australia. http://www.fish.wa.gov.au/Documents/research_reports/fr236.pdf

Hovey, R.K., Van Niel, K.P., Bellchambers, L.M., Pember, M.B. (2012). Modelling deep water habitats to develop a spatially explicit, fine scale understanding of the distribution of the Western Rock Lobster, *Panulirus cygnus*. *PLoS ONE* 7(4): e34476. doi:10.1371/journal.pone.0034476

Smale, D.A., Kendrick, G.A., Harvey, E.S., Langlois, T.J., Hovey, R.K., Van Niel, K.P., Waddington, K.I., Bellchambers, L.M., Pember, M.B., Babcock, R.C., Vanderklift, M.A., Thomson, D.P., Jakuba, M.V., Pizarro, O. and Williams, S.B. (2012). Regional-scale benthic monitoring for Ecosystem-Based Fisheries Management (EBFM) using an Autonomous Underwater Vehicle (AUV). *ICES Journal of Marine Science* doi:10.1093/icesjms/fss082

de Lestang, S., Caputi, N., How, J., Melville-Smith, R., Thomson, A. and Stephenson, P. (2011). *Stock Assessment for the West Coast Rock Lobster Fishery*. Fisheries Research Report No. 217. Department of Fisheries, Western Australia. 192p.

Johnston, D.J., Harris, D., Caputi, N. and Thomson, P. (2011). Decline of a blue swimmer crab (*Portunus pelagicus*) fishery in Western Australia – history, contributing factors and future management strategy. *Fisheries Research* 109(1): 119-130.

Potter, I.C., Chuwen, B.M., Hesp, S.A., Hall, N.G., Hoeksema, S.D., Fairclough, D.V., and Rodwell, T.M. (2011). Implications of the divergent use of a suite of estuaries by two exploited marine fish species. *Journal of Fish Biology* 79 (3): 662-691.

Sampey, A., Fromont, J. and Johnston, D.J. (2011). Demersal and epibenthic fauna in a temperate marine embayment, Cockburn Sound, Western Australia: determination of key indicator species. *Journal of the Royal Society of Western Australia* 94, 1-18.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

West Coast Biodiversity Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Habitat & Ecosystem							
1.1 Bycatch							
All Fisheries	Ongoing	■	■	■	■	■	Through liaison with individual Fisheries (WRL, Trawl)
1.2 Listed Species							
Humpback whale interaction	Ongoing	■	■				DoF FRDC project
1.3 Habitat							
Developing and monitoring broad scale habitat map for West Coast Bioregion	Ongoing	■	■	■	■	■	MEMS / UWA
Fine scale fishery independent habitat mapping for western rock lobster	Ongoing	■					Monitoring existing fine scale habitat maps of the central west coast.
Coral habitats in Houtman Abrolhos Islands	Ongoing	■	■	■	■	■	A DoF project examining the effects natural and anthropogenic impacts on sensitive coral habitats at the Abrolhos
Near shore seagrass	Ongoing						Seagrass communities are currently being studied by ECU
1.4 Ecosystem/Environment							
Western rock lobster	Ongoing	■	■	■	■	■	Monitoring the effects of western rock lobster fishing on the ecosystem
Marine park monitoring	Ongoing	■	■	○	○	○	Capes Marine Park
Fish Kills	Ongoing	■					Gov't response to fish kills coordinated through Fisheries Research (Fish Health).
FHPA monitoring - primarily Houtman Abrolhos Islands	Ongoing	■	■	■	■	■	
1.5 Oceanography							
1.6 Other impacts on fishery							
MWADZ - Houtman Abrolhos Islands	Ongoing	■	○	○	○	○	Baseline data collection for proposed Mid-west aquaculture location
Artificial Reefs		■	○	○	○	○	Implementation and monitoring of new artificial reefs
2. Management Analysis							
2.1 Socio-economic							
Social assessment							
Economic Analysis							
2.2 Resource Access (Shares)							
2.3 Compliance Research							
2.4 Management Systems							
3. Stakeholder Consultation and Reviews							
MSC	Completed						Pre-assessment in 2014
Annual Risk Assessment Process	Ongoing	■	■	■	■	■	
MPRA Annual Audit	Ongoing	■	■	■	■	■	
COPS with DPAW	Ongoing	■	■	■	■	■	

West Coast – Abrolhos Islands FHPA

Description and Scope of Issues

The Houtman Abrolhos Islands (Abrolhos) are a series of islands and reefs located at the edge of the continental shelf between 28°15'S and 29°S, approximately 60km offshore from the mid-west coast of Western Australia. Uniquely located within a temperate geographical region but bathed in warm water from the southward flowing Leeuwin current, the Abrolhos is an extremely diverse and important asset of the Western Australian environment. The Abrolhos is significant in geological terms and for the conservation of flora and fauna.

State territorial waters around the Abrolhos contain some of the most highly valued marine systems in the State. Furthermore, these waters include the sites of some of the most important historic shipwrecks in Australia, with associated historic sites located on the islands themselves. In recognition of its importance, the Abrolhos was declared as the first Fish Habitat Protection Area in Western Australia in 1999. It remains the largest in the State and is the only area in which DoF has primary management responsibility for the entire area (including the terrestrial component). A detailed overall management plan, released in 1998, is currently being revised. There are also management plans for tourism and aquaculture.

Relevant Resource Assets and Risks from all Activities

West Coast Abrolhos Ecosystem	Moderate Risk
West Coast Benthic Abrolhos	Low / Moderate Risk
West Coast External Climate	High Risk

Summary of historical research completed

Bornt, K.R., Mclean, D.L., Langlois, T.J., Harvey, E.S., Bellchambers, L.M., Evans, S.N. and Newman, S.J. (in prep). Target demersal fish species exhibit variable responses to long-term protection from fishing and a marine heatwave anomaly at the Houtman Abrolhos Islands. *Coral Reefs*

Markey, K., Abdo, D.A., Bosserelle, C. and Evans, S.N. (in prep). Keeping it Local: dispersal limitations of coral larvae to the high latitude coral reefs of the Houtman Abrolhos Islands. *PLoS ONE*

Shedrawi, G., Harvey, E.S., Mclean, D.L., Prince, J., Bellchambers, L.M. and Newman, S.J. (2014). Evaluation of the effect of closed areas on a unique and shallow water coral reef fish assemblage reveals complex response. *Coral Reefs* doi:10.1007/s00338-014-1160-3

Abdo, D.A., Bellchambers, L.M. and Evans, S.N. (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. doi:10.1371/journal.pone.0043878

Evans, S.N., Bellchambers, L.M., and Murray, K. (2012). Mapping shallow water habitats of the Wallabi Group, Houtman Abrolhos Islands, using remote sensing techniques. Fisheries Research Report No. 237. Department of Fisheries, Western Australia. 28p

See further list of historical publications in previous editions of this document.

Current Research Focus

To develop programs to meet the following objectives:

- Assess the status of key indicator fish and invertebrate stocks distributed within FHPAs, particularly the Abrolhos FHPA.
- Satisfy the relevant fish and invertebrate abundance and biodiversity key performance indicators set to maintain the FHPAs, particularly the Abrolhos FHPA.
- Determine the effectiveness of the FHPA fish and fishery related management procedures.
- Establish a system of benthic habitat monitoring in the Abrolhos FHPA to provide a baseline against which future anthropogenic changes can be assessed.
- Monitor and understand the resilience of coral reef communities to environmental change using the Abrolhos FHPA as a model system.

Priority Setting Process

Assessments of required research are made through departmental meetings, which involve discussions of stock status, previous research conducted, current research and existing research gaps required for more informed management. Relevant discussions of research outcomes and needs with stakeholder groups occur regularly.

Review Timeline

The management of the Abrolhos Islands was reviewed in 2007 (DoF 2007) – (FMP 220).

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

West Coast Abrolhos Islands FHP Regions Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Habitat & Ecosystem							
1.1 Biology							
Dhufish Regional Biology	Completed						
Dhufish Reproductive Biology	Completed						
Pink Snapper Biology	Completed						
Baldchin Groper	Ongoing						UWA PhD
Breaksea Cod Biology	Completed						
Coral Trout Biology	Underway						PhD + ECU
Spangled Emperor Biology	Underway						
Red Throat Emperor	Underway						DoF and ECU
1.2 Listed Species							
1.3 Habitat							
Fine Scale - Long term Monitoring of reef ecosystem	Ongoing	■			■		DoF
Broad Scale - Develop habitat maps and monitor for the shallow water marine habitat	Ongoing / Developing	○	○				DoF
Coral Connectivity	Ongoing						UWA PhD

West Coast Abrolhos Islands FHP Regions Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1.4 Ecosystem/Environment							
Mid-West Aquaculture Zone	Ongoing	■					Baseline data collection for proposed Mid-West Aquaculture Zone
General fin fish assemblages	Ongoing	■		■		■	DoF BRUVS
1.5 Oceanography							
Fine-scale long-term temperature and water motion monitoring	Ongoing	■	■	■	■	■	Long term monitoring of coral reef habitat
Mid-West Aquaculture Development Zone	Completed	■					MWADZ Baseline hydrodynamic data collection
1.6 Impacts on ecosystems							
1.7 Monitoring							
Annual C & E Assessment	Ongoing						
Commercial Catch & Effort Reporting	Ongoing	■	■	■	■	■	WRL, Scallop and Demersal Finfish
Age Structure of Indicator Species	Ongoing	■		■		■	Using BRUVS and species specific indices
Statewide survey of boat-based recreational fishing		■		■		■	Biennial phone-diary survey
Abrolhos Specific Recreational Fishing Indicator	Developing	○				○	
Abrolhos Recreational Usage	Developing	■	■	■	■	■	Notification Database new in 2014
Charter Boat Catch and Effort	Ongoing	■	■	■	■	■	Tour Operator Return Book, annual reporting in SRFAR.
2. Management Analysis							
2.1 Socio-economic							
Social assessment	Developing	○					Cabinet Sub-committee investigation on development options for the Houtman Abrolhos Islands
Economic Analysis	Developing	○					Cabinet Sub-committee investigation on development options for the Houtman Abrolhos Islands
2.2 Resource Access (Shares)							
2.3 Compliance Research							
2.4 Management Systems							
3. Industry Development							
3.1 Production Technology	None						
Development of Mid-West Aquaculture Zone	Ongoing/Developing	■	■				Baseline data collection and submission of impact assessment to EPA
3.2 Post Harvest	None						
3.3 Marketing	None						
4. Stakeholder Consultation and Reviews							
MSC							
Stakeholder engagement	Ongoing	■	■	■	■	■	

West Coast – West Coast Demersal Scalefish Resource

Description and Scope of Issues

The demersal scalefish resource in the West Coast Bioregion (WCB) is fished mostly by commercial, charter and recreational line fishers. Approximately 100 species are caught by the fisheries each year, with fishers in each sector primarily targeting West Australian dhufish (*Glaucosoma hebraicum*) and Snapper (*Chrysophrys auratus*). Substantial catches are also taken of other species, such as Redthroat emperor (*Lethrinus miniatus*), Bight redfish (*Centroberyx gerrardi*) and Baldchin groper (*Choerodon rubescens*). A range of species is taken in offshore waters, including Eightbar grouper (*Hyporthodus octofasciatus*), Hapuku (*Polyprion oxygeneios*), Blue-eye trevalla (*Hyperoglyphe antarctica*) and Ruby snapper (*Etelis carbunculus*). Demersal species are also landed by the Western Rock Lobster Fishery, temperate demersal gillnet and demersal long-line fisheries in the WCB, the South-west Managed Trawl Fishery, the Cockburn Sound Line and Pot Managed Fishery and the Commonwealth's Western Deepwater Trawl Fishery.

Relevant Resource Assets and Risks from Fishery

West Coast Inshore Demersal scalefish suite	Moderate Risk
West Coast Offshore Demersal scalefish suite	Low Risk
West Coast Bycatch species	Moderate Risk
West Coast Listed Species	Negligible Risk
West Coast Inshore Habitats	Negligible Risk
West Coast Marine Ecosystems	Negligible-Low Risk

Summary of historical research completed

Completed studies of the biology of the demersal indicator species, West Australian dhufish, Snapper and Baldchin groper include their reproductive biology, growth, age composition, mortality, diets and stock structure. The biology of other demersal species has also been studied, including Breaksea cod (*Epinephelides armatus*) and Western blue groper (*Achoerodus gouldii*). Biological studies have been completed of several species in the offshore demersal suite.

Current Research Focus

The current research focus is to collect biological data (age composition of the catch) necessary for ongoing stock assessments of indicator species to monitor the recovery of demersal scalefish in the WCB. This follows an independently reviewed assessment in 2007 that demonstrated overfishing had been occurring (Wise *et al.* 2007¹). Significant management restructuring was introduced to reduce catch, effort and fishing mortality to allow stock recovery. Commercial, charter and recreational line fishers catches of demersal species in the WCB are also monitored to ensure they remain below 50% of 2005/06 catches for each sector during this recovery phase. A recent assessment demonstrated that recovery has commenced for WA dhufish and Snapper (Fairclough *et al.* 2014). Two additional

¹ Wise, B.S., St John, J., Lenanton, R.C. (eds.) (2007). Spatial scales of exploitation among populations of demersal scalefish: implications for management. Part 1: Stock status of the key indicator species for the demersal scalefish fishery in the West Coast Bioregion. Final report to the FRDC on Project No. 2003/052. Fisheries Research Report No. 163. Department of Fisheries, Western Australia. 130 pp.

indicator species, Redthroat emperor and Bight redfish, are now being monitored to diversify the indicator species composition in the different management areas of the fishery.

Proposed or Possible Research Initiatives

- Relationship of snapper stocks in the Gascoyne and West Coast Bioregions - Review snapper stock relationships with consideration of effects of environmental change
- Recruitment strength - Examine oceanic productivity via remote sensing vs recruitment strength of indicator species (incl. other bioregion/suite indicators) (Proposed Curtin/ARC funding)

Priority Setting Process

Priorities are reviewed on an annual basis through consultation between scientists of the Finfish Branch (Research Division) and fishery managers during the annual review of FishPlan. Priority settings are also discussed with stakeholders.

Review Timeline

Including the most recent Level 3 assessment, three indicator species (WA dhufish, Snapper and Baldchin groper) have been used to monitor and assess the status of the suite of inshore demersal species in the WCB. Assessments in 2007 and 2009 were independently reviewed, while methods applied in the 2013 assessment have also been peer-reviewed. This fishery was last reviewed as part of the MSC pre-assessment process in 2014.

The next Level 3 assessment of fishing mortality rates for each indicator species is due for completion in 2016/17.

Recent Publications

Fairclough, D.V., Molony, B.W., Crisafulli, B.M., Keay, I.S., Hesp, S.A., Marriott, R.J. (2014). Status of demersal finfish stocks on the west coast of Australia. Fisheries Research Report 253. Department of Fisheries, Western Australia. 92 pp.

Fairclough, D.V., Brown, J.I., Carlish, B.J., Crisafulli, B.M. and Keay, I.S. (2014) *Breathing life into fisheries stock assessments with citizen science*. Scientific Reports, 4 . Article No. 7249.

Fairclough, D.V., Edmonds, J.S., Jackson, G., Lenanton, R.C.J., Kemp, J., Molony, B.W., Keay, I.S., Crisafulli, B.M., Wakefield, C.B. (2013). A comparison of the stock structures of two exploited demersal teleosts, employing complementary methods of otolith element analysis. *Journal of Experimental Marine Biology and Ecology* 439: 181-195.

French, B., Clarke, K.R., Platell, M.E., Potter, I.C. (2013). An innovative statistical approach to constructing a readily comprehensible food web for a demersal fish community. *Estuarine, Coastal and Shelf Science* 125: 43-56.

Wakefield, C.B., Newman, S.J., Marriott, R.J., Boddington, D.K., Fairclough, D.V. (2013). Contrasting life history characteristics of the eightbar grouper *Hyporthodus octofasciatus* (Pisces: Epinephelidae) over a large latitudinal range reveals spawning omission at higher latitudes. *ICES Journal of Marine Science* 70: 485-497.

Berry, O., England, P., Fairclough, D., Jackson, G., Greenwood, J. (2012). Microsatellite DNA analysis and hydrodynamic modelling reveal the extent of larval transport and gene

flow between management zones in an exploited marine fish (*Glaucosoma hebraicum*). Fisheries Oceanography 21: 243-254.

Fisher, E.A. (2012). Tools for assessing data-limited fisheries and communicating stock status information. Ph.D. thesis, Murdoch University, Western Australia. 238 pp.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

West Coast Demersal Scalefish Resource Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
West Australian dhufish biology	Complete						Several studies completed
Snapper biology	Complete						Several studies completed
Baldchin groper biology	Complete						Several studies completed
Redthroat emperor biology	Underway	■	■				IFM West
Bight redfish biology	Underway	■	■				South Coast NRM
1.2 Other Biology studies							
Juvenile West Australian dhufish	Ongoing	■	■	■			Studies on juvenile recruitment to artificial reefs and natural habitats (NRM, and Royalties for Regions)
Movement	Underway	■	■				Movement of snapper associated with spawning aggregations in Cockburn Sound (DoF).
Stock structure of Bight redfish (genetics, microchemistry)	Underway	■	■				South Coast NRM (incl. South Coast Bioregion & Great Australian Bight)
Relationship of snapper stocks in the Gascoyne and West Coast Bioregions	Proposed						Review snapper stock relationships with consideration of effects of environmental change
Food-webs of fishes in south-western Australia	Complete						FRDC (MU)
1.3 Stock Assessment							
Annual catch and effort assessment	Ongoing	■	■	■	■	■	Commercial fisheries that catch demersal species in the WCB, charter fishery
Level 3 fishing mortality assessments against biological reference points (indicator species)	Periodic			■			DoF
1.4 Fishery Monitoring							
Commercial catch and effort	Ongoing	■	■	■	■	■	Statutory logbooks
Charter catch and effort	Ongoing	■	■	■	■	■	Tour Operator Return Book
State-wide survey of boat-based recreational fishing	Periodic		■		■		Biennial phone-diary survey to provide estimates of recreational effort and catch
Age structure of indicator species	Ongoing	■	■	■	■	■	DoF sample collection

West Coast Demersal Scalefish Resource Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Recruitment strength	Ongoing	■	■	■	■	■	Egg survey/DEPM model for snapper in Cockburn Sound, BRUVS survey of juvenile recruitment (DoF). Testing validity of visual snapper egg identification methods using molecular approaches. Study of recruitment strength/habitats of juvenile baldchin groper (UWA)
Recruitment strength	Proposed		O	O	O		Examine oceanic productivity via remote sensing vs recruitment strength of indicator species (incl. other bioregion/suite indicators) (Proposed Curtin/ARC funding)
Monitoring byproduct of demersal species in other fisheries in WCB	Ongoing	■	■	■	■	■	Compulsory reporting via logbooks
Testing use of passive acoustic methods for monitoring indicator species	Complete						Curtin (FRDC)
2. Habitat & Ecosystem							
2.1 Bycatch	Completed						WAMSI 4.4
2.2 Listed Species	Not needed						Low Risk from fishery
2.3 Habitat	Not needed						Low Risk from fishery.
2.4 Ecosystem/Environment							
Community structure	Complete						WAMSI WC Bioregion ecosystem study. Developing indicators of community structure for Abrolhos, Rottnest and Metropolitan regions
Offshore demersal suite	Underway	■	■	■	■	■	PhD, The influence of latitude and depth on the assemblage structure of deep water West Australian demersal fishes (50-570m). DoF/FRDC/UWA/CSIRO
2.5 Oceanography	Complete						CSIRO (WAMSI) investigated oceanographic influences on dispersal of larvae of WA dhufish. Proposed to evaluate same for Snapper between Gascoyne and West Coast Bioregions
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic							
Social assessment	Complete						WAMSI (UWA and MU)
Economic Analysis	Complete						WAMSI, FRDC (UWA and MU)
Evaluation of Rec fisher incentives	Complete						WAMSI (UWA and MU)
3.2 Resource Access (Shares)							
Determination of access shares	Complete						
Monitoring of shares	Ongoing	■	■	■	■	■	IFM
3.3 Compliance Research	Nil						NA
3.4 Management Systems							
	Complete						Exploration of the effectiveness of alternative management responses to variable recruitment (MU) - FRDC

West Coast Demersal Scalefish Resource Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
4. Industry Development	Nil						Nothing identified. MSC pre-assessment completed in 2014 for consideration
5. Stakeholder and Consultation Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete	■					MSC pre-assessment reviewed in 2014
Other	Periodic			■			Independent reviews of assessment methods by Haddon (2007), O'Neill (2009) and of methods adopted from Fisher (2012).

This assessment does not include the specific needs for the Abrolhos Islands region (see the Abrolhos Islands section for details).

West Coast – Western Rock Lobster

Description and Scope of Issues

Commercial: The West Coast Rock Lobster Managed Fishery (WCRLF) targets the western rock lobster, *Panulirus cygnus*, on the west coast of Western Australia between Shark Bay and Cape Leeuwin, using baited traps (pots). With an annual value of production that averages about \$350 million, this is Australia's most valuable single-species fishery.

Recreational: The recreational rock lobster fishery primarily targets western rock lobsters in the Perth metropolitan area and Geraldton, using baited pots and by diving.

Relevant Resource Assets and Risks from Fishery

West Coast Crustaceans Shelf (Lobsters)	Moderate Risk
West Coast Nearshore Molluscs (Octopus)	Moderate Risk
West Coast Listed Species (Whales and Sea lions)	Moderate Risk
West Coast Nearshore Habitats	Low Risk
West Coast Ecosystem (Marine)	Low – Moderate Risk

Summary of historical research completed

Research activities into the western rock lobster have been underway for decades with a large amount of research having already been completed. This research covers lobster biology, ecology, stock assessment and the examination of fleet and fishery dynamics. A comprehensive listing of all these projects is contained in the Stock Assessment for the West Coast Rock Lobster Fishery document (de Lestang *et al.* 2012).

A risk assessment workshop to examine the low puerulus settlement was held in April 2009 and a report on this workshop can be found on the Department's website¹. A significant amount of research projects were developed from this workshop to examine the cause of these low settlement levels in recent years. Six projects were subsequently funded by the FRDC and final reports are available:

- Project 1. Identifying factors affecting the low western rock lobster puerulus settlement in recent years (Caputi *et al.* 2014b);
- Project 2. Evaluating source-sink relationships of the Western Rock Lobster Fishery using oceanographic modelling (Caputi *et al.* 2010);
- Project 3. Evaluating the potential use of change-in-ratio and index removal techniques for determining harvest rates and efficiency increases in the Western Rock Lobster Fishery (de Lestang *et al.* 2012b);
- Project 4. Evaluation of population genetic structure in the western rock lobster (Kennington 2012);
- Project 5. Assessing possible environmental causes behind the reduced colonization of puerulus collectors by a wide suite of species (de Lestang *et al.* 2011); and
- Project 6. A joint funded project between the FRDC and the Marine National Facility - RV Southern Surveyor. Biological Oceanography of the Western Rock Lobster – Winter / Spring Dynamics (Waite *et al.* 2014).

These projects have added to the current knowledge of western rock lobster larvae and settlement and the relationships these have with the environment. The FRDC Project 1 above (in collaboration with CSIRO) identified earlier lobster spawning (from warmer waters) and reduced winter storms as two key factors that may be associated with the seven years of lower settlement. A paper on this research was recently presented at the 10th International Conference and Workshop on Lobster Biology and Management in Cancun Mexico and will be submitted to ICES Journal of Marine Science as part of the conference proceedings.

A project to assess the economic performance of the fishery was funded by the Seafood CRC. This project is examining maximum economic yield assessment, in light of the recent move towards a quota management system, and ways to incorporate the economic assessment into the outputs generated by the stock assessment model (Caputi *et al.* 2014b).

Current Research Focus

Research activities focus on assessing stock sustainability, forecasting future recruitment, breeding stock levels and determining the Maximum Economic Yield levels for quota setting. This involves fishery-dependent and independent monitoring of breeding stock levels and puerulus settlement as well as lobster market behaviour. Industry performance is monitored through compulsory daily catch disposal records which contain a volunteer research section from fishers and monthly returns from processors, and a commercial monitoring program, all of which are used for modelling and stock assessment.

Current biological projects include a three-year FRDC-funded tag-recapture programme designed to determine current biomass and exploitation levels as well as more information of the movement and growth of lobsters under recent increased levels of biomass.

¹ http://www.fish.wa.gov.au/Documents/occasional_publications/fop071.pdf

The Department is also currently working on a project designed to reduce interactions between the pot ropes and floats and whales which migrate through the fishery from May until November each year. The project is determining what gear modifications might lead to a reduction in entanglements as well as determining when and where the majority of whales migrate through the fishery. Outcomes from this project will lead to the fishery remaining a 12 month fishery.

An environmental management strategy was developed for use in the assessment of the broader ecosystem impacts of rock lobster fishing in the context of Ecological Sustainable Development (ESD) and MSC certification. This strategy includes research into the ecosystem effects of rock lobster fishing in deep water.

The latest ecosystem-based project aims to examine the effects of western rock lobster fishing on the deep-water ecosystem off the west coast of Western Australia. This was started in 2009, using a comparison between fished and unfished deep water areas in deep water (~40 m) off Leeman. Preliminary results of this research indicate a substantial increase in lobster biomass and average carapace length of lobsters within the unfished region. A key output of this research will be a greater understanding of the carrying capacity of deep-water reefs systems within the WCRLF. A paper from this research was recently presented at the 10th International Conference and Workshop on Lobster Biology and Management in Cancun Mexico in 2014¹.

Another project examining lobster populations in fished and unfished zones is ongoing at Rottneest Island. This project consists of annual sampling using pots and underwater dive surveys at Kingston Reef, Armstrong Bay and Parker Point sanctuary zones. Results from the first five years after the no-take regions were implemented have shown a slight increase in lobster numbers within the latter two protected areas. This study also aims to provide additional information on growth, natural mortality and size/sex-specific catchability.

Concern about the status of the breeding stock in the Big Bank region resulted in this area being closed to lobster fishing. Additional independent breeding stock survey sites have been sampled in this area since 2009 to generate baseline information to assess the effects of this closure.

For the recreational component of this fishery, an annual mail survey of participants has been used to estimate the annual catch and effort for the past 28 years. The trends generated by these data, together with data on puerulus settlement are used to predict the recreational catch and effort in following seasons. Since 2000/01, phone diary surveys of recreational rock lobster fishers have also been undertaken in some years. Estimates of recreational catch using this method have been compared to the estimates from mail surveys. Phone diary surveys are considered to be more accurate than those from mail surveys because they reduce the recall bias in the annual mail surveys and have a higher participation rate. Sample sizes for the phone diary surveys were increased after the 2006/07 survey to improve the accuracy of the estimates.

Proposed or Possible Research Initiatives

- Habitat -recruitment relationships - FRDC proposal to understand relationship between habitat and puerulus recruitment requirements
- Examining the price-supply relationship within the WRL markets

¹ <http://www.dmc-cancun.com/icw12014/index.php/component/content/?view=featured>

Priority Setting Process

Commercial: This is undertaken through the meetings between the Department of Fisheries and industry facilitated by WAFIC/Western Rock Lobster Council (WRLC).

Recreational: This process is facilitated by Recfishwest.

Review Timeline

A stock assessment workshop took place from 20 – 24 May 2010. The objectives of the workshop were motivated by the audit conditions set by the MSC's auditors for the WCRLF, as well as the need for regular review of the 2010 stock assessment. The workshop considered the structure of the current model to be appropriate, however, its complexity could be simplified. The workshop also advised that more data sources and parameters should be incorporated within the model to improve its estimates of precision. A major outcome of the workshop was the development of an ITQ version of the model that also incorporated many of the suggested changes made by the reviewers.

This version of the model has been completed and now used as the current version of the model. Upon its completion it was again subjected to review by André Punt (April/May 2011).

The WCRLF was re-assessed by the MSC in March 2012 and was recertified for another five years.

Recent Publications:

Caputi, N., Feng, M., de Lestang, S., Denham, A., Penn, J., Slawinski, D., Pearce, A., Weller, E., How, J. (2014a). Identifying factors affecting the low western rock lobster puerulus settlement in recent years. Final FRDC Report – Project 2009/18. Fisheries Research Report No. 255. Department of Fisheries, Western Australia. 144 pp.

Caputi, N., de Lestang, S., Reid, C., Hesp, A., How, J., Stephenson, P. (2014b). Decision-support tools for economic optimization of Western Rock Lobster fishery. Fisheries Research Report No. 257. Department of Fisheries, Western Australia. 100 pp.

de Lestang, S. (2014). The orientation and migratory dynamics of the western rock lobster, *Panulirus cygnus*, in Western Australia. *ICES Journal of Marine Science* doi:10.1093/icesjms/fst205

Waite, A.M., Beckley, L.E., Jeffs, A., Saunders, M., Sawstrom, C., O'Rourke, R., Raes, E., Thompson, P.A., Feng, M., Caputi, N., Sachlikidis, N., Chan, S., Wang, M., Sutton, A., Nguyen, H.M. (2014). Biological oceanography of western rock lobster larvae. FRDC Project No. 2010/047. The University of Western Australia. 128 pp.

Caputi, N., de Lestang, S., Frusher, S., Wahle, R.A. (2013). The Impact of Climate Change on Exploited Lobster Stocks. In: Phillips, B. (ed.), *Lobsters: Biology, Management, Aquaculture & Fisheries*, 2nd Edition. Wiley-Blackwell. 488 pp.

Reid, C., Caputi, N., de Lestang, S., Stephenson, P. (2013). Assessing the effects of moving to maximum economic yield effort level in the western rock lobster fishery of Western Australia. *Marine Policy* 39: 303-313.

de Lestang, S., Caputi, N., How, J., Melville-Smith, R., Thomson, A., Stephenson, P. (2012a). Stock Assessment for the West Coast Rock Lobster Fishery. Fisheries Research Report No. 217. Department of Fisheries, Western Australia. 200 pp.

- de Lestang, S., Hoenig, J., Frusher, S., Hall, N.G. (2012b). Evaluating the potential use of change-in-ratio and index removal techniques for determining harvest rates and efficiency increases in the Western Rock Lobster Fishery. FRDC Project 2009/019. Fisheries Research Report No. 234. Department of Fisheries, Western Australia, 40 pp.
- Kennington, W.J., Berry, O., Groth, D.M., Johnson, M.S., Melville-Smith, R. (2012). Evaluation of population genetic structure in the western rock lobster. FRDC Project No. 2009/020. The University of Western Australia. 111 pp.
- de Lestang, S., How, J., Foster, S. (2011). Assessing possible environmental causes behind the reduced colonisation of Western Rock Lobster puerulus collectors by a wide suite of species. FRDC Project 2008/085. Fisheries Research Report No. 218. Department of Fisheries, Western Australia. 60 pp.
- Feng, M., Caputi, N., Penn, J., Slawinski, D., de Lestang, S., Weller, E., Pearce A. (2011). Ocean circulation, Stokes drift, and connectivity of western rock lobster (*Panulirus cygnus*) population. *Canadian Journal of Fisheries and Aquatic Sciences* 68, 1182-1196.
- Caputi, N., Feng, M., Penn, J., Slawinski, D., de Lestang, S., Weller, E., Pearce, A. (2010). Evaluating source-sink relationships of the western rock lobster fishery using oceanographic modelling. Final FRDC Report – Project No. 2008/087. Fisheries Research Report No. 209. Department of Fisheries, Western Australia. 68 pp.

Key to symbols in the matrix/summary tables:

- Indicates that the activity is funded and planned to occur.
- Indicates that the activity is part of a proposal but is not yet funded.

West Coast Western Rock Lobster Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)	Ongoing	■	■	■	■	■	Still some work required. Direct aging study funded by the FRDC
1.2 Other Biology							
Recruitment dynamics	Complete						
Migration	Complete						
Lobster spawning rates	Complete						
Lobster mating behaviour	Underway	■	■				UWA PhD student
By-product Octopus basic biology	Complete						The basic life history studied / recruitment
1.3 Stock Assessment							
Annual assessment	Ongoing	■	■	■	■	■	
Continue updating new model	Ongoing	■	■	■	■	■	Models updated as new data developed
Deep water depletion assessment	Complete						
Change in ratio and index removal	Complete	■					Funded by the FRDC
Tagging study	Underway	■	■	■			Funded by the FRDC
1.4 Fishery Monitoring							
Commercial catch and effort	Ongoing	■	■	■	■	■	
Processor returns	Ongoing	■	■	■	■	■	
Commercial monitoring	Ongoing	■	■	■	■	■	

West Coast Western Rock Lobster Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Puerulus monitoring	Ongoing	■	■	■	■	■	
Research logbooks	Ongoing	■	■	■	■	■	
Spawning stock survey	Ongoing	■	■	■	■	■	
Fishing power	Complete						No longer as important under quota management
Recreational catch and effort	Ongoing	■	■	■	■	■	Annual mail survey to license holders
Stock & recruitment	Ongoing	■	■	■	■	■	
Meshed pot monitoring	Ongoing	■	■	■	■	■	
2. Habitat & Ecosystem							
2.1 Bycatch	Ongoing	■	■	■	■	■	Monitoring
2.2 Listed Species	Ongoing	■	■	■	■	■	Monitoring of all interactions
Whale interactions	Ongoing	■	■	■	■	■	Examine float rig design and fishing behaviour (FRDC funded)
Sea lion interactions and behaviour	Complete						Pot design to stop juvenile sea lions entering pots has been developed and implemented
2.3 Habitat	Ongoing	■	■	■	■	■	
Seagrass and limestone reef effects	Complete						Sufficient for management
Coral reef effects	Ongoing	■	■	■	■	■	Study at the Abrolhos Islands
Habitat mapping	Ongoing	■	■	■	■	■	
Habitat -recruitment relationships	Proposed		○	○	○		FRDC proposal to understand relationship between habitat and puerulus recruitment requirements
2.4 Ecosystem/Environment							
Deepwater ecosystem study	Ongoing	■	■	■	■	■	Closed area monitoring
Jurien Bay inshore	Complete						SRFME/WAMSI study
Dongara inshore	Complete						CSIRO studies in the 1980s
Rottnest Sanctuary zones	Underway	■	■	■			Comparing fished vs. unfished
2.5 Oceanography							
Leeuwin Current monitoring	Ongoing	■	■	■	■	■	
Oceanographic Modelling	Complete						FRDC funded
2.6 Other impacts on fishery							Nothing identified
3. Management Analysis							
3.1 Socio-economic							
Bio-Economic modelling	Complete						
Economic Analysis (MEY)	Complete						Examination of Maximum Economic Yield
Price-catch relationship	Underway		■				Under negotiations with consultants
3.2 Resource Access (Shares)							
Determination of access shares	Complete						Needed for IFM / ITQ
Monitoring of shares	Ongoing	■	■	■	■	■	Needed for IFM / ITQ
3.3 Compliance Research							
Enforcement efficiency	Ongoing	■	■	■	■	■	
3.4 Management Systems							
Input vs output controls	Complete						Industry moving to quota in 2010/11

West Coast Western Rock Lobster Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
4. Industry Development							
4.1 Production Technology							
Puerulus grow out	Complete						First stage complete - Awaiting outcomes of policy on ownership of puerulus
More efficient lobster pot design	Complete						First stage complete
4.2 Post Harvest							
4.3 Marketing							Completed by industry
5. Stakeholder Consultation and Reviews							
Stakeholder engagement	Ongoing	■	■	■	■	■	WAFIC/WRLC - annual review of R&D plan
Annual Management Meetings/Coastal Tours	Ongoing	■	■	■	■	■	
Stock assessment	Ongoing	■	■	■	■	■	Last completed in detail in 2010
MSC audits	Ongoing	■	■	■	■	■	Yearly MSC audits

West Coast – Nearshore and Estuarine Finfish Resources

Description and Scope of Issues

The finfish resources in West Coast nearshore and estuaries waters are structurally complex, they are multi-sector (commercial, recreational and non-harvest), multi-species and some species comprise genetically distinct breeding stocks in different estuaries (e.g. black bream, *Acanthopagrus butcheri*, and cobbler, *Cnidogobius macrocephalus*). The commercial catch includes Australian salmon (*Arripis truttaceus*), whitebait (*Hyperlophus vittatus*), sea mullet (*Mugil cephalus*), Australian herring (*Arripis georgianus*), yellow-eye mullet (*Aldrichetta forsteri*), yellow-finned whiting (*Sillago schomburgkii*), southern garfish (*Hyporhamphus melanochir*) and many other species. The recreational catch includes Australian herring, whiting (*Sillago* spp. and *Sillaginodes punctata*), tailor (*Pomatomus saltatrix*), southern garfish, black bream and many other species.

The status of many stocks is strongly affected by non-fishing impacts, including coastal development, habitat degradation within estuary catchments and reduced river flows. These fisheries are small-scale and have relatively low commercial value but have high social, recreational and historical values.

Relevant Resource Assets and Risks from Fishery

West Coast Nearshore Finfish	High Risk
West Coast Estuarine Finfish	Low Risk (Severe Risk from non-fishing)
West Coast Listed Species	Negligible Risk

West Coast Nearshore Habitats	Negligible Risk (Moderate Risk from non-fishing)
West Coast Estuarine Habitats	Negligible Risk (Severe from non-fishing)
West Coast Estuarine Ecosystems	Low Risk (Severe from non-fishing)

Summary of historical research completed

The basic biology is adequately understood for most captured species from an extensive set of research projects that have been undertaken, mainly by the Department and Murdoch University since the 1970s. An FRDC project in the 1990s developed a method to monitor juvenile recruitment for Australian herring, salmon, mullet and whiting. Recruitment sampling is ongoing and indices are used to predict fishery landings.

A state-NRM funded project assessed the status of herring, whiting, tailor and southern garfish stocks during 2009-2012. This major project developed an annual sampling regime for herring to determine age structure of the breeding stock, from which the rate of fishing mortality (F) could be estimated. The sampling regime was adopted and F-based stock assessments for herring are now ongoing. Age-based assessments of whiting, tailor and garfish were also undertaken in 2009-2012. The same project also examined the species composition of the 'whiting' suite in west and south coast fishery landings.

Numerous recreational fishing surveys have been conducted in nearshore waters of the West Coast Bioregion since the early 1970s. Recent surveys have been focused on boat-based fishing. The most recent estimates of total recreational catches nearshore waters are from the National Recreational and Indigenous Fishing Survey conducted in 2000/01. Although boat-based catches are now estimated bi-annually by phone diary surveys, shore-based catches (which are substantial for nearshore species) are not regularly surveyed. Thus, the total nearshore recreational catch is not known. Partial information was provided by restricted surveys (April-June, Perth area only) of shore-based recreational fishing in 2010 and 2014.

The most recent estimates of recreational catches in west coast estuaries are from surveys conducted in 2007/08 (Lai *et al.*, cited in Johnson *et al.* 2014 FRR No. 258, pages 70-105). The recreational fishers catch the majority share (50-100%) of finfish in each estuary, except Peel-Harvey Estuary. This has implications for the collection of information because commercial catches cannot be used to generate indices of abundance or provide samples in most estuaries.

Current Research Focus

Indicator species were selected for these resources using a risk assessment process. Indicators for estuaries are black bream, cobbler (estuary stocks only), sea mullet and Perth herring. Indicators for the nearshore suite are Australian herring, tailor, southern school whiting, southern garfish (Cockburn Sound only) and whitebait.

The status of nearshore and estuarine finfish stocks in the West Coast Bioregion are assessed using CAES data, voluntary recreational logbook (Research Angler Program) data, fishery-independent surveys of annual recruitment and age-based monitoring for some species. Trends in commercial and/or recreational catch rates, where available, form the basis of most assessments. Fishery data is limited for most estuaries, especially in recreational-only estuaries.

Murdoch University regularly undertakes ecological projects relating to fish in West Coast estuaries.

Proposed or Possible Research Initiatives

- Perth herring - Need to re-examine age & growth. Validate otolith annuli. Ages previously determined from scales & are unreliable
- Sea mullet - Examine stock structure, age structure & current biological parameters (growth rate, etc.) in WA
- Tailor - Examine stock structure in WA
- Cockburn Sound garfish - Implement periodic age structure monitoring
- Whitebait - Fishery-independent monitoring
- Climate change & ocean warming - Impact of declining rainfall in estuaries; range shifts due to ocean warming
- Coastal habitat condition - Cumulative impacts of coastal developments
- Resource Access (Shares)
- Compliance
- Management Systems

Priority Setting Process

Priorities are reviewed on an annual basis through consultation between scientists of the Finfish Branch (Research Division) and fishery managers during the annual review of FishPlan. Discussions are also held between the Department of Fisheries, industry members and peak bodies (WAFIC, Recfishwest).

Review Timeline

The commercial fisheries were reviewed as part of the MSC pre-assessments in 2014.

Recent Publications

Fisher, E.A., Hesp, S.A., Hall, N.G., Sulin, E.H. (2014). Predicting the impacts of shifting recreational fishing effort towards inshore species. Final Report on FRDC Project No. 2010/001. Murdoch University, Western Australia.

Brown, J., Dowling, C., Hesp, A., Smith, K., Molony, B. (2013). Status of nearshore finfish stocks in south-western Western Australia. Part 3: Whiting (Sillaginidae). Final NRM Report - Project No. 09003. Fisheries Research Report No. 248. Department of Fisheries, Western Australia. 128 pp.

Smith, K., Brown, J., Lewis, P., Dowling, C., Howard, A., Lenanton, R., Molony, B. (2013a). Status of nearshore finfish stocks in south-western Western Australia. Part 1: Australian herring. Final NRM Report - Project No. 09003. Fisheries Research Report No. 246. Department of Fisheries, Western Australia.

Smith, K., Lewis, P., Brown, J., Dowling, C., Howard, A., Lenanton, R., Molony, B. (2013b). Status of nearshore finfish stocks in south-western Western Australia. Part 2: Tailor. Final NRM Report - Project No. 09003. Fisheries Research Report No. 247. Department of Fisheries Western Australia.

Smith, K.A., Norriss, J. (2011). The status of the black bream *Acanthopagrus butcheri* (Pisces: Sparidae) population in Lake Clifton, south-western Australia. Journal of the Royal Society of Western Australia 94: 25-28.

Key to symbols in the summary matrix:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

West Coast Nearshore and Estuarine Finfish Resources Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Black bream	Complete						Adequate for management
Cobbler	Complete						Adequate for management
Sea mullet	Complete						Adequate for management
Whitebait	Complete						Adequate for management
Southern school whiting	Complete						Adequate for management
Australian herring	Complete						Adequate for management
Tailor	Complete						Adequate for management
Southern garfish	Complete						Adequate for management
Perth herring	Possible						Need to re-examine age & growth. Validate otolith annuli. Ages previously determined from scales & are unreliable
1.2 Other Biology							
Sea mullet	Proposed		○	○	○		Examine stock structure, age structure & current biological parameters (growth rate, etc.) in WA
Tailor	Proposed		○	○	○		Examine stock structure in WA
King George whiting stock structure	Underway						FRDC project lead by Victoria (mainly focused on east Australian stocks)
Age-based model (Swan River bream)	Underway						Murdoch University project
1.3 Stock Assessment							
Annual trends in catch and CPUE	Ongoing	■	■	■	■	■	CAES data & voluntary recreational logbooks (Research Angler Program). Insufficient data to estimate recreational catch
Annual trends in juvenile recruitment	Ongoing	■	■	■	■	■	Beach seining, volunteer angling (tailor only)
Age-based assessment using 'weight-of-evidence' approach (herring)	Ongoing	■	■	■	■	■	Otoliths collected (west & south coasts). NRM-funded project completed 2012
1.4 Fishery Monitoring							
Commercial catch & effort	Ongoing	■	■	■	■	■	CAES compulsory monthly catch & effort returns. Minimal data from estuaries (except Peel-Harvey) & limited data from nearshore areas due to commercial fishing restrictions/closures
Juvenile recruitment surveys	Ongoing	■	■	■	■	■	Annual beach seining (whiting, herring, mullet, others) & volunteer angling (tailor) programs

West Coast Nearshore and Estuarine Finfish Resources Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Fishing tournament & club records	Ongoing	O	O				RAP
Age structure monitoring	Ongoing	■	■	■	■	■	Herring only (W & S coasts)
Cockburn Sound garfish	Proposed	O		O		O	Implement periodic age structure monitoring
Whitebait	Possible						Fishery-independent monitoring
State-wide survey of boat-based recreational fishing	Periodic		■		■		Biennial phone-diary survey
Onsite survey of shore-based recreational fishing in the Perth Metropolitan area	Underway	■	■				Nearshore species, including herring, garfish and whiting
Voluntary recreational logbook	Ongoing	■	■	■	■	■	Research Angler Program (RAP). Not fully funded
2. Habitat & Ecosystem							
2.1 Bycatch	Not needed						Low risk
2.2 Listed Species	Not needed						Low risk
2.3 Habitat							
2.4 Ecosystem/Environment							
Fish community surveys	Occasional						Faunal surveys in estuaries by Murdoch University & others
Fish kills	Occasional						Respond to reports & investigate cause of fish kills. Opportunistic sampling, logistically difficult, limited resources available
Climate change & ocean warming	Possible						Impact of declining rainfall in estuaries; range shifts due to ocean warming
Coastal habitat condition	Possible						Cumulative impacts of coastal developments
2.5 Oceanography							
Leeuwin Current monitoring	Ongoing	■	■	■	■	■	Influence on larval dispersal & recruitment
2.6 Other impacts on fishery	Not needed						
3. Management Analysis							
3.1 Socio-economic	Not needed						
3.2 Resource Access (Shares)	Possible						
3.3 Compliance Research	Possible						
3.4 Management Systems	Possible						
4. Industry Development							Nothing identified
5 Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete	■					Pre-assessment in 2014
Other	Complete	■					Nearshore review in 2014

West Coast – Purse Seine Fishery

Description and Scope of Issues

The West Coast Purse Seine Fishery operates between latitudes 31°S and 33°S (the metropolitan fishery). There are also two purse seine development zones currently operating north and south of this area; the Northern Development Zone and the Southern Development Zone. The metropolitan fishery mainly targets both pilchards (*Sardinops sagax*) and sardinella (the tropical sardine *Sardinella lemuru*), whilst the Northern Development Zone targets sardinella and the Southern Development Zone targets pilchards. There is no recreational fishery.

Relevant Resource Assets and Risks from Fishery

West Coast Pelagic

Low Risk

Summary of historical research completed

Many aspects regarding the biology of this species, including its reproductive and distributional characteristics were determined through a major research project completed during the early-mid 1990s. This gathered data on the biology and stock assessment of pilchards in this region and other areas of WA. Directed research during the period 1999-2007 focused on fishery-independent spawning biomass surveys using egg production techniques and age structured samples, was completed as part of a six-year FRDC-funded project examining the regrowth of the pilchard stocks in WA following the two mass mortality events in the mid to late 90s (Gaughan *et al.* 2008¹). These biomass surveys and age monitoring programs have stopped.

Exploratory fishing for the *Sardinella lemuru*, offshore of Geraldton on the Mid-West coast of Western Australia, in the early 1990s led to the establishment of a developmental purse seine fishery in this region. The biology and fishery for sardinella in WA was therefore investigated over a three-year period by the Department between July 1995 and June 1998 with the aim of providing stock assessment advice. Egg production techniques of estimating biomass were unsuccessfully attempted for this species.

Pilchards and other small pelagic fish are consumed by several species of seabirds, pinnipeds, cetaceans and protected sharks (white shark), but there is currently no evidence to indicate any major interactions between these and the purse seine industry in the West Coast Bioregion.

Current Research Focus

Given the current small size of the catch of both species in this region and the low risk to the stocks, the current level of research and monitoring is restricted to an annual examination of the commercial catch and effort data supplied by the fishers. The resources previously allocated were shifted to other, higher-risk fisheries in the southern bioregions.

¹ Gaughan, D.J., Craine, M., Stephenson, P., Leary, T., Lewis P. (2008). Regrowth of pilchard (*Sardinops sagax*) stocks off southern WA following the mass mortality event of 1989/99. Fisheries Research and Development Corporation Final Report on Project No. 2000/135. Fisheries Research Report No. 176. Department of Fisheries, Western Australia, 82 pp.

Priority Setting Process

Priorities are reviewed on an annual basis through consultation between scientists of the Finfish Branch (Research Division) and fishery managers during the annual review of FishPlan.

Review Timeline

The science was reviewed extensively in the late 1990s and early 2000s while the fishery was recovering after the mass mortality events. This fishery was last reviewed as part of the MSC pre-assessment in 2014.

Given the small amount of activity no matrix is provided.

West Coast – Abrolhos Islands and Mid-West, South West and South Coast Trawl Fisheries

Description and Scope of Issues

The Abrolhos Islands and Mid-West Trawl Managed Fishery (AIMWTMF) is based on the take of saucer scallops (*Amusium balloti*), with a small component targeting the western king prawn (*Penaeus latisulcatus*) in the Port Gregory area. The Port Gregory area has seen negligible fishing in recent years due to changes in the fishing season dates. Annual pre-season scallop surveys indicate very low recruitment since 2011. The 2012 abundance estimate was the lowest since 1997, most likely due to high water temperatures associated with the very strong La Niña climate events and strong Leeuwin Current, combined with poor recruitment in previous years. Consequently, the fishery was not opened in 2012. Predicted catches for 2013 to 2015 were also below the target range (95 to 1830 tonnes whole weight) and the fishery remains closed for 2015. It may take several years of favourable conditions for the stock to recover. Consideration is being given to intervention measures such as translocation and/or the release of hatchery-produced spat to aid in rebuilding the spawning stock. The fishery has now been closed for several years to provide maximum protection to all remaining stock. Fisheries management has responded appropriately to the environmental change in productivity.

The South West Trawl Managed Fishery (SWTMF) includes two of the state's smaller scallop fishing grounds – Fremantle and Geographe Bay. It is a multi-species fishery that targets western king prawns and saucer scallops. The South Coast Trawl Fishery (SCTF) principally targets scallops and associated by-products, although in years of low scallop catches licensees have an option to use other trawl gear to target fish species. Scallop landings for the fishery have varied dramatically over the years, depending primarily on the strength of recruitment. While the fishery has theoretical access to a large section of the coastal waters, it is effectively restricted to small areas of higher scallop abundance.

The catches in all these fisheries are taken using otter trawling.

Relevant Resource Assets and Risks from Fishery

West Coast Crustaceans Shelf	Moderate Risk
West Coast Molluscs Nearshore	Moderate Risk

Summary of historical research completed

Monitoring of the scallop stocks in these fisheries is undertaken using daily logbooks which became mandatory in 2008. Prior to this, monthly catch and effort returns were used. Research into the biological and environmental aspects of WA scallop stocks and commercial exploitation, has been carried out by the Department since the late 1960s. This research was initially aimed at determining basic biology of the species to ensure that the scallops were being harvested at ecologically sustainable levels whilst achieving the best economic returns from the available scallop resource.

A survey of the bottom types in the AIMWTMF was undertaken in 1994. A detailed study of the SWTMF fishery in Geographe Bay was completed by the Department which examined the potential impacts on bycatch species and the benthic habitat of this region and found it had minimal impacts.

Current Research Focus

In the AIMWTMF research is primarily aimed at the monitoring of the fishery through the use of daily logbooks and completing pre-season surveys to forecast the following seasons catch and to determine opening and closing dates. Due to low recruitment and apparent slow growth rate of scallops in parts of the Abrolhos Islands, additional sampling surveys were undertaken in 2009 and 2010 to collect scallop samples to monitor size composition and for analysis by the Fish Health Unit. A small tagging study was undertaken in late 2009 to provide additional growth information and 30 tagged scallops have been returned by fishers. Due to the apparent collapse of the scallop stocks in the Abrolhos Islands in late 2011, small-scale sampling of scallop abundance has been undertaken in 2013 and 2014 in addition to the annual surveys.

Preliminary square mesh net cod-end trials were undertaken in May 2010 but further trials are required although alternative mesh designs are now available (i.e. T90).

A comprehensive EPBC assessment of this fishery has determined that performance should be reported annually against measures relating to the breeding stocks of target species (saucer scallop). Some information on ongoing bycatch levels and composition will be required to meet the requirements of the EPBC assessments and has also been highlighted as part of the MSC pre-assessment process. Some limited information has been gathered in the Abrolhos Islands and the South Coast during a NHT-funded project (UWA) in 2008 but this information will need to be supplemented using the annual scallop survey.

Research will continue investigating the environmental influences that affect recruitment to scallop stocks in all of the states scallop fisheries and environmental factors (including the marine heat wave) affecting recruitment have been examined as part of an FRDC project on climate change effects on fisheries in WA.

A 12-month pilot project commenced in July 2014 to determine the feasibility of hatchery rearing of scallops (and possibly translocation of adult scallops) to supplement breeding stocks, with an initial focus within the SWTMF and potential application to the Abrolhos Islands and Shark Bay in the future. Funding applications have been made to FRDC for three

years from 2015/16 for two projects that will assist in further understanding the environmental factors influencing scallop recruitment and survival of scallops, any potential for intervention to aid in recovery of the breeding stock and to determine key habitat requirements and cost effective monitoring of those habitats. In addition, information sharing will occur as part of an environmental monitoring program that commenced in 2014 associated with the proposed Aquaculture Development Zones within the Abrolhos Islands, where one of these areas are within and adjacent to the scallop trawl grounds.

Proposed or Possible Research Initiatives

- Modelling water movements and larval transport in collaboration with UWA
- Social assessment

Priority Setting Process

Initial assessments were made through internal departmental meetings in 1998 discussing research undertaken, current research, and research and development gaps, with a plan was drafted for five years. Regular meetings (at least annually) have been held with the Research Division and the AIMWTMF licensees to discuss research priorities and planning. Additional research needs have also been highlighted through the ESD assessment processes, for which a re-assessment was completed in 2013, and through the MSC pre-assessment process in 2014.

Review Timeline

Early research and publications on the biology and spawning stock recruitment/environment relationships for scallops have been peer reviewed.

Significant independent peer review of all aspects of the fishery, including the stock assessment components have been conducted through the ESD assessments of the AIMWTMF and the SCTF (in 2005, 2008 and 2013) to meet the Commonwealth's requirements for export accreditation under the EPBC Act. In addition, the DoF has in the past three years adopted a schedule for peer review of the assessments for all fisheries. This "rolling" schedule aimed to generate major reviews of five to eight fisheries per year, employing a mix of internal and external fisheries experts (e.g. universities, CSIRO and interstate fisheries departments). The Shark Bay scallop fishery was reviewed in August 2010 (Penn, Joll and Gaughan 2010) and, at the same time, the research methodology overlaps employed in the Abrolhos Islands scallop fishery were also discussed during the Shark Bay scallop review.

These fisheries were reviewed as part of the MSC pre-assessment process for the South and West Coast Bioregion in 2014.

Key to symbols in the matrix/summary tables:

- Indicates that the activity is funded and planned to occur.
- Indicates that the activity is part of a proposal but is not yet funded.

Abrolhos Islands and Mid-West, South West and South Coast Trawl Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, natural Mortality)							
Scallop biology	Complete						Studies completed in the 1980s
1.2 Other Biology							
Recruitment dynamics	Complete						Studies completed in the 1980s
1.3 Stock Assessment							
Stock-recruitment-environment effects	Ongoing	■	■	■	■	■	
Fishery independent surveys and monitoring	Annual	■	■	■	■	■	Determines forecasts of next year's catch for AIMWTMF
Survey indices-catch relationships	Ongoing	■	■	■	■	■	AIMWTMF only
1.4 Fishery Monitoring							
Logbooks	Ongoing	■	■	■	■	■	
Pre-season skippers briefings	Ongoing	■	■	■	■	■	
Fishing power monitoring	Ongoing	■	■	■	■	■	
Processor returns	Ongoing	■	■	■	■	■	
Effort impact assessment (GIS)	Ongoing	■	■	■	■	■	EPBC requirement for AIMWTMF
2. Habitat & Ecosystem							
2.1 Bycatch							
BRD implementation	Complete						Implemented in 2003 for AIMWTMF
Bycatch monitoring	Complete			O			NHT (MF) funding for 07/08 but may require further data collection and is planned during the 2014 annual survey
Bycatch in trawled and untrawled areas	Complete						Study completed in 1990s for SWTMF - low risk
2.2 Listed Species							
Listed species interactions - daily logbooks	Ongoing	■	■	■	■	■	EPBC requirement/MOU with DoE underway for AIMWTMF, low risk in SWTMF
2.3 Habitat							
Habitat mapping and videoing – sensitive habitats	Complete						NHT (MF) funding for 07/08. Low risk in SWTMF and study completed in 1990s. Additional habitat work as part of aquaculture zone baseline studies in 2014 in the Abrolhos Islands
2.4 Ecosystem/Environment							
Formal risk assessment	Periodic					■	EPBC requirement
2.5 Oceanography							
Leeuwin Current monitoring	Ongoing	■	■	■	■	■	
Modelling water movements and larval transport	Possible						In collaboration with UWA
2.6 Other impacts on fishery	Not needed						No other risk identified
Aquaculture sites (established in 2014)	Underway	■	■				Additional habitat work as part of Aquaculture zone baseline studies in 2014 in the Abrolhos Islands.

Abrolhos Islands and Mid-West, South West and South Coast Trawl Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
3. Management Analysis							
3.1 Socio-economic							
Social assessment	Possible						
Economic analysis –average price data	Ongoing	■	■	■	■	■	
Fuel consumption./expenses	Ongoing	■	■	■	■	■	
3.2 Resource Access (Shares)							
Rock Lobster – Scallop interaction	Complete						Resolved
Marine Park Planning	Ongoing	■	■	■	■	■	For all scallop fisheries
3.3 Compliance Research							
3.4 Management Systems							
4. Industry Development							
4.1 Production Technology							
Re-seeding of spat to increase spawning stock	Underway	■	○	○	○		FRDC funding application submitted for 2015/16 funding round - pilot project commenced
Health and quality monitoring (opportunistic sampling)	Underway	■	■	■			As part of pilot project and will continue if FRDC funding application successful
4.2 Post Harvest							
4.3 Marketing							
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete	■					pre-assessment completed in 2014
Other	Periodic					■	Next EPBC review due in 2018

West Coast – Blue Swimmer Crab Fishery

Description and Scope of Issues

Blue swimmer crabs (*Portunus armatus*) are found along the entire WA coast in a wide range of inshore and continental shelf areas, from the inter-tidal zone to at least 50 metres in depth. Blue swimmer crabs are targeted using a variety of fishing gear. The commercial blue swimmer crab fisheries in the West Coast Bioregion use traps in the Cockburn Sound Crab Managed Fishery, the Warnbro Sound Crab Managed Fishery, the West Coast Estuarine Managed Fishery (Swan-Canning and Peel-Harvey Estuaries), and the Mandurah to Bunbury Developing Crab Fishery.

Crabbing is one of the most popular recreational fishing activities. In the West Coast Bioregion it is centred largely on the estuaries and coastal embayments from Geographe Bay

north to the Swan River and Cockburn Sound. While the majority of recreational fishers use either drop nets or scoop nets, diving for crabs is also popular.

Relevant Resource Assets and Risks from Fishery

West Coast Nearshore Crustaceans (Crabs)	Moderate - High Risk
West Coast Nearshore Habitats	Low Risk
West Coast Ecosystem (Marine)	Low Risk

Summary of historical research completed

Information on the biology and ecology of blue swimmer crabs in the West Coast Bioregion was generated through a number of FRDC-funded projects conducted by the Department and Murdoch University. Data for the assessment of crab stocks was traditionally obtained from commercial catch and effort data. Additional programs now include on-board catch monitoring during the commercial fishing season, and fishery-independent trawl and trap surveys conducted by the Department to provide information on the status of the spawning stock and subsequent strength of recruitment, along with data on the general crab population. A number of recreational fishing surveys were also undertaken in the late 1990s to provide estimates of recreational shore-based and boat-based catches of blue swimmer crabs in the Swan-Canning Estuary (Malseed and Sumner 2001a¹) and the Peel-Harvey Estuary (Malseed and Sumner 2001b²).

The decline in recruitment experienced within the Cockburn Sound fishery since 2003 resulted in the fishery being closed in December 2006. A comprehensive research program funded by the Minister of Fisheries through DIBF was developed for Cockburn Sound that included:

- Monitoring the recovery of the breeding stock and strength of recruitment in Cockburn Sound following the closure;
- Modifying and improving the juvenile index for the Cockburn Sound crab fishery, including developing a residual index;
- Examining the genetic difference between the Cockburn Sound stocks with those in Warnbro Sound and the Swan River (Chaplin and Sezmis 2008³); and
- Developing a commercial monitoring program for Warnbro Sound and Swan River crab fisheries.

In addition, an assessment of the potential impact on Cockburn Sound crab stocks of the Fremantle Port Authority's Outer Harbour development proposed for the southern area of Jervois Bay was completed in early 2009.

Based on concerns for the sustainability of crab stocks in the Peel-Harvey Estuary, a research program for this region was also funded through DBIF. This involved

- A comprehensive recreational survey undertaken between November 2007 and October 2008, refer to Fisheries Research Report 258.

1 Malseed, B.E., Sumner, N.R. (2001a). A 12-month survey of recreational fishing in the Swan-Canning Estuary Basin of Western Australia during 1998-99. Fisheries Research Report No. 126. Department of Fisheries, Western Australia. 44 pp.

2 Malseed, B.E., Sumner, N.R. (2001b). A 12-month survey of recreational fishing in the Peel-Harvey Estuary of Western Australia during 1998-99. Fisheries Research Report No. 127. Department of Fisheries, Western Australia. 48 pp.

3 Chaplin, J.A., Sezmis, E. (2008). A genetic assessment of the relationships among the assemblages of the blue swimmer crab, *Portunus pelagicus*, in Cockburn Sound, the Swan River Estuary and Warnbro Sound. Final Report prepared for the Department of Fisheries, Western Australia. Murdoch University, Western Australia.

- A monthly commercial monitoring program to assess the impact of commercial fishing in the Peel-Harvey Estuary, Comet Bay and Mandurah-Bunbury fisheries.
- Fishery-independent monitoring of crab stocks inside and outside the Peel-Harvey Estuary.

Fishery-independent trawl and trap surveys conducted during 2009 indicated that the strength of both recruitment and breeding stock in Cockburn Sound had improved sufficiently to allow the crab fishery to re-open to both the commercial and recreational sectors for the 2009/10 fishing season. A precautionary management approach was adopted between 2009/10-2013/14, including a 20% reduction in commercial pot numbers, changes to commercial size limits and a reduction in the length of the commercial and recreational fishing season.

Current Research Focus

Although the three-year DBIF project in Cockburn Sound has now been completed, the comprehensive program developed to monitor the recovery of the Cockburn Sound crab stock has been maintained to assess the impacts of the fishery's re-opening, and provide timely data to managers to prevent a repeat of the stock decline experienced in the mid-2000s. Despite conservative management, a low proportion of berried females in the 2012/13 spawning season resulted in a recruitment failure in the Cockburn Sound fishery in 2013. In response, an adaptive management approach was adopted for the 2013/14 fishing season. Commercial monitoring during the 2013/14 season revealed that stock levels remained very low and commercial catch rates fell to 0.5 kg/trap lift, prompting an early commercial season closure in April. Fishery-independent monitoring during 2014 indicated very low recruitment (equivalent to levels prior to the closure in 2006) and a very low breeding stock index, which resulted in a recommendation to close the Cockburn Sound fishery for the 2014/15 season.

Current research is now focused on refining the breeding stock index and investigating environmental factors that may be affecting the crab stock in Cockburn Sound, as the latest fishery collapse does not appear to be related to fishing pressure. Preliminary histological examination and disease screening has revealed that crabs were in poor nutritional condition. An Expression of Interest for funding from FRDC has been submitted, which will focus on determining the underlying reasons for the second collapse, including an investigation of nutritional condition and the development of a biomass dynamic model for assessing the state of the stock.

The commercial monitoring and fishery-independent trap programs developed to assess and monitor the South-West commercial crab fisheries are continuing to inform management decisions in these fisheries.

All commercial crab fisheries in the West Coast Bioregion underwent MSC pre-assessment in 2014, with the exception of the Peel-Harvey Estuary which is undergoing MSC full assessment in early 2015. This will be the first recreational fishery to undergo the MSC full assessment process. The work has involved the development of harvest strategies and control rules for these fisheries.

Proposed or Possible Research Initiatives

- Survey of shore-based recreational fishing in the Peel-Harvey Estuary

Priority Setting Process

Research priorities are set in consultation with management, and feedback obtained during meetings with industry and major stakeholder groups (WAFIC, Recfishwest) as required.

Review Timeline

Two external reviews were undertaken on the Cockburn Sound and Peel-Harvey Estuary crab fisheries as part of the DBIF projects and two reports have been published in 2011 (Cockburn Sound) and 2014 (Peel-Harvey Estuary).

The crab fisheries in the Swan-Canning Estuary, Cockburn Sound, Warnbro Sound and between Mandurah and Bunbury were recently reviewed as part of the MSC pre-assessment process for the West Coast Bioregion in 2014. The crab fishery in the Peel-Harvey Estuary is now moving to full assessment in early 2015.

The Mandurah to Bunbury Developing Crab Fishery is currently being reviewed as part of its transition into interim managed status.

Recent Publications

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

Johnston, D., Harris, D., Caputi, N., de Lestang, S., Thomson, A. (2011). Status of the Cockburn Sound Crab Fishery. Fisheries Research Report No. 219. Department of Fisheries, Western Australia. 104 pp.

Johnston, D., Harris, D., Caputi, N., Thomson, A. (2011). Decline of a blue swimmer crab (*Portunus pelagicus*) fishery in Western Australia – History, contributing factors and future management strategy. *Fisheries Research* 109(1): 119-130.

de Lestang, S., Bellchambers, L.M., Caputi, N., Thomson, A.W., Pember, M.B., Johnston, D.J., Harris, D.C. (2010). Stock-Recruitment-Environment Relationship in a *Portunus pelagicus* Fishery in Western Australia. In: Kruse, G.H., Eckert, G.L., Foy, R.J., Lipcius, R.N., Sainte-Marie, B., Stram, D.L., Woodby D. (eds.), *Biology and Management of Exploited Crab Populations under Climate Change*. Alaska Sea Grant, University of Alaska Fairbanks. doi: 10.4027/bmecpcc.2010.06.

Key to symbols in the matrix/summary tables:

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○ Indicates that the activity is part of a proposal but is not yet funded.

West Coast Blue Swimmer Crab Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Blue swimmer crab biology, size at maturity and release mortality	Complete						Studies completed in 1990s
Review of blue swimmer crab reproductive biology and growth	Underway	■	■				As part of investigating second collapse of Cockburn Sound fishery
1.2 Other Biology							
Genetic structure of populations	Complete						A study of genetic differences between Cockburn Sound, Swan River and Warnbro Sound was completed in 2008
Tagging studies	Underway	■	■				Part of Recfishwest project - Cockburn Sound and Swan River
1.3 Stock Assessment							
Stock assessment (indices of breeding stock and recruitment abundance)	Ongoing	■	■	■	■	■	For Cockburn Sound and Peel-Harvey Estuary
Annual catch and effort assessment	Ongoing	■	■	■	■	■	For all commercial crab fisheries in West Coast Bioregion
1.4 Fishery Monitoring							
Catch and effort returns (CAES)	Ongoing	■	■	■	■	■	
Commercial monitoring	Ongoing	■	■	■	■	■	Monthly for all west coast commercial crab fisheries
Fishery-independent research surveys – Cockburn Sound	Ongoing	■	■	■	■	■	Trawl and trap surveys to determine recruitment and breeding stock levels
Fishery-independent research surveys – Peel-Harvey Estuary	Ongoing	■	■	■	■	■	Trap surveys to determine recruitment and breeding stock levels
State-wide survey of boat-based recreational fishing	Periodic		■		■		Biennial phone-diary survey to provide estimates of effort and catch.
Recreational fishing camera monitoring (Peel-Harvey Estuary)	Underway	■	■				Camera survey to determine the day and night patterns of shore-based activity at key locations
Shore-based recreational fishing survey in the Peel-Harvey Estuary	Proposed		○				Funding application submitted for the 2015 Recreational Fishing Initiatives Fund.
Logbook	Ongoing	■	■	■	■	■	Mandurah-Bunbury fishery
Environmental - Temperature	Ongoing	■	■	■	■	■	Temperature loggers in Cockburn Sound and Peel-Harvey Estuary
2. Habitat & Ecosystem							
2.1 Bycatch	Nil						Low Risk
2.2 Listed Species	Nil						Low Risk
2.3 Habitat	Nil						Low Risk
2.4 Ecosystem/Environment	Nil						Low Risk
2.5 Oceanography							
2.6 Other impacts on fishery							None identified

West Coast Blue Swimmer Crab Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)	Underway	■	■				IFAAC resource allocations for Peel-Harvey Estuary and Cockburn Sounds
3.3 Compliance Research	Ongoing	■	■	■	■	■	Focus on Peel-Harvey Estuary
3.4 Management Systems	Underway	■	■				Mandurah-Bunbury transition from Developing Fishery to Interim Managed Fishery
4. Industry Development							
5. Stakeholder Consultation and Reviews							
Annual Management Meetings	Ongoing	■	■	■	■	■	
MSC	Periodic	■	■				Pre-assessments in 2014. MSC full assessment of Peel-Harvey Estuary fishery in 2015
Other		■	■				Mandurah to Bunbury Developing Crab Fishery currently being reviewed as part of its transition into interim managed status.

West Coast – Abalone Managed Fishery

Description and Scope of Issues

The WA commercial abalone fishery is a dive fishery operating in shallow coastal waters along WA's western and southern coasts and is divided into eight management areas. In the west coast the commercial fishery targets mainly Roe's abalone, which are harvested by a diver working off 'hookah' using a diving 'iron' to prise abalone off rocks. The commercial Roe's abalone fishery is managed primarily through output controls in the form of total allowable commercial catches (TACCs), set annually for each area.

The recreational fishery in the west coast is a dive and wade fishery that mainly operates in the metropolitan region and targets Roe's abalone. This fishery has a very restricted set of seasonal and daily opening times.

The sophisticated suite of management arrangements in place and the proactive management used in the Abalone Fishery have resulted in the maintenance of abalone stocks and the successful continuation of a fishery on a vulnerable species in a highly populated area.

Relevant Resource Assets and Risks from Fishery

West Coast Nearshore Molluscs (Abalone)

Moderate Risk

West Coast Listed Species	Negligible Risk
West Coast Nearshore Habitats	Negligible Risk
West Coast Marine Ecosystems	Negligible Risk

Summary of historical research completed

An extensive amount of research on the biology and stock status of Roe's abalone has been undertaken to support the management of this fishery. The basic biology (growth, reproduction, maturity) and ecological studies (population densities, settlement and recruitment) for Roe's abalone have been completed by researchers from the WA Museum in the 1980s, and the Department of Fisheries in the 1990s and 2000s. Preliminary aquaculture studies on Roe's abalone have been completed by Fremantle TAFE, however most of the aquaculture research has focused on the larger greenlip and brownlip species.

The historical time series of daily catch information on the total weight of abalone collected, the hours fished, the date and location of harvest and the person(s) harvesting has been used to generate a standardized catch per unit effort (CPUE) model to be developed that accounts for variation in spatial and temporal fishing effects, as well as technological improvements that aid fishing efficiency. An FRDC-funded disease survey of entire Australian abalone stocks was completed in 2006 was also of relevance to this fishery.

State-wide phone diary surveys were undertaken in 2004/05 and 2006/07 to provide estimates of the recreational catch of Roe's abalone. For each survey, around 500 licence holders were randomly selected from the licensing database, with selection stratified by licence type (abalone or umbrella) and respondent location (country or Perth metropolitan area). The licence holders were sent a diary to record their fishing activity and were contacted every three months by telephone for the duration of the abalone season. Since 2007, recreational catch estimates for Roe's abalone have been based only on information collected during ongoing annual field surveys (see below).

Current Research Focus

Commercial: Current research is focused on stock assessment using catch and effort statistics, fishery-independent surveys of Perth metropolitan stocks, and investigation into restocking techniques using hatchery – bred animals (aquaculture) and translocation of wild stocks. Commercial abalone divers provide daily catch information which are used to assist in research, compliance and management matters. The standardized CPUE data are now being used in a decision-rule framework for quota setting in of the fishery on an annual basis.

Size and density of Roe's abalone across the near-shore sub-tidal reef habitat are measured annually at 11 indicator sites between Mindarie Keys and Penguin Island. Nine of these are fished while the other 2 are the Waterman's Reserve Marine Protected Area (MPA), and the Cottesloe Fish Habitat Protection Zone. The ability of this survey data to provide a predictive index for future stock abundance is a current topic of research.

The Department has also obtained an externally funded project from the Seafood CRC ("2012/236 Recovering a collapsed abalone stock through translocation") to investigate the viability of assisted restoration of depleted abalone populations. This project involves investigation into restocking and aquaculture techniques, and includes a genetic component.

Recreational: An annual field survey provides estimates of the catch and effort from each stock of Roe's abalone stock within the Perth fishery. This method provides a comprehensive

assessment for this region but is too resource-intensive to be applied outside of the Perth metropolitan area. A catch prediction model based on environmental conditions and number of abalone licenses is currently being developed to assist in the management of the new 40 tonne TARC (Total Allowable Recreational Catch).

Priority Setting Process

Annual meetings are held between the Department and the commercial abalone industry. Input on the recreational program has previously been obtained from the RFAC and the IFAAC groups.

Review Timeline

The fishery and stocks are reviewed annually, with quota decisions made each February. A mid-season research update is carried out during August - September. The research associated with this fishery was reviewed during a workshop in October 2010. External reviewers were Professor Neil Loneragan of Murdoch University and Dr Steve Mayfield of SARDI (South Australian Research and Development Institute).

Recent Publications

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

Hart, A.M., Fabris, F.P., Brown, J., Caputi, N. (2013). Biology, history, and assessment of Western Australian abalone fisheries. Fisheries Research Report No. 241. Department of Fisheries, Western Australia. 90 pp.

Key to symbols in the matrix/summary tables:

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West Coast Abalone Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Roe's biology - growth etc.	Complete						Sufficient for management
Reproduction/fecundity, spawning periodicity	Complete						Research by the Museum completed in the 1980s
Disease survey/atlas	Complete						FRDC funded survey of entire Australian abalone stocks completed in 2006
Early juvenile life history and habitat, natural mortality and predation	Ongoing	■	■	■	■	■	Natural mortality studies underway for Roe's metropolitan stocks
1.2 Other Biology							
Environmental effects on recruitment	Ongoing	■	■	■	■	■	Long-term datasets on annual recruitment and relevant environmental factors are being developed

West Coast Abalone Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1.3 Stock Assessment							
Catch statistics (wildstock)	Ongoing	■	■	■	■	■	40 years of catch and effort statistics
Mapping of areas	Periodic						FRDC funded project using GPS trackers, headed up by TAFI; Use of Google Map to evaluate Perth metro reef areas
Fishing efficiency	Ongoing	■	■	■	■	■	Environmental and technological factors continually monitored
Commercial length frequency monitoring	Ongoing	■	■	■	■	■	Catch sampling from industry used to estimate F
Population dynamics and harvest strategy assessment model	Ongoing	■	■	■	■	■	Model under development
Recreational Impact	Ongoing	■	■	■	■	■	Annual monitoring of recreational catch
Yield and egg-per-recruit analysis for size limits	Ongoing	■	■	■	■	■	Analysis in 2009 assessment
1.4 Fishery Monitoring							
Research monitoring and recruitment sites	Ongoing	■	■	■	■	■	11 sites annually surveyed, including marine protected areas.
Recreational fishery monitoring – field surveys	Ongoing	■	■	■	■	■	Perth fishery, annual counts of high density and plane surveys of low density zones
2. Habitat & Ecosystem							
2.1 Bycatch	Not Needed						No bycatch
2.2 Listed Species	Not Needed						No interactions
2.3 Habitat	Not Needed						Low risk
2.4 Ecosystem/Environment	Ongoing						Medium Risk – marine heatwave has significant deleterious effect for this species
2.5 Oceanography							Collaboration with CSIRO
2.6 Other impacts on fishery							
Restocking and aquaculture	Underway	■	■	■			External CRC funded project
Abalone Health - contingency plan and monitoring and diagnosis	Ongoing	■	■	■	■	■	
Ocean Reef Marina Development	Underway	■	■	■			Proposed development in most productive area of Roe's abalone fishery
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)	Complete						IFAAC process completed for Perth fishery,
3.3 Compliance Research							
3.4 Management Systems							
Translocation/protocol	Ongoing	■	■	■	■	■	
4. Industry Development							None identified
5. Stakeholder Consultation and Reviews							
Annual management meetings	Ongoing	■	■	■	■	■	
MSC	Complete	■					Pre-assessment in 2014.

West Coast Abalone Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Review	Periodic	■					Major assessment reports peer reviewed

West Coast – Octopus Fishery and Aquaculture

Description and Scope of Issues

The octopus fishery in WA primarily targets *Octopus cf. tetricus*, with occasional bycatch of *O. ornatus* and *O. cyanea* in the northern parts of the fishery, and *O. maorum* in the southern and deeper sectors. Fishing activities targeting octopus in WA can be divided in four main categories: bycatch from the West Coast Rock Lobster Managed Fishery (WCRLF); the Cockburn Sound (Line and Pot) Managed Fishery (CSLPPF); the Developmental Octopus Fishery (DOF); and recreational fishery. In addition to these 4 main sectors, numerous trawl and trap fisheries land small amounts of octopus as a bycatch.

During the past decade, the octopus fishery in WA has doubled, while human consumption of octopus has increased 5-fold. This trend is reflected by an increase in market price from around \$4 to over \$14 per kilogram, with similar trends observed overseas. The recent introduction of a new gear type into the developing octopus fishery has increased fishing efficiency dramatically and opened up new fishing grounds. These advancements are further increasing the rapid rise of the octopus fishery. However, there are significant knowledge gaps in the fisheries biology of *Octopus cf. tetricus*, with only small-scale biological studies having been carried out at present. To address this issue a major project funded by the FRDC has been carried out to determine the stock status and future sustainable harvest of the fishery.

Initial trials have indicated that *O. tetricus* can easily acclimate to captivity, has fast growth rates, readily accepts frozen/moist foods, is highly fecund and can demand a solid market price with value adding. These attributes have generated an interest from industry in culturing *O. tetricus*. A major obstacle to achieving this goal is to closing the life cycle of the species. FRDC funding was attained to conduct this research with promising initial results.

Relevant Resource Assets and Risks from Fishery

West Coast Nearshore Molluscs	Moderate Risk
West Coast Listed Species	Low Risk
West Coast Nearshore Habitats	Negligible Risk
West Coast Marine Ecosystems	Negligible Risk

Summary of historical research completed

While predation on lobsters by octopus has been studied, minimal stock assessment research has been carried out on the octopus fishery. A daily catch and effort logbook has been tested

and introduced into the DOF, and some sub-sections of the CSLP, and two University theses on aspects of the biology and fishery of *Octopus cf. tetricus* have been completed.

Current Research Focus

The aforementioned FRDC-funded projects granted to the Department of Fisheries are titled:

- 2010/200, “Innovative development of the *Octopus tetricus* fishery in Western Australia” and
- 2009/206 “Development of Octopus Aquaculture.”

These projects have developed robust stock assessment and aquaculture methodologies for *O. cf. tetricus* to assist the future development of octopus as a sustainable fishery and important seafood product of WA.

Priority Setting Process

Research priorities are set through meetings with the Department of Fisheries, industry and other stakeholders. In addition, each of the FRDC projects are bound by a project agreement which has set aims and a series of milestones that need to be achieved.

Review Timeline

The Fisheries Research Division reviews the fishery and stocks annually in December.

Recent Publications

Leporati, SC, Hart AM, Larsen R, Franken LE, De Graaf MD (2015). Octopus life history relative to age, in a multi-gear developmental fishery. *Fisheries Research* 165: 28-41

Leporati, S.C., Hart, A.M. (2015). Stylet weight as a proxy for age in a merobenthic octopus population. *Fisheries Research* 161: 235-243.

Franken, L.E. (2010). The Western Australian Developmental Octopus Fishery: Assessment, Development and Biology. Honours Thesis, University of Groningen. 102 pp.

Herwig, J. (2010). Life history and ecology of *Octopus cyanea* at Ningaloo Reef, Western Australia: assessing its vulnerability. Honours Thesis, University of Western Australia. 54 pp.

Key to symbols in the summary matrix:

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West Coast Octopus Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Age and Growth	Complete						FRDC 2010/200
Size-at-maturity	Complete						FRDC 2010/200

West Coast Octopus Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Mortality	Complete						FRDC 2010/200
1.2 Other Biology							
Genetics	Low Priority						Genetics work on <i>O. cf. tetricus</i> would help establish species connection with East Coast
1.3 Stock Assessment							
Sustainability of stocks	Ongoing	■	■	■	■	■	Current FRDC project will determine the present stock status and a means of predicting future sustainable catch rates
1.4 Fishery Monitoring							
Research logbook implementation	Ongoing	■	■	■	■	■	
1.5 Aquaculture							
Develop the hatchery techniques for octopus larvae and juveniles	Complete						FRDC 2009/206
Optimising octopus ranching and grow out	Complete						FRDC 2009/206
2. Habitat & Ecosystem							
2.1 Bycatch							Negligible Risk
2.2 Listed Species							Negligible Risk
2.3 Habitat							Negligible Risk
2.4 Ecosystem/Environment							Negligible risk
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)							
3.3 Compliance Research							
3.4 Management Systems							
4. Industry Development	Ongoing	■	■	■	■	■	Expansion of the DOF (developing octopus fishery) currently underway. Fishery proceeding to Interim Managed Fishery in 2015
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete	■					Pre-assessment in 2014.
Review	Periodic		O				At conclusion of current FRDC projects

Gascoyne Coast Bioregion

Gascoyne – Biodiversity Issues

Description and Scope of Issues

The attractive features of the Gascoyne, including its protected coastal waters and fish stocks, have resulted in the area being a focus of marine management, beginning in the 1960s. The state's earliest marine habitat protection areas, in the form of extensive prawn nursery trawl closures over the sand flats and seagrass beds, were introduced in the 1960s in both Shark Bay and Exmouth Gulf. This system of fisheries closures, later expanded to cover all significant coral areas, has provided long-standing protection to virtually all fragile marine habitats in the Bioregion. The subsequent development of marine parks over Ningaloo Reef and the inner gulfs of Shark Bay have added further, complementary protection to these highly valued areas. In June 2011 the World Heritage Committee inscribed the Ningaloo Coast on the World Heritage List.

Specific commercial fishing regulations implemented in the 1970s and 1980s also preclude the use of large-mesh gillnets and longlines throughout the Gascoyne, to prevent the incidental entanglement of the large populations of dugongs and turtles which inhabit the region. These controls have also provided protection for the large shark species, including whale sharks, which are a feature of this region. More recently, bycatch reduction devices (grids) installed in trawl nets have increased the protection encountered on trawl grounds.

Relevant Resource Assets and Risks from Fishing Activities

Shark Bay Gulf Benthic Habitats	Moderate Risk
Ningaloo Benthic Habitats	Low Risk
Zuytdorp Benthic Habitats	Negligible Risk
Gascoyne Protected Species - Non-fish (turtles)	Low Risk
Gascoyne Protected Species - Non-fish (mammals)	Low Risk
Gascoyne Protected Species - Fish	Low Risk
Shark Bay Gulf Ecosystem	Low Risk
Ningaloo Ecosystem	Low Risk
Zuytdorp Ecosystem	Low Risk

Summary of historical research completed

Bycatch: To date most of the research on bycatch in this Bioregion has focused on the trawl fisheries, which extract large quantities of discarded bycatch relative to target and by-product species. All trawl fisheries in this Bioregion now include Bycatch Reduction Devices (BRD) to reduce the incidental catch of turtles and other large fauna as well as secondary bycatch devices such as square mesh panels to reduce the capture of fish species. The Department of Fisheries has undertaken a number of studies on the potential impacts on bycatch species and on the benthic habitats, from prawn and scallop fisheries in Shark Bay and Exmouth Gulf. These published studies found the impact to be minimal. There was some concern during the

1990s that commercial snapper (*Chrysophrys auratus*) catches were declining in Shark Bay due to trawling bycatch of juveniles. The Department of Fisheries found no difference between *C. auratus* stocks, inside and outside trawled areas, and suggested the reason for declining adult stocks might be due to increased recreational fishing. Interaction rates with endangered, threatened and protected species (ETPS) have received attention in most fisheries with the inclusion of protected species interactions included on daily logbooks and Catch and Effort Statistics (CAES) forms.

Current Research Focus

Many of the studies in this region have been done as part of WAMSI Nodes 1, 3 & 4.

Bycatch Monitoring and Assessment - Establishing a risk analysis of interaction rates between the collective fisheries and bycatch to identify which species, species groups or fisheries require more detailed assessment (WAMSI 4.4.1). This assessment includes Endangered, threatened and Protected species (ETPS), discarded undersize target species, and all other discarded species in this Bioregion. This work was published in late 2010.

Input to Department of the Environment's north-west Marine Bioregional planning.

Priority Setting Process

WAMSI projects, of which the above bycatch project is associated, were developed by executive direction of the Department with research input.

Recent Publications

Molony, B.W., Newman, S.J., Joll, L., Lenanton, R.C.J., Wise, B. (2011). Are West Australian waters the least productive waters for finfish across two oceans? A review with a focus on finfish resources in the Kimberley region and North Coast Bioregion. *Journal of the Royal Society of Western Australia* 94: 323-332.

Evans, R., Molony, B. (2010). Ranked Risk Assessment for bycatch in multiple fisheries: a Bioregional risk assessment method. Fisheries Research Report No 212. Department of Fisheries, Western Australia. 88 pp.

Review Timeline

The bycatch project is a one-year project and it is being reviewed through the WAMSI project review process. The project was completed in 2010 and was published as a peer-reviewed Fisheries Department Research Report series. It is available to download from the Department's website.

Key to symbols in the matrix/summary tables:

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Gascoyne Biodiversity Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
General finfish communities	Complete						
2. Habitat & Ecosystem							
2.1 Bycatch	Complete						WAMSI 4.4.1 - Captured species assessments & monitoring
2.2 Listed Species	Complete						WAMSI 4.4.1 - Captured species assessments & monitoring
2.3 Habitat							
Habitat Mapping	Ongoing		■	■	■		Examining the relationship between fishery recruitment, essential benthic habitats and environmental drivers in Exmouth Gulf and Shark Bay
2.4 Ecosystem/Environment							
Biodiversity, Trophic interaction, anthropogenic influences etc.	Complete						WAMSI 4.2 & 4.3
Climate change	Ongoing						WAMSI (CSIRO, UWA, AIMS) FRDC
2.5 Oceanography							
Hydrodynamic modelling	Ongoing						WAMSI (CSIRO, UWA, AIMS):
Hydrodynamics & nutrient dynamics of shelf waters in relation to LC.	Complete						SRFME (including Southern Surveyor cruise).
2.6 Impacts on ecosystem							
3. Management Analysis							
3.1 Socio-economic							
Social assessment	Underway						NRP/WAMSI, CSIRO Cluster, Sustainable Tourism CRC, NRM. E.g. Human Usage survey. Note: some underway but more work is planned
3.2 Management Systems	Complete						WAMSI 4.1. Applying EBFM framework.
	Complete						DEH/NOO south west regional plan
4. Stakeholder Consultation and Reviews							
Annual Management Meetings	Ongoing	■	■	■	■	■	
	Complete						

Gascoyne – West Coast Deep Sea Crab Fishery

Description and Scope of Issues

The West Coast Deep Sea Crustacean Managed Fishery operates between Cape Leeuwin and the Northern Territory border and is managed by TAC of 140t for crystal crabs and 14t each for champagne and giant crabs which was introduced in 2008. The fishery targets crystal (snow) crabs, with minor catches of giant (king) crabs and champagne (spiny) crabs using baited pots operated in a longline formation in the offshore waters of the west coast.

In the late 1990s, when this fishery first commenced, it targeted champagne crabs. However, within a couple of years the fishery moved into deeper waters targeting crystal crabs. Since 2001 catches of champagne crabs have been insignificant. Landings of giant crab have always been minimal (<1 t per annum).

Relevant Resource Assets and Risks from Fishery

West Coast Crustaceans

Moderate Risk

Summary of historical research completed

The FRDC has funded research on aspects of the crystal, giant and champagne crab fisheries and final reports are available on all three projects.

Biological (growth, reproduction, movement patterns etc.) and fisheries data are available for crystal crabs in Melville-Smith *et al.* (2007¹). That study showed the main distribution on the west coast to be between North West Cape and Fremantle although the range did go much further south. Tagging has shown the species to be slow growing with best estimates suggesting legal sized male crabs to be ~13-15 years old and some large crabs in the population being ~30 years old. The species is capable of substantial movement patterns, with the majority moving <50 km, but some moving >100 km while they were at large.

Reproductive data, including size at maturity for both sexes and seasonality of spawning, is available for champagne crabs in Smith *et al.* (2004²).

Comprehensive biological information is available for giant crabs in Australian waters in Levings *et al.* (2001³) although sampling was most intense in the centre of that species' distributional range off Victoria and South Australia and less so in WA.

Current Research Focus

Research monitoring of the West Coast Deep Sea Crustacean Managed Fishery is currently undertaken utilising fishers' catch disposal records and voluntary logbook logbooks data to monitor activities. Additional on-board commercial sampling is conducted up to four times per season. Additional programs have been developed and are being implemented to better understand discard rates and bycatch. These include on-board video monitoring and industry catch monitoring of 'closed' pots, designed to retain small crabs.

1 Melville-Smith, R., Norton, S.M.G., Thomson, A.W. (2007). Biological and Fisheries Data for Managing Deep Sea Crabs in Western Australia. Final report to the FRDC on Project No. 2001/055. Fisheries Research Report No. 165. Department of Fisheries, Western Australia, 248 pp.

2 Smith, K.D., Potter, I.C., Hall, N.G. (2004). Biological and fisheries data for managing the deep-sea crabs *Hypothalassia armata* and *Chaceon bicolor* in Western Australia. FRDC Final Report for Projects 1999/154 and 2001/055. Murdoch University, Western Australia.

3 Levings, A., Mitchell, B.D., McGarvey, R., Mathews, J., Laurenson, L., Austin, C., Murphy, N., Miller, A., Rowsell, M., Jones, P. (2001). Fisheries biology of the giant crab *Pseudocarcinus gigas*. FRDC Final Report, Project 93/220 and 97/132.

Proposed or Possible Research Initiatives

- Genetic stock structure (all species)

Priority Setting Process

Research and management meetings are held annually with industry, with additional meetings as required.

Review Timeline

The fishery was recently reviewed as part of the MSC pre-assessment process. The fishery is now moving to full assessment and a full review of the fishery is expected to occur in early 2015.

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West Coast Deep Sea Crab Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Crystal crab biology	Complete						
Giant and champagne crab biology	Complete						
Re-assessment of growth and reproduction (crystal crabs)	Underway	■	■	■			New FRDC project examining the possibility of aging crystal crabs
Re-assessment of migration (crystal crabs)	Underway	■	■				Needs to be re-assessed in light of new information on possible movement patterns
Genetic stock structure (all species)	Proposed		○	○	○		Needed for addressing MSC pre-assessment condition. In discussions with UTas & LaTrobe researchers but need to explore funding options
1.2 Other Biology	Not needed						No other species caught in numbers
1.3 Stock Assessment							
Annual assessment	Ongoing	■	■	■	■	■	
1.4 Fishery Monitoring							
Commercial catch and effort	Ongoing	■	■	■	■	■	
Processor returns	Ongoing	■	■	■	■	■	
Commercial length frequency monitoring	Ongoing	■	■	■	■	■	
2. Habitat & Ecosystem							
2.1 Bycatch	Ongoing	■	■	■	■	■	Negligible risk but done as part of commercial monitoring. There is also video footage (see below)
2.2 Listed Species							

West Coast Deep Sea Crab Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Whales; dolphins; turtles	Ongoing	■	■	■	■	■	Negligible risk but done as part of reducing whale entanglements in WA pot and line fisheries
2.3 Habitat							
Benthic muds	Nil						Negligible risk
2.4 Ecosystem/Environment							
Ghost fishing; other trophic levels	Nil						Negligible risk
2.5 Oceanography							
2.6 Other impacts on fishery							Nothing identified
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)							
3.3 Compliance Research							
3.4 Management Systems							
Harvest Strategy decision rules	Ongoing	■	■	○	○	○	
4. Industry Development							
5. Stakeholder Consultation and Reviews							
Annual Management Meetings	Ongoing	■	■	■	■	■	
MSC	Periodic		■				Undergoing MSC full assessment in early 2015.
Other							

Gascoyne – Gascoyne Demersal Scalefish Fishery

Description and Scope of Issues

The Gascoyne Demersal Scalefish Fishery encompasses commercial and recreational fishing for demersal scalefish such as snapper (*Chrysophrys auratus*), goldband snapper (*Pristipomoides multidentis*), spangled emperor (*Lethrinus nebulosus*) and red emperor (*Lutjanus sebae*) in the continental shelf waters of the Gascoyne Coast Bioregion. This includes the activities of the Gascoyne Demersal Scalefish Fishery (GDSF) and recreational fishing from both licensed charter and private vessels.

Snapper in oceanic waters off Shark Bay ('oceanic' stock) and those in waters off Kalbarri are currently treated as separate populations; the latter are managed under arrangements within the West Coast Demersal Scalefish Fishery. An Integrated Fisheries Management (IFM) process for the Gascoyne has recently (late 2014) commenced.

Relevant Resource Assets and Risks from Fishery

Gascoyne Demersal Scalefish

Moderate - High Risk

Gascoyne Listed Species	Low Risk
Gascoyne Shelf Habitats	Negligible Risk
Gascoyne Ecosystems	Low Risk

Summary of historical research completed

Detailed research on snapper in oceanic waters off Shark Bay and the associated GDSF (formerly the Shark Bay Snapper Managed Fishery) was undertaken through the 1980s and early 1990s (see Marriott *et al.* 2011). An integrated stock assessment model for snapper was initially developed as part of an FRDC-funded project in 2002 and has been routinely updated since. Preliminary biological information on spangled emperor and other key emperor species in northwest WA was obtained via an FRDC-funded project in the early 1990s. Further biological research on spangled emperor and goldband snapper was undertaken 2007-2009 (see Marriott *et al.* 2011). The first major survey of recreational fishing throughout the entire Gascoyne Coast Bioregion was undertaken in 1998/99 and was repeated (boat-based fishing only) in 2007/08. Statewide surveys of boat-based recreational fishing were undertaken in 2011/12 and 2013/14.

Current Research Focus

The current focus is monitoring the ongoing recovery of the snapper (oceanic) spawning stock. Commercial snapper catches are sampled on a monthly basis to provide representative catch-at-age data that are incorporated into stock assessment updates (L5) every 3 years. An updated stock assessment (L3) for goldband snapper is due to be completed in 2015 (samples collected previously). Base level monitoring of spangled emperor only is on-going; level of fishing in 2007/08 was determined to be unacceptable (Marriott *et al.* 2011). Limited biological research into red emperor is ongoing.

Proposed or Possible Research Initiatives

- Age-based assessments for spangled emperor
- Age-based assessments for red emperor
- Spangled emperor, age structure of catch
- Spangled emperor, low-cost proxies for age monitoring
- Red emperor, age structure of catch

Priority Setting Process

Priorities are reviewed on an annual basis via internal consultation between scientists of the Finfish Branch (Research Division) and fishery managers as part of regular review of FishPlan. Priority settings are also discussed with Stakeholders.

Review Timeline

The stock assessment of snapper was externally reviewed in July 2006.

Stock assessment for oceanic snapper (L5) was updated in 2014, with goldband snapper (L3) scheduled to be updated in 2015. The EPBC-WTO Exemption for this fishery is due to be reviewed by September 2015.

An MSC pre-assessment of this fishery was undertaken in 2013.

Recent Publications

Marriott, R., Jackson, G., Lenanton, R., Telfer, C., Lai, E., Stephenson, P., Bruce, C., Adams, D., Norriss, J. (2012). Biology and stock status of demersal indicator species in the Gascoyne Coast Bioregion. Fisheries Research Report No. 228, Department of Fisheries, Western Australia. 210 pp.

Marriott, R.J., Adams, D.J., Jarvis, N.D.C., Moran, M.J., Newman, S.J., Craine, M. (2011). Age-based demographic assessment of fished stocks of spangled emperor, *Lethrinus nebulosus* in the Gascoyne Bioregion of Western Australia. *Fisheries Management and Ecology* 18: 89-103.

Key to symbols in the summary matrix:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

Gascoyne Demersal Scalefish Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Identification of indicator species	Complete						See RAF ¹
Snapper (oceanic stock) biology	Complete						Adequate for management
Goldband snapper biology	Complete						Adequate for management
Spangled emperor biology	Complete						Adequate for management
Red emperor biology	Underway	■	■				Limited biological sampling occurring
1.2 Other Biology							
1.3 Stock Assessment							
Age-structured modelling for snapper	Periodic			■			Need to monitor stock recovery to 40% target level (next L5 assessment in 2017)
Age-based assessments for goldband snapper	Periodic	■					Update L3 assessment in 2015
Age-based assessments for spangled emperor	Proposed						
Age-based assessments for red emperor	Proposed						
1.4 Fishery Monitoring							
Snapper, age structure of catch	Periodic	■		■			Need to monitor stock recovery to 40% target level (next L5 assessment in 2017)
Spangled emperor, age structure of catch	Proposed	○	○				Indicator species, will need additional resources to continue
Spangled emperor, low-cost proxies for age monitoring	Proposed	○	○				Continuation based on evaluation of methods and funding available
Red emperor, age structure of catch	Proposed	○	○				
CAES catch and effort data	Ongoing	■	■	■	■	■	Daily logbooks since February 2008
Charter boat catch and effort	Ongoing	■	■	■	■	■	Tour Operator Return Book

¹ DoF. (2011). Resource Assessment Framework (RAF) for finfish resources in Western Australia. Fisheries Occasional Publication No. 85. Department of Fisheries, Western Australia. 28 pp.

Gascoyne Demersal Scalefish Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
State-wide survey of boat-based recreational fishing	Periodic		■		■		Biennial phone-diary survey
2. Habitat & Ecosystem							
2.1 Bycatch	Not needed						Negligible risk
2.2 Listed Species	Not needed						Negligible risk
2.3 Habitat	Not needed						Negligible risk
2.4 Ecosystem/Environment	Not needed						Low risk
2.5 Oceanography	Not needed						Low risk
2.6 Other impacts on fishery	Not needed						Low risk
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)	Underway	■	■				IFM process commenced in 2014
3.3 Compliance Research							
3.4 Management Systems	Underway	■	■				Capacity setting and allocation of snapper catch other than <i>C. auratus</i> in 2014/15. Harvest strategy being developed
4. Industry Development							
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete						Pre-assessment in 2013
Other	Periodic	■	■				Stock assessment for oceanic snapper (L5) was updated in 2014, with goldband snapper (L3) scheduled to be updated in 2015. The EPBC-WTO Exemption for this fishery is due to be reviewed by September 2015.

Gascoyne – Blue Swimmer Crab Fishery

Description and Scope of Issues

The blue swimmer crab (*Portunus armatus*) is found along the entire WA coast in a wide range of inshore and continental shelf areas, from the inter-tidal zone to at least 50 m in depth. Fishing for this species in the Gascoyne Coast Bioregion is centred in the embayment of Shark Bay, but it is also retained as a byproduct of the Exmouth Gulf Prawn Managed Fishery. Shark Bay crabs are harvested commercially by the Shark Bay crab trap (5 trap permits) and Shark Bay prawn (18 licences) and scallop (10 licences) trawl fisheries and also supports a small (~1 t) but important recreational fishery. Prior to 2012, this was Australia's highest producing blue swimmer crab fishery. However, between July and December 2011,

commercial catch rates declined rapidly due to significantly low stock abundance across the region that appeared to be caused by environmental conditions generated by an unprecedented marine heatwave, combined with multiple flooding events during the summer of 2010/11. Commercial fishing for blue swimmer crabs in Shark Bay ceased in April 2012 on a voluntary industry-agreed basis to facilitate stock rebuilding. Since the closure, intensive monitoring of the resource and its recovery has been undertaken using a combination of trawl and trap based surveys. A Ministerial decision on allocating catch shares within the commercial sectors was made in June 2013 (trap – 66%, prawn trawl 33.8%, scallop trawl sector 0.2%). Approval was also given by the then Minister to develop a managed fishery management plan that would incorporate an Individual Transferable Quota system of entitlement to apply across all three commercial sectors in Shark Bay. Partial recovery of the stock led to limited opening of the fishery to allow for a 2013/14 commercial season with a TACC of 400 tonnes.

Relevant Resource Assets and Risks from Fishery

Gascoyne Nearshore Crustaceans (Crabs)	Moderate Risk
Gascoyne Listed Species	Low Risk
Shark Bay Gulf Habitats	Moderate Risk
Shark Bay Gulf Ecosystems	Low Risk
Exmouth Gulf Habitats	High Risk
Exmouth Gulf Ecosystems	Low Risk

Summary of historical research completed

Prior to 2012, data for the assessment of blue swimmer crab stocks in the Gascoyne Coast Bioregion was obtained from fishers' compulsory catch and effort returns and voluntary daily logbooks. Department of Fisheries' research staff also conducted quarterly catch monitoring surveys aboard commercial crab trap vessels in Shark Bay.

Some base-line information on the biology and ecology of blue swimmer crabs has been generated by a number of FRDC-funded projects conducted by the Department of Fisheries and Murdoch University over the past decade. A FRDC project completed in early 2005 produced a preliminary stock assessment of the Shark Bay blue swimmer crab fishery.

A review of the available blue swimmer crab research data for Shark Bay conducted in 2010/11 suggested possible signs of the blue swimmer crab breeding stock size and abundance in decline. However, before an accurate assessment of sustainable catch levels could be determined for the Shark Bay stock, an extreme marine heatwave event during the summer of 2010/11 resulted in significant decline in the stock by the end of 2011 and subsequent voluntary closure of the commercial fishery in April 2012.

Current Research Focus

A FRDC project (2012/015), which commenced in July 2012, has been assessing the stock recovery, and addressing general biological information relating to life-cycle and history traits of blue swimmer crabs in Shark Bay. Another objective of this project is determining the socio-economic significance of the crab resource to both the trap and trawl sectors in Shark Bay including the economic impact from the fishery closure.

Resumption of commercial fishing in 2013 and 2014 did not appear to adversely impact on stock recovery. Stock indices of spawning, recruitment and legal biomass continue to show improvements from data obtained from fishery independent and dependent survey programs that have been established. Fishing activities and fishing behaviour is changing both due to the changed stock abundance within Shark Bay but also due to the transition to a quota based management system.

Priority Setting Process

Research priorities are set in consultation with management, and feedback obtained during meetings with industry groups and major stakeholders (WAFIC, Recfishwest) as required.

Review Timeline

Assessment for the Shark Bay Crab (Interim) Managed Fishery is now undertaken on an annual basis in conjunction with the TACC setting process and also to monitor its recovery.

The crab fishery in Shark Bay was reviewed as part of the MSC pre-assessment process for the Gascoyne Coast Bioregion in 2013.

Recent Publications

Harris, D., Johnston, D., Sporer, E., Kangas, M., Felipe, N., Caputi, N. (2012). Status of the Blue Swimmer Crab Fishery in Shark Bay, Western Australia. Fisheries Research Report No. 233. Department of Fisheries, Western Australia. 84 pp.

Key to symbols in the matrix/summary tables:

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○ Indicates that the activity is part of a proposal but is not yet funded.

Gascoyne Blue Swimmer Crab Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Blue swimmer crab biology	Underway	■	■				Size at maturity and fecundity estimates completed. Life cycle model being developed
1.2 Other Biology							
Genetic structure of populations	Complete						
1.3 Stock Assessment							
Stock assessment (indices of breeding stock and recruitment abundance)	Ongoing	■	■	■	■	■	For Shark Bay detailed stock assessment will be undertaken annually to monitor recovery of stock and as part of the TACC setting process
Annual catch and effort assessment	Ongoing	■	■	■	■	■	
1.4 Fishery Monitoring							
Commercial catch and effort returns (CAES)	Ongoing	■	■	■	■	■	

Gascoyne Blue Swimmer Crab Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Processor returns	Ongoing	■	■	■	■	■	For Shark Bay only
Commercial monitoring	Periodic	■					Under review for Shark Bay
State-wide survey of boat-based recreational fishing	Periodic		■		■		Biennial phone-diary survey
Fishery-independent research surveys	Ongoing	■	■	■	■	■	For Shark Bay, a fishery independent trawl survey program has been established since 2012
2. Habitat & Ecosystem							
2.1 Bycatch	Complete	■					Documented as part of MSC pre-assessment
2.2 Listed Species							Negligible Risk
2.3 Habitat							Negligible Risk
2.4 Ecosystem/Environment							Low Risk
Heavy metal content of crabs	Complete						
2.5 Oceanography							
2.6 Other impacts on fishery	Complete						Marine heatwave impact on crab stocks assessed as part of two FRDC projects
3. Management Analysis							
3.1 Socio-economic	Underway	■					FRDC project - assess the socio-economic impacts of the exploitation of the Shark Bay crab stock
3.2 Resource Access (Shares)	Complete						For Shark Bay, inter-sectorial catch allocation has been determined as 66% to trap sector, 33.8% to prawn trawl sector and 0.2% to scallop trawl sector.
3.3 Compliance Research							
3.4 Management Systems							
4. Industry Development							A significant amount of work is undertaken in this area by industry in this region
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete						Pre-assessment in 2013
Other	Ongoing	■	■	■	■	■	Assessment for the Shark Bay Crab (Interim) Managed Fishery is now undertaken on an annual basis in conjunction with the TACC setting process and also to monitor its recovery.

Gascoyne – Exmouth Gulf Prawn Fishery

Description and Scope of Issues

The Exmouth Gulf Prawn Fishery (EGPF) is the second largest prawn fishery in WA and is located in the relatively sheltered waters in Exmouth Gulf. This otter trawl fishery targets western king prawns, brown tiger prawns, endeavour prawns and banana prawns when available.

Management of this fishery is based on input controls, which include limited entry, seasonal, and area openings and closures, moon closures, ban on daylight fishing and gear controls (including maximum headrope allocation). These management arrangements are designed to keep fishing effort at levels that will maintain sufficient spawning biomass of prawns (particularly brown tiger prawns).

The yearly cycle of operation for the fishery is dynamic and multi-faceted. Opening and closing dates vary each year, depending on environmental conditions, moon phase and the results of fishery-independent surveys, which estimate brown tiger and western king prawn recruitment and brown tiger prawn spawning stock. Annual catch predictions for both species assist with season fishing arrangements.

Relevant Resource Assets and Risks from Fishery

Gascoyne Nearshore Crustaceans (Prawns)	Moderate Risk
Gascoyne Listed Species	Low Risk
Exmouth Gulf Habitats	Low Risk
Exmouth Gulf Ecosystems	Negligible Risk

Summary of historical research completed

Research and monitoring of the fishery has been conducted for about 45 years. Since the commencement of the fishery in 1963, catch and effort statistics (both target and non-target (byproduct) species) has been collected for the EGPF including daily logbook information which provides a valuable long-term data that spans varying effort levels and environmental variations.

Fishery-independent surveys have been undertaken each year since the 1980s to determine the brown tiger prawn spawning stock and recruitment levels and surveys specifically to measure western king prawn recruitment levels commenced in 2004. The recruitment indices for both species are used to provide a catch prediction for the season. Some inshore sampling in the nurseries for brown tiger prawns was conducted in 1998 and a FRDC (1999/222) project sampled for presence and abundance of seagrass and algal communities on both the eastern and western parts of Exmouth Gulf during 1999-2001 as part of a tiger prawn stock enhancement project. The Department continued sampling selected inshore sites for seagrass/algal abundance in 2003, 2005 and 2006 (Loneragan *et al.* 2013).

The Department has completed direct comparisons of boats between twin and quad gear to ensure catch efficiencies are incorporated into tiger prawn catch rate thresholds.

A FRDC funded program on the implementation of bycatch reduction devices was completed in 2002 (Kangas and Thomson 2004¹) with full implementation of grids during that year and

¹ Kangas, M., Thomson, A. (2004). Implementation and assessment of bycatch reduction devices in the Shark Bay and Exmouth Gulf trawl fisheries. Final FRDC Report on Project No.

of secondary devices by 2004. Another project funded by FRDC (2000/132), focussed on inshore fish assemblages of the Pilbara and Kimberley coasts, also quantified inshore and trawl caught fish species in Exmouth Gulf. The FRDC-funded biodiversity project (2002/038) compared faunal assemblages in trawled and untrawled areas within the EGPF and was completed in 2007 (Kangas *et al.* 2007¹, Kangas and Morrison 2013).

Current Research Focus

Research activities continue to focus on stock assessment and surveys to monitor annual recruitment of brown tiger prawns and the residual spawning stock levels, and a pre-season survey of king prawns to assist with harvesting strategies. Monitoring of fleet fishing activity and daily catch rates is undertaken to determine the timing of the closure of the brown tiger prawn spawning area. All boats complete daily shot by shot logbooks, which, together with survey data and catch unload records, provide the information sources for managing the fishery. In addition within season advice is provided on harvesting strategies and optimising value of catch whilst ensuring sustainability.

The joint evaluation and implementation of gear modifications (including square mesh cod-end trials) to reduce bycatch and improve product quality is ongoing. Sampling of bycatch composition and abundance has been undertaken during 2008 and 2009 during some square mesh cod-end trials to supplement the information gained through the biodiversity study conducted in 2004.

Monitoring of seagrass/algal abundance in nursery sites is required to understand the decline in brown tiger prawn abundance in recent years due to an apparent correlation between seagrass abundance and recruitment for tiger prawns (Loneragan *et al.* 2013). A FRDC funding application has been submitted for the 2015 funding round to evaluate cost effective sampling techniques of nursery habitats in Exmouth Gulf (and Shark Bay).

A comprehensive ESD assessment of this fishery has determined that performance should be reported annually against measures relating to the breeding stocks of target prawn species, bycatch species impacts, listed species interactions, habitat effects and provisioning effects.

Environmental factors (including the marine heatwave) affecting recruitment have been examined as part of an FRDC project on climate change effects on fisheries in WA.

Proposed or Possible Research Initiatives

- Endeavour prawn biology
- Closure of sensitive habitats on trawl grounds
- Temperature loggers
- Tidal movements
- Social assessment
- Extension of Co-Management

2000/189. Department of Fisheries, Western Australia. 70 pp.

¹ Kangas, M.I., Morrison, S., Unsworth, P., Lai, E., Wright I., Thomson A. (2007). Development of biodiversity and habitat monitoring systems for key trawl fisheries in Western Australia. Final FRDC Report on Project No. 2002/038. Fisheries Research Report No 160. Department of Fisheries, Western Australia. 333 pp.

Priority Setting Process

Initial assessments were made through internal departmental meetings in 1998 discussing research undertaken, current research and research and development gaps and a plan was drafted for five years. A formal risk assessment including reviewing research priorities was undertaken in late 2002 for the EGPF. Annual meetings are still held with industry to discuss research priorities and planning. Additional research needs have also been highlighted through the ESD assessment process for which a re-assessment was completed in 2012.

Review Timeline

Early research and publications on the biology and spawning stock recruitment/environment relationships have been peer reviewed.

Significant independent peer review of all aspects of the fishery, including the stock assessment components have been conducted through the ESD assessments of the fishery to meet the Commonwealth's requirements for export accreditation under the EPBC Act. This has occurred on three occasions (2002, 2007 and 2012).

In addition, the DoF has in the past three years adopted a schedule for peer review of the assessments for all fisheries. This "rolling" schedule aimed to generate major reviews of five to eight fisheries per year, employing a mix of internal and external fisheries experts (e.g. universities, CSIRO and inter-state fisheries departments). The Exmouth Gulf and Shark Bay prawn fisheries were both reviewed by Dr Malcolm Haddon, CSIRO, in October 2012.

The fishery underwent MSC pre-assessment in 2013 and is undergoing full assessment in 2014/15.

Recent Publications

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

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

Loneragan N.R., Kangas M., Haywood M.D.E., Kenyon R.A, Caputi N., Sporer E. (2013). Impact of cyclones and aquatic macrophytes on recruitment and landings of tiger prawns *Penaeus esculentus* in Exmouth Gulf, Western Australia. *Estuarine, Coastal and Shelf Science* 127: 46-58.

Key to symbols in the matrix/summary tables:

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○ Indicates that the activity is part of a proposal but is not yet funded.

Exmouth Gulf Prawn Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet and Natural Mortality)							
Brown tiger prawn biology	Complete						Completed in 1970-1990s
Western king prawn biology	Complete						Completed in 1970s
Endeavour prawn biology	Proposed		O	O			Low risk - possibly part of future PhD
Banana prawn biology							Low risk - only caught infrequently
1.2 Other Biology							
Recruitment dynamics of western king prawns	Ongoing	■	■	■	■	■	
1.3 Stock Assessment							
Stock-recruit-environment effects	Ongoing	■	■	■	■	■	Reports published 1980s and 1990s
Modelling	Ongoing	■	■	■	■	■	Possibly part of future PhD
Yield/recruit, \$/recruit	Ongoing	■	■	■	■	■	
Catch/effort relationships	Ongoing	■	■	■	■	■	
Recruitment-catch relationship	Ongoing	■	■	■	■	■	
1.4 Fishery Monitoring							
Logbooks	Ongoing	■	■	■	■	■	
Pre-season skippers briefings	Ongoing	■	■	■	■	■	
Processor returns - target and non-target (byproduct) spp.	Ongoing	■	■	■	■	■	
Database maintenance	Ongoing	■	■	■	■	■	
Recruit and spawning stock indices	Ongoing	■	■	■	■	■	
Effort impact assessment (GIS)	Ongoing	■	■	■	■	■	EPBC requirement
Juvenile habitat monitoring	Periodic		■	■	■		FRDC funding application
Fishing power monitoring	Ongoing	■	■	■	■	■	
2. Habitat & Ecosystem							
2.1 Bycatch							
BRD implementation (grids)	Complete						Completed in 2002
BRD implementation (secondary devices)	Complete						Completed in 2004 with observer work. Ongoing and additional trials on an opportunistic basis
Bycatch monitoring	Periodic		■	■			Review every 5 years. Need to establish a sampling program at an appropriate level.
Square mesh cod-ends or T90	Underway		O	O			Industry initiative – requires observers to document effectiveness
2.2 Listed Species							
Listed species interactions - logbooks	Ongoing	■	■	■	■	■	EPBC requirement/MOU with DoE underway
2.3 Habitat							
Habitat/effort monitoring	Ongoing	■	■	■	■	■	EPBC requirement (area of trawling only)
Closure of sensitive habitats on trawl grounds	Proposed						Industry consultation required

Exmouth Gulf Prawn Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
2.4 Ecosystem/Environment							
Biodiversity of trawled and untrawled areas	Periodic			■			Review every 5-10 years
Formal risk assessment	Periodic				■		EPBC requirement
US TED Accreditation	Periodic	■					Industry initiative
2.5 Oceanography							
Temperature loggers	Proposed		O				To be reviewed
Tidal movements	Proposed						Information available from other sources
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic							
Social assessment	Possible						Social assessment
Economic Analysis – average price data	Ongoing	■	■	■	■	■	Economic Analysis – average price data
Fuel consumption/expenses	Ongoing	■	■	■	■	■	Fuel consumption/expenses
Extension of Co-Management	Complete						FRDC report completed 2009 (P. Rogers, Murdoch University)
3.2 Resource Access (Shares)							
Retained non-target species (Byproduct)	Underway	■	■	■	■	■	Trialling size limits for crabs and bugs
3.3 Compliance Research							
3.4 Management Systems							
4. Industry Development							
4.1 Production Technology							
Onboard handling	Complete						Freezer boats since 2012
4.2 Post Harvest							
4.3 Marketing							
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC		■					Undergoing MSC full assessment in 2014/15.
Other	Periodic				■		Next EPBC re-assessment in 2017/18

Gascoyne – Inner Shark Bay Scalefish Fishery

Description and Scope of Issues

This fishery incorporates commercial and recreational fishing for scalefish species in inner Shark Bay. The Shark Bay Beach Seine and Mesh Net Managed Fishery (SBBSMNF) uses a combination of seine net gears to mainly take four species/groups: whiting (*Sillago* spp.), sea mullet (*Mugil cephalus*), tailor (*Pomatomus saltatrix*) and western yellowfin bream (*Acanthopagrus latus*). Most recreational fishing is boat-based with vessels launching from boat ramps at Denham, Monkey Mia or Nanga. The main recreational targets are Shark Bay demersal finfish species, including snapper (*Chrysophrys auratus*) and grass (bluelined) emperor (*Lethrinus laticaudis*), as well as Gascoyne nearshore finfish species such as whiting, tailor, western butterflyfish (*Pentapodus vitta*), school mackerel (*Scomberomorus queenslandicus*) and blackspot tuskfish (*Choerodon schoenleinii*). A limited number of licensed charter vessels operate out of Denham and Monkey Mia.

Relevant Resource Assets and Risks from Fishery

Shark Bay Gulf Demersal Finfish	Moderate Risk
Gascoyne Nearshore Finfish	Moderate Risk
Gascoyne Listed Species	Negligible Risk
Shark Bay Habitats	Negligible Risk
Shark Bay Gulf Ecosystems	Low Risk

Summary of historical research completed

Comprehensive research has been carried out on the SBBSMNF target species since the 1960s. Performance indicators for these species were determined as part of an ERA process completed in 2003. Comprehensive research on snapper in the inner gulfs was undertaken between 1996/97 and 2005 with integrated stock assessment models used to assess the status of the Eastern Gulf, Denham Sound and Freycinet Estuary stocks separately and determine appropriate levels of TAC since 2003.

The first major survey of recreational fishing across the Gascoyne Coast Bioregion, including the inner gulfs, was undertaken in 1998/99 and was repeated in 2007/08; recreational surveys focused on the inner gulfs only were carried out at the main boat ramps each year 2000-2010.

Current Research Focus

The current focus is monitoring the status of the three separate inner gulf snapper spawning stocks and the four main target species taken by the SBBSMNF.

Integrated stock assessment models are used to assess the status of the three snapper stocks and are updated every 3 years (most recently in 2014).

Assessment of the four target species taken by the SBBSMNF is based primarily on analysis of the commercial and charter vessel catch and effort data obtained from monthly statutory returns.

Statewide surveys of boat-based recreational fishing in the Gascoyne Coast Bioregion were carried out in 2011/12 and 2013/14.

Priority Setting Process

Priorities are reviewed on an annual basis via internal consultation between scientists of the Finfish Branch (Research Division) and fishery managers as part of regular review of FishPlan. Priority settings are also discussed with stakeholders.

Review Timeline

An MSC pre-assessment of the SBBSMNF was undertaken in 2013. Stock status and management arrangements for snapper in the inner gulfs will be reviewed in late 2014. An IFM process is now underway for demersal scalefish in the Gascoyne Coast Bioregion.

Recent Publications

Jackson G., Moran M. (2012). Recovery of inner Shark Bay snapper (*Chrysophrys auratus*) stocks: relevant research and adaptive recreational fisheries management in a World Heritage Property. *Marine and Freshwater Research* 63: 1180-1191.

Jackson, G., Cheng, Y.W., Wakefield C.B. (2012). An evaluation of the daily egg production method to estimate spawning biomass of snapper (*Chrysophrys auratus*) stocks in inner Shark Bay, Western Australia, following more than a decade of surveys 1997-2007. *Fisheries Research* 117-118: 22-34.

Wise, B., Telfer, C.F., Lai, K.M., Hall, N., Jackson, G. (2012). Long-term monitoring of boat-based recreational fishing in Shark Bay, Western Australia; providing advice for sustainable fisheries management in a World Heritage Area. *Marine and Freshwater Research* 63: 1129-1142.

Jackson, G., Norriss, J.V., Mackie, M.C., Hall N.G. (2010). Spatial variation in life history characteristics of snapper (*Chrysophrys auratus*) within Shark Bay, Western Australia. *New Zealand Journal of Marine and Freshwater Research* 44: 1-15.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

Inner Shark Bay Scalefish Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Whiting biology	Complete						Adequate for management
Sea mullet biology	Complete						Adequate for management
Tailor biology	Complete						Adequate for management
Western yellowfin bream biology	Complete						Adequate for management
Snapper biology	Complete						Adequate for management
1.2 Other Biology							Nil required
Sea mullet	Proposed		○	○	○		Examine stock structure, age structure & current biological parameters (growth rate, etc.) in WA

Inner Shark Bay Scalefish Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Tailor	Proposed		O	O	O		Examine stock structure in WA
1.3 Stock Assessment							
CAES catch and effort data	Ongoing	■	■	■	■	■	SBBSMNF
Egg production estimates of snapper in each gulf stock	Periodic			■	■		Stocks completed on 3-5 year rotation
Model-based assessment for snapper	Planned					■	Next review due 2018
1.4 Fishery Monitoring							
CAES data	Ongoing	■	■	■	■	■	
State-wide survey of boat-based recreational fishing	Periodic		■		■		Biennial phone-diary survey
Age structure monitoring (whiting)	Underway	■	O				As part of MSC assessment process
2. Habitat & Ecosystem							
2.1 Bycatch	Not needed						Low risk
2.2 Listed Species	Not needed						Low risk
2.3 Habitat	Not needed						Low risk
2.4 Ecosystem/Environment	Not needed						Low risk
2.5 Oceanography	Not needed						Low risk
2.6 Other impacts on fishery	Not needed						Low risk
3. Management Analysis							
3.1 Socio-economic	Not needed						Not a priority
3.2 Resource Access (Shares)	Not needed						Not a priority
3.3 Compliance Research	Not needed						Not a priority
3.4 Management Systems	Not needed						Not a priority
4. Industry Development							Not a priority
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete						MSC pre-assessment in 2013
Other	Periodic	■					Stock status and management arrangements for snapper in the inner gulfs will be reviewed in late 2014. An IFM process is now underway for demersal scalefish in the Gascoyne Coast Bioregion.

Gascoyne – Shark Bay Prawn Fishery

Description and Scope of Issues

The Shark Bay Prawn Fishery (SBPF) has the highest prawn production in Western Australia. The fishery targets western king prawns, brown tiger prawns and a variety of smaller prawn species including coral prawns and endeavour prawns in restricted areas of Shark Bay using otter trawls. Retention of non-target species, in particular blue swimmer crabs provide additional income which allows this fishery to remain viable in today's economic climate. Fishing during the season involves 'real time' flexible fishing arrangements based on advice from the Research Division through voluntary rolling area openings and assessments of western king and brown tiger prawn size via fishery-independent surveys. These openings and closures are designed to increase size, quality and market value of prawns while protecting the stocks from recruitment over-fishing. Permanently closed nursery areas within the fishery prevent the fishing of small prawns and provide habitat preservation, while spatio-temporal closures serve to maintain both brown tiger and western king prawn breeding stocks above the target abundance levels.

Relevant Resource Assets and Risks from Fishery

Gascoyne Nearshore Crustaceans	Moderate Risk
Gascoyne Listed Species	Low Risk
Shark Bay Gulf Habitats	Low Risk
Shark Bay Gulf Ecosystems	Negligible Risk

Summary of historical research completed

Research and monitoring of the fishery has been conducted since 1962 when the fishery commenced. Catch and effort statistics (both target and non-target (byproduct) species) and daily logbook information has been collected from fishers at the outset, providing a valuable long-term data set from which stock assessments can be made. Furthermore, this long-term data collection is valuable to the Department because it spans varying effort levels and environmental variations throughout the history of the SBPF.

Research was completed in the 1970's on the biology of the main target species and the determination of the habitat requirements of each of the species and the stock recruitment dynamics were also completed in the 1980's.

Fishery-independent data has also been collected since 1991 (with current sampling regime since 2000) to gauge the level of recruitment of both species during March and April each year and to determine the level of brown tiger (and western king) prawn spawning stock during June to August. Since 2013, additional sampling of the southern spawning grounds (south CPL) has also been undertaken in September.

Between 2002 and 2004 bycatch reduction devices (BRDs) were implemented in this fishery and the implementation process included an observer program documenting the efficiency of BRD (Kangas and Thomson 2004¹). An FRDC-funded project was finalised on the biodiversity of bycatch in trawled and untrawled areas within Shark Bay in 2007 (Kangas *et al.* 2007; Kangas and Morrison 2013).

¹ Kangas, M., Thomson, A. (2004). Implementation and assessment of bycatch reduction devices in the Shark Bay and Exmouth Gulf trawl fisheries. Final FRDC Report on Project No. 2000/189. Department of Fisheries, Western Australia. 70 pp.

The calibration of catch rates between twin and quad gear has been undertaken to measure changes in fishing efficiency (DoF, unpublished).

Fleet interaction issues have been and continue to need to be addressed including snapper bycatch issues (Moran and Kangas 2003¹) and scallop-prawn interactions (Chandrapavan *et al.* 2012; Kangas *et al.* 2012). A FRDC-funded project focusing on minimising gear conflict and resource sharing issues in the Shark Bay trawl fisheries commenced in 2008 and was completed in 2011 (Chandrapavan *et al.* 2012; Kangas *et al.* 2012). This included hydrographic modelling of scallop and prawn larval movement within Shark Bay in collaboration with UWA.

A FRDC project, in collaboration with Edith Cowan University, analysed prawn logbook data using geostatistics to provide a better understanding of stock and fleet dynamics and to assess the appropriateness of the tiger prawn spawning area was completed in mid-2008 (Mueller *et al.* 2008²).

Current Research Focus

Stock assessment and monitoring of the status of prawn stocks, particularly brown tiger prawns is the primary focus but provision of advice on optimising the value of catch has also been a key research activity. This includes fisheries dependent monitoring (logbook program and processor unload records) and fishery-independent surveys that provide recruitment and spawning stock indices and within season prawn size and abundance information for ‘real-time’ management. Also harvesting strategies provide industry the opportunity to optimise the value of catches with targeting of larger prawns whilst protecting smaller sizes. This requires ‘real-time’ management, closer industry liaison and monitoring. Additional within-season surveys are also conducted in Denham Sound to optimise size at capture as well as provide information (triggers) for opening additional areas in Denham Sound that have been closed since 2004. Environmental factors (including the marine heat wave) affecting recruitment have been examined as part of an FRDC project on climate change effects on fisheries in WA.

Proposed or Possible Research Initiatives

- Closure of sensitive habitats
- Temperature loggers
- Onboard handling

Priority Setting Process

Initial assessments were made through internal departmental meetings in 1998 discussing research undertaken, current research and research and development gaps and a plan was drafted for five years. Research programs and gaps were discussed in a 2006 review of the Shark Bay prawn and scallop fisheries through workshops with licensees and other stakeholders. In subsequent years, research issues were discussed with SBPF licensees during their association meetings.

¹ Moran, M., Kangas M. (2003). The effects of the trawl fishery on the stock of pink snapper, *Chrysophrys auratus*, in Denham Sound, Shark Bay. Fisheries Research Bulletin No. 31. Department of Fisheries, Western Australia. 52 pp.

² Mueller, U., Kangas, M., Dickson, J., Denham, A., Caputi, N., Bloom, L., Sporer, E. (2008). Spatial and temporal distribution of western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*) and saucer scallops (*Amusium balloti*) in Shark Bay for fisheries management. Final FRDC Report on Project No. 2005/038. Edith Cowan University. 214 pp.

Review Timeline

Early research and publications on the biology and spawning stock recruitment/environment relationships have been peer reviewed.

Significant independent peer review of all aspects of the fishery, including the stock assessment components have been conducted through the ESD assessments of the fishery to meet the Commonwealth's requirements for export accreditation under the EPBC Act. This has occurred on three occasions (2002, 2007 and 2012).

In addition, the Department has in the past three years adopted a schedule for peer review of the assessments for all fisheries. This "rolling" schedule aimed to generate major reviews of five to eight fisheries per year, employing a mix of internal and external fisheries experts (e.g. universities, CSIRO and inter-state fisheries departments). The Shark Bay and Exmouth Gulf prawn fisheries were both reviewed by Dr Malcolm Haddon, CSIRO, in October 2012.

The fishery underwent MSC pre-assessment in 2013 and is undergoing full assessment in 2014/15.

Recent Publications

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

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

Chandrapavan, A, Kangas, M.I., Sporer E.C. (2012). Performance of square-mesh codends in reducing discards and by-catch in the Shark Bay scallop fishery. *Marine and Freshwater Research* 63: 1142-1151.

Kangas, M.I., Chandrapavan, A., Hetzel Y.L., Sporer E.C. (2012). Minimising gear conflict and resource sharing issues in the Shark Bay trawl fisheries and promotion of scallop recruitment. FRDC Final Report on Project No. 2007/051. Department of Fisheries, Western Australia. 122 pp.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

Shark Bay Prawn Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Brown tiger prawn biology	Complete						Completed in the 1970-1980s
Western king prawn biology	Complete						Completed in the 1970-1980s
Coral prawn biology	Minimal						Low risk

Shark Bay Prawn Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1.2 Other Biology							
Juvenile habitat monitoring	Complete						Completed in the 1970s
1.3 Stock Assessment							
Tiger prawn spawning stock assessment (catch rate analysis)	Ongoing	■	■	■	■	■	Provides key performance indicators for fishery
Stock-recruitment-environment effects	Ongoing	■	■	■	■	■	Undertaken for tiger and king prawns since the 1990s
Modelling	Ongoing	■	■	■			Some work done in late 1990s but new modelling being undertaken presently
Yield/recruit, \$/recruit	Ongoing	■	■				Bio-economic analysis underway
Spatial analysis	Complete						ECU FRDC project completed in early 2008
1.4 Fishery Monitoring							
Commercial catch monitoring	Ongoing	■	■	■	■	■	Logbooks and processor unloads
Fishery independent surveys/size composition and abundance surveys	Ongoing	■	■	■	■	■	
Logbooks	Ongoing	■	■	■	■	■	
Pre-season skippers briefing	Ongoing	■	■	■	■	■	
Effort – benthic impact assessment (GIS)	Ongoing	■	■	■	■	■	EPBC/MSC requirement
Fishing power monitoring/gear modifications	Ongoing	■	■	■	■	■	
Processor returns (target and non-target spp. (byproduct))	Ongoing	■	■	■	■	■	
Database maintenance	Ongoing	■	■	■	■	■	Needs consolidation and upgrade
2. Habitat & Ecosystem							
2.1 Bycatch							
BRD implementation (grids)	Complete						Implemented in 2002 and industry modifications ongoing
BRD implementation (secondary devices)	Complete						Implemented in 2004 with limited observer work ongoing
Bycatch monitoring	Periodic		■	■			Review every 5 years, opportunistic sampling during surveys and any observer trips. Need to establish a sampling program at an appropriate level
2.2 Listed Species							
Listed species interactions - logbooks	Ongoing	■	■	■	■	■	EPBC requirement/MOU with DoE underway
2.3 Habitat							
Habitat/effort impacts	Ongoing	■	■	■	■	■	EPBC requirement
Coral/sponge habitat mapping	Required						DPaW
Closure of sensitive habitats	Proposed						Industry consultation required
2.4 Ecosystem/Environment							
Biodiversity of trawled and untrawled areas	Periodic		■				Review every 5-10 years
Formal risk assessment	Periodic				■		EPBC requirement
2.5 Oceanography							
Leeuwin Current monitoring	Ongoing	■	■	■	■	■	
Temperature loggers	Proposed		O				To be reviewed

Shark Bay Prawn Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic							
Social assessment	Underway	■	■				Dealt with in part with socio-economic study re-SB crabs as part of FRDC 2012/015
Economic analysis – average price data	Ongoing	■	■	■	■	■	
Fuel consumption/expenses	Ongoing	■	■	■	■	■	
3.2 Resource Access (Shares)							
Prawn-scallop fleet interactions and catch share – crab and snapper interactions	Ongoing	■	■	■	■	■	Currently review of prawn scallop fishery management/research arrangements
Prawn-scallop gear interactions	Complete						FRDC 2007/08 (2 year project)
Retained non-target species	Ongoing	■	■	■	■	■	Crab catch share Issues needs to be resolved.
World Heritage Areas							
3.3 Compliance Research							
3.4 Management Systems							
4. Industry Development							
4.1 Production Technology							
Onboard handling	Proposed		○				Improved bycatch handling
Hoppers	Complete						Industry initiative – all boats now using them
4.2 Post Harvest							
4.3 Marketing							
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC		■					Undergoing MSC full assessment in 2014/15.
Other	Periodic				■		Next EPBC re-assessment in 2017/18

Gascoyne – Shark Bay Scallop Fishery

Description and Scope of Issues

The Shark Bay Scallop Fishery (SBSF) is a limited entry, otter trawl fishery that operates within the waters of Shark Bay which is located in the Gascoyne Coast Bioregion of WA. This is usually WA's most significant scallop fishery and has significant overlap with the Shark Bay prawn fishery, with 18 boats licensed to operate in both fisheries. The SBSF employs a constant escapement policy to ensure carry-over of spawning biomass to subsequent breeding seasons. Generally, catch rate target levels (400 to 450 kg meat weight per day) are used to limit fishing mortality during the key spawning period (April to June). Ceasing the take of scallops can be triggered by reaching this level, or during May, irrespective of catch rate.

Catch predictions for 2012 to 2014 (based on fishery-independent surveys in November the previous year) were extremely low for both Denham Sound and northern Shark Bay. These low yield predictions necessitated that the entire stock be protected to maximise spawning success, and the fishery remained closed for 2012 to 2014. This decline in productivity appears to be due to several years of suppressed recruitment caused by record high water temperatures associated with very strong La Niña climate events and strong Leeuwin Current. The survey in November 2014 indicated some recovery in scallop abundance in Denham Sound with a catch prediction at levels to allow precautionary fishing (after the key spawning period) in 2015. However, although a low level of recovery was observed in northern Shark Bay this main fishing area will remain closed to scallop fishing/retention for 2015.

Relevant Resource Assets and Risks from Fishery

Gascoyne Nearshore Molluscs	Moderate Risk
Gascoyne Listed Species	Low Risk
Shark Bay Gulfs Habitats	Low Risk
Shark Bay Ecosystems	Negligible Risk

Summary of historical research completed

Research carried out by the Department since the late 1960s determined the basic biology of the saucer scallop (*Amusium balloti*) to ensure that the scallops are being harvested at ecologically sustainable levels whilst achieving the best economic returns from the available scallop resource. Annual management arrangements are tailored to the expected abundance of scallops due to the significant correlation (0.81) that was determined between the abundance of recruits and residuals and the following year's catch (Joll and Caputi 1995¹).

A number of fleet interaction issues, including snapper bycatch (Moran and Kangas 2003²), and scallop-prawn interactions (Chandrapavan *et al.* 2012; Kangas *et al.* 2012) have been examined. Experimental approaches to harvesting and protection of spawning stock and newly settled scallops are being investigated, including refining catch rate targets to cease fishing and further temporal and spatial closures.

¹ Joll, L.M., Caputi, N. (1995). Environmental influences on recruitment in the saucer scallop (*Amusium balloti*) fishery of Shark Bay, Western Australia. *ICES Marine Science Symposia* 199: 47-53.

² Moran, M., Kangas M. (2003). The effects of the trawl fishery on the stock of pink snapper, *Chrysophrys auratus*, in Denham Sound, Shark Bay. Fisheries Research Bulletin No. 31. Department of Fisheries, Western Australia.

Bycatch reduction devices (BRDs) were implemented in this fishery and the implementation process included an observer program documenting the efficiency of BRDs, namely grids in the scallop fishery (Kangas and Thomson 2004¹). An FRDC funded project was finalised on the biodiversity of bycatch in trawled and untrawled areas within Shark Bay (Kangas *et al.* 2007²; Kangas and Morrison 2013).

A FRDC project, in collaboration with Edith Cowan University was completed in mid 2008 (Mueller *et al.* 2008³). This study analysed scallop logbook and survey data using geostatistics to provide a better understanding of stock and fleet dynamics and to assess the correlation of commercial catches and high abundance areas delineated in surveys. The study indicated that the annual survey was a good indicator of ‘high’ and ‘low’ scallop abundance areas within the fishery.

A FRDC-funded project focusing on minimising gear conflict and resource sharing issues in the Shark Bay trawl fisheries commenced in 2008 and was completed in 2011. This included hydrographic modelling of scallop and prawn larval movement within Shark Bay in collaboration with UWA.

Current Research Focus

Focus: Fishing for scallops (prior to the closure in 2012 following the recruitment failure and high mortality of adult scallops in 2011) commenced earlier to optimise the meat size of scallops which requires real-time monitoring (daily) of catch rates so fishing can cease at an agreed target catch rate level to ensure sufficient spawning stock is left during the key spawning period. If recovery occurs, this strategy may need to be reviewed until full recovery is evident.

Activities: Research for monitoring the status of the scallop stock is based on detailed logbook records and processor unloads provided by industry when the fishery is open. An annual research survey is carried out in November, which, together with existing detailed biological knowledge, enables an annual catch forecast to be provided. The Department has been conducting pre-season surveys that monitor the strength of recruitment (and residual stock abundance) in Shark Bay since 1982. These surveys measure the abundance of residuals and recruits to the Shark Bay population each year and provide an annual index of recruitment, which is independent of catch records (Joll and Caputi 1995). Daily catch rate information (cumulative catch against CPUE) is used to determine the available stock within main fishing grounds and in conjunction with the catch prediction from the annual survey allows an assessment of residual scallop stock abundance. This information has, in the last few years, been used to determine how much stock can be taken after the spawning period closure. The methodology will need to be reviewed once fishing resumes. In addition, it is planned to commence a standardised survey in February to determine scallop size and abundance prior to any potential fishing (March/April onwards) as in May 2014 there was evidence of recruiting scallops after an apparent successful ‘later spawning’ event and successful settlement which was not detected during the annual November survey.

Research will continue investigating the environmental influences that affect recruitment to scallop stocks in Shark Bay and environmental factors (including the marine heat wave)

¹ Kangas, M., Thomson, A.W. (2004). Implementation and assessment of bycatch reduction devices in the Shark Bay and Exmouth Gulf trawl fisheries. Final FRDC Report on Project No. 2000/189. Department of Fisheries, Western Australia. 70 pp.

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

³ Mueller, U., Kangas, M., Dickson, J., Denham, A., Caputi, N., Bloom, L., Sporer, E. (2008). Spatial and temporal distribution of western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*) and saucer scallops (*Amusium balloti*) in Shark Bay for fisheries management. Final FRDC Report on Project No. 2005/038. Edith Cowan University. 214 pp.

affecting recruitment have been examined as part of an FRDC project on climate change effects on fisheries in WA.

Funding applications have been made to FRDC for three years from 2015/16 for two projects that will assist in further understanding the environmental factors influencing scallop recruitment and survival of scallops, any potential for intervention to aid in recovery of the breeding stock and to determine key habitat requirements and cost effective monitoring of those habitats.

Proposed or Possible Research Initiatives

- Closure of sensitive habitats
- Temperature loggers
- Marine Park Monitoring
- Social assessment

Priority Setting Process

Initial assessments were made through internal departmental meetings in 1998 discussing research undertaken, current research and research and development gaps and a plan was drafted for five years. In 2006 a review of the Shark Bay prawn and scallop fisheries was undertaken which involved workshops with licensees and other stakeholders. In subsequent years, research issues have been discussed with Shark Bay scallop fishery licensees during their association meetings. Some additional research requirements were identified through the ESD process for which a re-assessment was completed in 2007.

Review Timeline

Early research and publications on the biology and spawning stock recruitment/environment relationships have been peer reviewed.

Significant independent peer review of all aspects of the fishery, including the stock assessment components have been conducted through the ESD assessments of the fishery to meet the Commonwealth's requirements for export accreditation under the EPBC Act. This has occurred on three occasions (2002, 2007 and 2012).

In addition, the Department has in the past three years adopted a schedule for peer review of the assessments for all fisheries. This "rolling" schedule aimed to generate major reviews of five to eight fisheries per year, employing a mix of internal and external fisheries experts (e.g. universities, CSIRO and inter-state fisheries departments). The SBSF was reviewed in August 2010 (Penn, Joll and Gaughan 2010).

The fishery underwent MSC pre-assessment in 2013.

Recent Publications

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

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

Chandrapavan, A, Kangas, M.I., Sporer E.C. (2012). Performance of square-mesh codends in reducing discards and by-catch in the Shark Bay scallop fishery. *Marine and Freshwater Research* 63: 1142-1151.

Kangas, M.I., Charapavan, A., Hetzel Y.L., Sporer E.C. (2012). Minimising gear conflict and resource sharing issues in the Shark Bay trawl fisheries and promotion of scallop recruitment. FRDC Final Report on Project No. 2007/051. Department of Fisheries, Western Australia. 122 pp.

Mueller, U., Kangas, M., Sporer, E., Caputi N. (2012). Variability in the spatial and temporal distribution of the saucer scallop, *Amusium balloti* in Shark Bay – management implications. *Marine and Freshwater Research* 63: 1152-1164.

Key to symbols in the matrix/summary tables:

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○ Indicates that the activity is part of a proposal but is not yet funded.

Shark Bay Scallop Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Scallop biology	Complete						Completed in the 1970-1980s
Meat size and quality		■	■	■	■		Additional information on spatial and temporal differences in meat size and quality will be collected on an opportunistic basis
1.2 Other Biology							
Recruitment dynamics	Complete						Studies completed in the 1980s
Larval advection	Complete						FRDC project UWA PhD student
1.3 Stock Assessment							
Stock-recruitment-environment effects	Ongoing	■	■	■	■	■	
Fishery independent surveys and monitoring	Ongoing	■	■	■	■	■	Effect of heatwave assessed
Survey indices-catch relationships	Ongoing	■	■	■	■	■	
Modelling/depletion exp.	Ongoing	■	■	■	■	■	
Spatial GIS	Ongoing	■	■	■	■	■	
Spatial analysis	Complete						ECU FRDC project completed in 2008
Catchability	Underway						Partly completed including day-night trials
Mesh selectivity trials	Complete						FRDC project, no industry adoption to date - new mesh now available at present industry driven
1.4 Fishery Monitoring							
Logbooks	Ongoing	■	■	■	■	■	
Pre-season skipper briefings	Ongoing	■	■	■	■	■	
Fishing power monitoring	Ongoing	■	■	■	■	■	
Processor returns	Ongoing	■	■	■	■	■	
Database maintenance	Ongoing	■	■	■	■	■	

Shark Bay Scallop Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Effort impact assessment (GIS)	Ongoing	■	■	■	■	■	EPBC requirement
Spatial analysis of survey and logbook data	Complete						ECU collaboration – student project
2. Habitat & Ecosystem							
2.1 Bycatch							
BRD implementation	Complete						Completed in 2003
Bycatch monitoring	Periodic		■				Review every 5 years
2.2 Listed Species							
Listed species interactions - logbooks	Ongoing	■	■	■	■	■	EPBC requirement/MOU with DoE underway
2.3 Habitat							
Habitat/effort impacts	Ongoing	■	■	■	■	■	EPBC requirement
Closure of sensitive habitats	Proposed						Industry consultation required
2.4 Ecosystem/Environment							
Biodiversity of trawled and untrawled areas	Periodic		■				Review every 5-10 years
Formal risk assessment	Periodic				■		EPBC requirement
Marine Park Monitoring	Possible						
2.5 Oceanography							
Leeuwin Current monitoring	Ongoing	■	■	■	■	■	
Temperature loggers	Proposed		O				To be reviewed
Modelling of currents	Complete						FRDC UWA PhD project
2.6 Other impacts on fishery							
Spatial closures	Underway	■					Evaluation after 2013/2014 closure in Denham Sound
3. Management Analysis							
3.1 Socio-economic							
Social assessment	Possible						Partly completed during SB review 06/07
Economic analysis – average price data	Ongoing	■	■	■	■	■	Bio-economic modelling revisited in 09/10
Fuel consumption/expenses	Ongoing	■	■	■	■	■	Bio-economic modelling revisited in 09/10
3.2 Resource Access (Shares)							
Prawn-scallop fleet interactions and catch share-snapper	Ongoing	■	■	■	■	■	Needed for the review of the three fisheries
Prawn-scallop gear interactions	Complete						Completed in 2008, 2012
3.3 Compliance Research							
3.4 Management Systems							
4. Industry Development							
4.1 Production Technology							
Aquaculture /reseeding	Underway	■	■				Pilot phase in 2014/15 with three year funding application in for 2015/16

Shark Bay Scallop Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
4.2 Post Harvest							
4.3 Marketing							
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete						Pre-assessment in 2013
Other	Periodic				■		Next EPBC re-assessment in 2017/18

North Coast Bioregion

North Coast – Biodiversity Issues

Description and Scope of Issues

On the north coast, marine habitats have been locally affected by port developments, oil and gas exploration and extraction, and some fishing activities across the continental shelf. The offshore Pilbara area in particular, was trawled by international vessels in the 1960s and 1970s; however, this activity was phased out in the early 1980s. Since that time, extensive fisheries closures over coastal and most offshore waters have been introduced to manage fish trawl and trap fishing. Trawling is subject to Ecologically Sustainable Development (ESD) requirements in accordance with Australian Government ‘Guidelines for the Ecologically Sustainable Management of Fisheries’ under the Environment Protection and Biodiversity Conservation Act 1999. Studies on the incidental capture of dolphins in Pilbara trawl fisheries have been undertaken. In addition to the extensive fisheries closures protecting marine habitats, the Bioregion has a number of Reef Protected Areas under Fisheries legislation and marine parks and reserves in some Kimberley inshore waters and around offshore islands and reefs. The current Government is undertaking a review of all proposed Commonwealth Marine Reserves.

North Coast Marine habitats are experiencing increasing pressure through a range of activities but most notably as a result of increased resource development activity in the area. The Department continues to engage with the Environmental Protection Authority through the environmental impact assessment process by providing advice on individual development proposals, which if implemented, have the potential to have an adverse impact on the marine environment. The North Coast is predicted to have relatively minor impacts from climate change compared to more southerly locations. The direct and indirect effect of dredging and seismic operations on fish and invertebrates requires assessment.

Relevant Resource Assets and Risks from all Fisheries

Benthic - Estuaries/Nearshore	Low Risk
Benthic - Pilbara	Low Risk
Benthic - Kimberley	Low Risk
Protected species - Non fish	Moderate Risk
Protected species - Non fish - mammals	Moderate Risk
Protected species - Fish	Moderate Risk
North Coast Ecosystem - Estuarine	Low Risk
North Coast Ecosystem - Pilbara marine	Low Risk
North Coast Ecosystem - Kimberley marine	Low Risk
North Coast - Climate	Low Risk
North Coast – Water quality	Moderate Risk

Summary of historical research completed

A summary of the research information available for this region was compiled as part of a WAMSI project undertaken by DPAW. In addition, a recently completed NRM project made recommendations on the development of a strategic framework to inform and guide a future Coastal and Marine Resource Condition Monitoring Program for the Pilbara and Kimberley Regions.

Current Research Focus

Many of the studies in this region are being developed as part of the broader WAMSI Kimberley suite of studies and are undertaken by agencies other than the Department of Fisheries. The Department undertakes collaborative research on WAMSI 1.1.1 Benthic Biodiversity; 1.1.2 Ecological processes in Kimberley benthic communities and 1.1.3 Ecological Connectivity.

Other research focus includes:

- Develop and implement research and monitoring programmes for the Lalang-garram Camden Sound Marine Park.
- Identify critical research gaps on the effects of dredging and seismic operations on fish and invertebrates.
- Benthic habitat modelling through Kimberley inshore and offshore waters (WAMSI 1.1.1).
- Develop fish habitat modelling for Kimberley inshore waters (collaborative project with WAMSI 1.1.1 Benthic biodiversity and Lalang-garram marine park research program).
- Interaction rates with endangered, threatened and protected species (ETPS) are now recorded on daily logbooks and Catch And Effort Statistics (CAES) forms.
- Investigate the importance of habitat type on fish recruitment (WAMSI 1.1.2).
- Investigate population and habitat connectivity of marine species (WAMSI 1.1.3).

Priority Setting Process

WAMSI projects were developed by executive direction of the Department with research input. The Department has developed a risk assessment process for the North Coast Bioregion under its processes of considering Ecosystem Based Fisheries Management as a management goal.

Recent Publications

Joliffe, C. (2013) Mangrove-reef connections: exploring the influence of proximity to mangroves on reef fish fauna in the Kimberley region, Western Australia. Honours Thesis, Faculty of Natural and Agricultural Sciences, The University of Western Australia.

Molony, B. W., Newman, S. J., Joll, L., Lenanton, R. C. J. and Wise, B. (2011). Are West Australian waters the least productive waters for finfish across two oceans? A review with a focus on finfish resources in the Kimberley region and North Coast Bioregion. *Journal of the Royal Society of Western Australia*. 94: 323–332.

Human, B.A., Murray, K., Zdunic, K., and Behn, G. (2010). Field trial of potential resource condition indicators, and an exploration of the utility of remote sensing, for mangroves and intertidal mud flats in the Pilbara – Pilot study. *Coastal and Marine Resource*

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

North Coast Biodiversity Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Habitat & Ecosystem							
1.1 Bycatch (Trawl fisheries)	Completed						Completed in the early 2000s
Removal of prawn trawl effort	Underway	■	■				Studies to monitor the potential change in fish and benthos assemblages following the removal of trawl fishing in areas of the Kimberley (DoF Marine Park funding)
1.2 Listed Species							
Dolphins	Completed						Studies to ameliorate catch of dolphins in fish trawl nets has been completed by both Murdoch University and the Department.
Whales	Developing	○					Proposal submitted to Inpex to deploy acoustic receivers in the Lalang-garram marine park (Curtin project submitted to JIP)
1.3 Habitat							
Habitat modelling	Underway	■	■				WAMSI 1.1.1
Fish Habitat modelling	Developing		■				Marine Park & WAMSI collaborative PhD project to start 2015/16
Developing RCTs for benthic habitats	Underway						
1.4 Ecosystem/Environment							
Marine Park monitoring	Underway	■	■				Research has commenced
Kimberley Biodiversity surveys	Underway	■	■				Research has commenced as part of Woodside funded surveys to the WA Museum
1.5 Oceanography							
Hydrodynamic modelling	Underway	■	■				WAMSI II studies (Kimberley)
Nutrient/plankton cycles on shelf	Underway						WAMSI II studies (Kimberley)
1.6 Other impacts on ecosystem							
Seismic impacts on fish and invertebrates	Developing	○					Project proposal submitted to JIP in collaboration with Curtin University
Seismic impacts review	Underway	■					Collaborative desktop review on the impacts of seismic on fish and invertebrates
Dredging impacts review	Underway	■					Collaborative desktop review on the impacts of dredging on fish and invertebrates (WAMSI)
2. Management Analysis							
2.1 Socio-economic							
Social assessment	Underway	■					WAMSI II studies (Kimberley)

North Coast Biodiversity Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Economic Analysis							
2.2 Resource Access (Shares)							
2.3. Compliance Research							
2.4 Management Systems							
3. Stakeholder Consultation and Reviews							
MSC							
Science	Completed						As part of WAMSI II

North Coast – Mackerel Managed Fishery

Description and Scope of Issues

The commercial mackerel fishery includes the taking of all species of the genera *Scomberomorus*, *Grammatorcynus* and *Acanthocybium*, but the main targeted species is narrow-barred Spanish mackerel (*Scomberomorus commerson*). Mackerel are usually taken by trolling close to the surface in coastal areas around reefs, shoals and headlands, with jigs also used to capture grey mackerel (*Scomberomorus semifasciatus*). Recreational fishers also use methods such as shore-based drift fishing with balloons and spear guns to target mackerel. The commercial fishery mainly operates between Geraldton and the WA/Northern Territory border, with the largest catches taken off the Kimberley and Pilbara coasts. The main area of the recreational fishery is between Perth and Dampier.

Relevant Resource Assets and Risks from Fishery

North Coast Pelagic Finfish	Low - Moderate Risk
North Coast Listed Species	Negligible Risk
North Coast Habitat	Negligible Risk
North Coast Ecosystems	Negligible Risk

Summary of historical research completed

There were two major projects on mackerel funded by FRDC in 2002 which focused on the narrow-barred Spanish mackerel. These projects provided descriptions of the biology, spatial structure and status of Spanish mackerel stocks in WA waters, and served as a basis for developing the future management arrangements for this fishery.

Current Research Focus

A cooperative FRDC project between the WA Department of Fisheries and research groups in the Northern Territory and Queensland is focusing on the stock structure of grey mackerel

(*Scomberomorus semifasciatus*). It was completed in late 2010 and outcomes and research advice are being considered by managers.

The fishery is monitored using the daily logbooks submitted by fishers and VMS. Catch and effort has now been constrained under the management plan through the use of TACCs in a number of zones.

Proposed or Possible Research Initiatives

- Shark depredation of catch. Northern Australian FRDC EOI submitted in 2014 but did not get FRAB support
- Determination of access shares between recreational and commercial sectors
- Monitoring of shares between recreational and commercial sectors
- Management Systems, review of TACC; may require additional monitoring
- Potential of expanded range and/or increased biomass of Spanish mackerel as a result of climate change

Priority Setting Process

Priorities are reviewed on an annual basis through consultation between scientists of the Finfish Branch (Research Division) and fishery managers during the annual review of FishPlan.

Review Timeline

The science underpinning this fishery was extensively reviewed in 2005. This fishery was last reviewed as part of the MSC pre-assessment in 2014.

Key to symbols in the summary matrix:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

North Coast Mackerel Managed Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Narrow-barred Spanish mackerel	Complete						
Grey/other mackerel	Complete						As part of a QLD-based FRDC research project, completed in 2011
1.2 Other Biology							
Stock structure of Spanish mackerel	Complete						
Grey mackerel stock structure	Complete						As part of a QLD based FRDC research project, completed in 2011
1.3 Stock Assessment							
Annual Assessment	Complete						No planned update; currently monitored by catch and effort data and VMS
Biomass Dynamics and Yield/Egg Per Recruit Modelling	Complete						Completed in 1998. No planned update; low priority

North Coast Mackerel Managed Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1.4 Fishery Monitoring							
Commercial catch and effort	Ongoing	■	■	■	■	■	Daily logbooks implemented in 2006
Charter catch and effort	Ongoing	■	■	■	■	■	Tour Operator Return Book
State-wide survey of boat-based recreational fishing	Periodic		■		■		Biennial phone-diary survey
2. Habitat & Ecosystem							
2.1 Bycatch	Not needed						Low risk
2.2 Listed Species	Not needed						Low risk
2.3 Habitat							Nothing identified
2.4 Ecosystem/Environment							Nothing identified
2.5 Oceanography							Nothing identified
2.6 Other impacts on fishery	Proposed						Shark depredation of catch. Northern Australian FRDC EOI submitted in 2014 but did not get FRAB support
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)							
Determination of access shares	Proposed						Between recreational and commercial sectors
Monitoring of shares	Proposed						Between recreational and commercial sectors
3.3 Compliance Research							
3.4 Management Systems	Proposed						Review of TACC; may require additional monitoring
4. Industry Development							Nothing identified. MSC pre-assessment completed in 2014 for consideration.
5. Stakeholder Consultation and Reviews							
Annual Management Meeting		■	■	■	■	■	
MSC	Completed	■					Pre-assessment completed in 2014.
Fishplan	Ongoing	■	■	■	■	■	

North Coast – Sea Cucumber Managed Fishery

Description and Scope of Issues

Sea cucumbers, also known as Beche-de-mer or trepang are in the Phylum Echinodermata, Class Holothuroidea. They are soft-bodied, elongated animals that usually live with their ventral surface in contact with the benthic substrate or buried in the substrate. The WA Sea cucumber fishery is based in the northern half of the state, from Exmouth Gulf to the Northern Territory border. It is a hand-harvest fishery, with animals caught principally by diving, and a smaller amount by wading. There are six target species caught commercially in

Western Australia, however historically, 99% of the catch is sandfish (*Holothuria scabra*) and deep-water redfish (*Actinopyga echinites*).

Relevant Resource Assets and Risks from Fishery

North Coast Echinoderms	Moderate Risk
North Coast Listed Species	Negligible Risk
North Coast Habitat	Negligible Risk
North Coast Ecosystems	Negligible Risk

Summary of historical research completed

A daily catch and effort logbook has been tested and introduced into the fishery. There are significant gaps in knowledge about the biology of the species harvested in this fishery, and current size-limits are based on Northern Territory fisheries.

Current Research Focus

Current research is focused on: stock assessment using monthly catch and effort statistics and development of stock performance indicators that incorporate finer-scale, species-specific information.

Proposed or Possible Research Initiatives

- Population survey (*Actinopyga echinites* at Barrow and Montebello Islands)
- Growth
- Size-at-maturity

Priority Setting Process

Meetings between the Department of Fisheries and industry.

Review Timeline

The Fisheries Research Division reviews the fishery and stocks annually in January/February.

Key to symbols in the summary matrix:

- Indicates that the activity is funded and planned to occur.
- Indicates that the activity is part of a proposal but is not yet funded.

North Coast Sea Cucumber Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							Information on growth and size at maturity are needed to improve the management of the Kimberley and Pilbara stocks
Growth	Proposed						
Size-at-maturity	Proposed						

North Coast Sea Cucumber Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1.2 Other Biology							
Genetics	Low Priority						Genetics work on <i>H. scabra</i> would help establish appropriate management boundaries
1.3 Stock Assessment							
Sustainability of stocks	Ongoing	■	■	■	■	■	
Fishery independent survey of redfish (<i>Actinopyga echinities</i>) stocks	Underway		■	■			To establish baseline biomass estimates in a newly developing fishery
1.4 Fishery Monitoring							
Research logbook implementation	Ongoing	■	■	■	■	■	
2. Habitat & Ecosystem							
2.1 Bycatch	Not needed						Negligible Risk
2.2 Listed Species	Not needed						Negligible Risk
2.3 Habitat	Not needed						Negligible Risk
2.4 Ecosystem/Environment	Not needed						Negligible risk
2.5 Oceanography	Not needed						Negligible Risk
2.6 Other impacts on fishery	Not needed						Negligible risk
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)	Underway						Fishery earmarked for management escalation to an Interim Managed Fishery
3.3 Compliance Research							
3.4 Management Systems	Underway						Fishery earmarked for management escalation to an Interim Managed Fishery
4. Industry Development							Industry want a move to an Interim Managed Fishery
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete						Pre-assessment in 2013
Other	Periodic						Reviews will coincide with EPBC – WTO re-assessments

North Coast – Nearshore Fisheries

Description and Scope of Issues

The Kimberley Gillnet and Barramundi Managed Fishery (KGBF) extends from the WA/NT border (129°E) to the top of Eighty Mile Beach, south of Broome (19°S). It encompasses the taking of any fish by means of gillnet in inshore waters and the taking of barramundi by any means. The area of the fishery south of Willie Creek is now closed to commercial fishing.

The species taken are predominantly barramundi (*Lates calcarifer*), king threadfin (*Polydactylus macrochir*) and blue threadfin (*Eleutheronema tetradactylum*). The main areas of the fishery are the river systems and tidal creek systems of the Cambridge Gulf, the Ria coast of the northern Kimberley and King Sound.

Recreational fishing activities are concentrated around key population centres, with a peak in activity during the dry season (winter months).

Relevant Resource Assets and Risks from Fishery

North Coast Nearshore Finfish	Moderate Risk
North Coast Listed Species	Low Risk
North Coast Habitats	Low Risk
North Coast Ecosystems	Low Risk

Summary of historical research completed

The biological characteristics required for fisheries management of the King threadfin and the Blue threadfin have been completed. The bycatch of elasmobranchs in the KGBF and along the Pilbara coast fishing area was examined by the Department during 2002 and 2003.

Current Research Focus

CAES data are used to assess the status of barramundi stocks targeted by this fishery. This status report is compiled annually and provided to industry and regional management.

Proposed or Possible Research Initiatives

- Barramundi
- Sawfish
- Pig eye shark
- Lemon shark
- Fishing mortality assessments against benchmarks (indicator species)
- Age Structure of Indicator Species
- Commercial monitoring (vessel monitoring at sea)
- Improving precision of estimates of catch and effort from recreational fishing
- Bycatch
- Sawfish
- Resource Access (Shares)

Priority Setting Process

Initial assessments were made through internal departmental meetings and forums discussing the history of research in the fishery, research activities that have been completed, current research as well as research and development gaps. Research issues have been discussed at annual industry consultation meetings once a year.

Review Timeline

Next planned review in late 2015.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

North Coast Nearshore and Estuarine Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
King threadfin	Complete						Sufficient for management
Blue threadfin	Complete						Sufficient for management
Barramundi	Proposed	○					Project identified
1.2 Other Biology							
Sawfish	Proposed	○					Project identified
Pig eye shark	Proposed	○					Project identified
Lemon shark	Proposed	○					Project identified
1.3 Stock Assessment							
Annual Catch and Effort Assessment	Ongoing	■	■	■	■	■	Ongoing
Fishing mortality assessments against benchmarks (indicator species)	Proposed						Under review
1.4 Fishery Monitoring							
Commercial Catch and Effort	Ongoing	■	■	■	■	■	Ongoing
Age Structure of Indicator Species	Proposed						Periodic
Commercial monitoring (vessel monitoring at sea)	Proposed						Periodic
Recreational Fishery surveys	Proposed						Periodic
Charter Boat Catch and Effort	Ongoing	■					Tour Operator Return Book
2. Habitat & Ecosystem							
2.1 Bycatch	Proposed						Periodic – Low risk – initial project completed
2.2 Listed Species							
Sawfish	Proposed	○					Project identified – High risk

North Coast Nearshore and Estuarine Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
2.3 Habitat	Not needed						Low risk – gillnet fishery
2.4 Ecosystem/Environment	Not needed						Nothing identified
2.5 Oceanography							
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)	Proposed						Needed for IFM
3.3 Compliance Research							
3.4 Management Systems							
4. Industry Development							
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete	■					Pre-assessment in 2014
Other			■				Major assessment reports peer reviewed every five years

North Coast – Pearl Oyster Managed Fishery and Pearl Production

Description and Scope of Issues

The Western Australian pearl oyster fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. It is a dive fishery that dates back to the 1850s operating in shallow coastal waters along the North West Shelf. The species targeted is the Indo-Pacific, silver-lipped pearl oyster (*Pinctada maxima*) and they are harvested by drift diving.

There is an extensive amount of relevant and accurate information on the biology of the silver lipped pearl oyster, history of this fishery (in excess of 30 years for the culture shell fishery and almost 100 years for the Mother Of Pearl fishery), as well as oyster culture, genetics, disease and pearl production techniques

Relevant Resource Assets and Risks from Fishery

North Coast Molluscs – Pearls	Low Risk
North Coast Listed Species	Negligible Risk
North Coast Habitat – Kimberley	Negligible Risk
North Coast Ecosystems	Negligible Risk

Summary of historical research completed

Fishery: Biology (growth, reproduction, maturity), ecological studies (population densities, settlement and recruitment), environmental effects and oceanography studies (larval drift and circulation, source-sink relationships) have been completed.

Historical time series of daily catch information on number of pearl oysters caught, diver hours, date and location of harvest. Historical catches and effort over the past 100 years have also been reviewed. An annual standardized catch per unit effort (CPUE) model has been developed that accounts for variation in spatial and temporal fishing effects, as well as technological improvements that aid fishing efficiency. The standardized CPUE data are being used in a harvest control-rule framework for quota setting in the fishery

Large scale surveys of Mother-of-Pearl (MOP) stocks and genetic relationships within and between Western Australian stocks of *P. maxima* have been established.

A recently study examined the management of bio-eroding sponges (*Cliona* sp.) on wild stocks, the project found no clear evidence that the incidence of this increasing.

The fishery is currently undergoing MSC certification.

Pearl oyster aquaculture and pearl production: Studies on culturing of oysters and pearls were completed during the late 1980s and early 1990s, and a major review of the history of exploitation and culture of pearls has been completed.

Current Research Focus

Current stock assessment research is focused on:

- Stock assessment using catch and effort statistics (taking into account discard rates) and recruitment and length-frequency sampling to estimate the total allowable catch.
- Development of an index of recruitment for predicting future years catch levels using the relative number of piggy back spat.
- Harvest control rules for determining the TAC.
- Environmental drivers (e.g. rainfall) of pearl oyster abundance.

Current production research focuses on environmental management, pearl oyster health, and improved health and safety for pearl divers, including:

- Comprehensive disease-testing program to the industry.
- Investigate aspects of oyster oodema disease (OOD) in *Pinctada maxima*, to assist in mitigating the impacts and understand pathways to disease and disease response in pearl oysters.

Proposed or Possible Research Initiatives

- Kimberley inshore bio-oceanography
- Irukandji jellyfish stings - Protection for divers
- Antifouling - Industry project

Priority Setting Process

Meetings between the Department of Fisheries and industry.

Review Timeline

The Stock Assessment Working Group (SAWG) reviews the fishery and stocks annually, with quota decisions made in October/November. A mid-season review is also carried out during April. The science used for this fishery was last reviewed by the stock assessment working group in October 2010.

Recent Publications

Hart, A.M., Thompson, A., Murphy, D. (2011). Environmental influences on stock abundance and fishing power in the silver-lipped pearl oyster fishery. *ICES Journal of Marine Science* 68(3): 444-453.

Jones, J.B., Crockford, M., Creeper, J., Stephens, F. (2010). Histopathology of oedema in pearl oysters (*Pinctada maxima*) – is oedema a general problem for sick bivalves? *Diseases in aquatic organisms* 91: 67-73.

Key to symbols in the summary matrix:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

Pearl Oyster Fishery and Pearl Production Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)	Complete						A number of studies using tag-recapture, monthly monitoring, and histological studies have been completed
Environmental effects on recruitment	Ongoing	■	■	■	■	■	Annual monitoring of recruitment and environmental variable such as rainfall, temperature, wind and SOI indices
MOP (FRDC)	Complete						A major project on demography and potential fishery completed in 2004
Growth rate of wildstock (FRDC)	Complete						Growth established in the northern, central, and southern sections of fishery
Heavy metals	Complete						
1.2 Other Biology							
Genetics (FRDC)	Complete						Two FRDC projects on connectivity completed
1.3 Stock Assessment							
Annual assessment of catch rates and sizes	Ongoing	■	■	■	■	■	Annual assessments and analysis of diver CPUE and size-frequency
1.4 Fishery Monitoring							
Statistics (wildstock)	Ongoing	■	■	■	■	■	120 year time-series of catch and effort in the fishery
2. Habitat & Ecosystem							
2.1 Bycatch	Not Needed						Negligible Risk
2.2 Listed Species	Not needed						Negligible Risk
2.3 Habitat	Not Needed						Negligible Risk
2.4 Ecosystem/Environment							

Pearl Oyster Fishery and Pearl Production Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Environmental impact of pearl oyster fishing	Not Needed						Low Risk
Environmental impact farm site	Complete						PPA project with University of Newcastle, looking at impacts on benthic habitat
Environmental impact/monitoring	Complete						PPA project with University of Newcastle, looking at impacts on benthic habitat
Site survey/food availability/density	Needed						
Site selection parameters	Needed						
EMS Template Pilot Project	Complete						Environmental monitoring studies
2.5 Oceanography							
NW Shelf study	Complete						Ongoing CSIRO modelling research at a bioregional scale
Kimberley inshore bio-oceanography	Complete New proposal						Larval drift studies for <i>Pinctada maxima</i> spawning and settlement areas
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic							
Occupational Health & Safety							WAFIC/PPA issue
Diver safety/farm profiles	Complete						Studies on pearl diving and decompression protocols
3.2 Resource Access (Shares)	Not Needed						No recreational fishery
3.3 Compliance Research							
Compliance evaluation	Complete						Independent report completed in 07/08
3.4 Management Systems							
EMS	Complete						EMS was completed by industry for farming operations
4. Industry Development							
4.1 Production Technology							
Culture development (move to longlines)	Complete						Move from bottom culture to long-line culture completed in early 1990s
Irukandji jellyfish stings	Proposed						Protection for divers
Antifouling	Proposed						Industry project
Seeding techniques (private)							
Hatchery development project (FRDC)	Complete						Major FRDC projects by the Department of Fisheries on spawning and hatchery culture
Growth rates/nursery spat (FRDC)	Complete						Major FRDC projects by the Department of Fisheries on nursery culture
MOP nuclei production (FRDC)	Complete						Examination of use of MOP shell to produce nuclei for pearl seeding
4.2 Post Harvest							
4.3 Marketing							Completed by industry
Market research/intelligence (Private)							
Promotion/Branding Market Research							

Pearl Oyster Fishery and Pearl Production Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
4.4 Fish Health							
Fish health and diagnostics	Ongoing	■	■	■	■	■	General fish health and diagnostic services for the pearling industry
Husbandry wildstock							
Disease survey/atlas (FRDC)	Complete						FRDC funded Australia-wide survey of wild stock diseases
Translocation/protocol	Periodic						
Ciliate project	Complete						Characterize the Intracellular ciliate found In Zone 1 pearl oysters
Haplosporidian project	Complete						Characterize the haplosporidian found In pearl oysters and rock oysters
Cliona management in wild stocks (FRDC)	Complete						FRDC funded project on bioeroding sponges in wild stocks
Diagnostic test for OOD	Underway	■	■	■	■		FRDC funded projects on Chlamydiales-like organisms, stress response; industry funded work on oedema disease
Test for oyster stress (Miroarrays)	Underway	■	■	■	■		FRDC project looking at generic stress response in <i>P. maxima</i>
5. Stakeholder Consultation and Reviews							
Annual Management Meetings	Ongoing	■	■	■	■	■	
MSC	Complete	■					Pre-assessment in 2014
Other							Major assessment reports peer reviewed

North Coast – Demersal Fisheries

Description and Scope of Issues

The demersal fisheries in this region targets, to varying degrees, 10 main species, bluespotted emperor (*Lethrinus punctulatus*), threadfin bream (Nemipteridae), brownstripe snapper (*Lutjanus vitta*), crimson snapper (*Lutjanus erythropterus*), red emperor (*Lutjanus sebae*), saddletail snapper (*Lutjanus malabaricus*), goldband snapper (*Pristipomoides multidens*), spangled emperor (*Lethrinus nebulosus*), frypan snapper (*Argyrops spinifer*) and Rankin cod (*Epinephelus multinotatus*). A range of species is also taken in offshore waters, including eightbar grouper (*Hyporthodus octofasciatus*) and ruby snapper (*Etelis carbunculus*).

In the Pilbara there are three separate commercial fisheries for these species - trawl, trap and line fisheries. In the Kimberley there is a single trap based fishery (NDSF). The trawl and trap fisheries are all managed primarily by the use of input controls in the form of individual transferable effort allocations monitored with a satellite-based vessel monitoring system.

Relevant Resource Assets and Risks from Fishery

North Coast Demersal Finfish

Moderate Risk

North Coast Listed Species

Moderate Risk

North Coast Habitat – Pilbara	Moderate Risk
North Coast Habitat – Kimberley	Negligible Risk
North Coast Ecosystems	Low Risk

Summary of historical research completed

Pilbara: Baseline research for managing the demersal fish stocks was undertaken in a series of research projects from 1993 to 1999, providing the basis for long-term monitoring of the stocks of the indicator species.

The catch of Listed species has been a focus of research from 2002 and is ongoing. All trawl vessels in the fishery ($n = 3$) were fitted with dual-lens above water and subsurface within-net camera systems from June to December 2012. Above water cameras recorded continuously (except during malfunctions). The observer coverage rates of 85.2% of trawl catches above water ($n = 1,916$ trawls observed), and 71.7% of day-trawls ($n = 774$ trawls observed) and 53.9% of day-trawl hours ($n = 1,013$ h observed) below water far exceeded that stipulated in the Bycatch Action Plan (22%) and levels achieved from previous studies from the PFTF. Capture rates of ETP megafauna were rare, despite very high levels of attendance in and around trawl nets by bottlenose dolphins ($> 75\%$ of trawls). All observed catches of ETP species were reported in statutory logbooks and these catches were consistent with previous data since exclusion grids were mandated in March 2006. This information is detailed in Wakefield *et al.* (2014).

Kimberley: Baseline research for managing the demersal fish stocks was undertaken in a research project from 1997 to 2000, providing the basis for long-term monitoring of the stocks of the indicator species. Age-based demographic data has been published on red emperor (Newman and Dunk 2002) and goldband snapper (Newman and Dunk 2003).

Current Research Focus

Pilbara: Monitoring and assessment of the Pilbara trawl, trap and line fisheries includes the collection of spatial data on effort and catch of 10 major target species from logbooks, VMS data, and weighed catches from unload data. Assessment of the status of the suite of retained demersal scalefish is based on the performance of indicator species using various assessment methods. These methods include trend analysis of catch rates using two measures of effort for five indicator species and the total catch in each of the trawl managed areas. In addition, otoliths are collected and ages determined for the indicator species, red emperor, rankin cod, bluespotted emperor and brownstripe snapper in each of the trawl-managed areas and the trap fishery. Estimates of fishing mortality are derived from each of these age structures and compared to internationally recognised Reference Points (RPs). Every four to five years the spawning biomass of two indicator species, red emperor and rankin cod, is assessed using the age-composition and catch rate data in an age-structured model.

Discussions are in progress on developing a collaborative project with CSIRO to update the work conducted by CSIRO in the 1980s on the North West Shelf benthos abundance and scalefish species composition. The monitoring of two shorter lived indicator species, bluespotted emperor and brownstripe snapper, have been increased from a Tier 2 (catch rate) to a Tier 3 (fishing mortality based) assessment. Collection of age structure data from different sources (fishery independent and markets) is currently in progress. A Tier 3 (fishing mortality based) assessment of the offshore demersal indicator species ruby snapper (*Etelis*

carbunculus) is also in progress for the line sector in the Pilbara as a result of increased catches in recent years.

Kimberley: The status of the demersal fish stocks in the NDSF is determined annually using catch and catch rates of the major species or species groups, and every four to five years using an age-based stock assessment model to assess the status of the two indicator species, red emperor and goldband snapper based on age-composition data collected in previous years. Ongoing monitoring of this fishery is being undertaken using both CAES and VMS data.

An FRDC-funded research project examining the relative catching efficiency of traps in the NDSF and to investigate resource availability and contribute to the stock assessment process in the NDSF has been completed.

The future catch from the NDSF may also include some species from the waters of Zone C in depths greater than 200 m. The resources of this zone are unlikely to be substantial, and given the lower production potential of these longer-lived, deeper-slope reef fish, and the sustainable catch from this zone is likely to be low.

Proposed or Possible Research Initiatives

- Goldband snapper (Pilbara)
- Bluespotted emperor (Pilbara) – Genetics, Stock structure using stable isotopes etc.
- Brownstripe snapper (Pilbara) – Genetics, Stock structure using stable isotopes etc.
- Crimson snapper (Pilbara)
- Cod species (Kimberley and Pilbara)
- Golden snapper
- Ruby snapper – Genetics, Stock structure using stable isotopes etc.
- Eightbar grouper - Genetics, Stock structure using stable isotopes etc.
- Improving precision of estimates of catch and effort from recreational fishing
- Bycatch – Monitoring and review (Pilbara)
- Ecosystem/Environment – Use of drifters to evaluate on-shelf oceanographic processes
- Oceanography
- Effects of Indonesian impacts (Kimberley)
- Social assessment
- Economic analysis
- Detailed determination of access shares
- Monitoring of shares
- Management of recreational sector
- Post Harvest – Seafood quality enhancement

Priority Setting Process

Commercial: Department–industry meetings for the fish trawl and trap fisheries.

Recreational: Recfishwest consultation.

Review Timeline

Pilbara: Pilbara stock assessment review is due in 15/16.

Kimberley: NDSF stock assessment review is due in 15/16.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

North Coast Demersal Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Red emperor	Complete						Sufficient for management
Goldband snapper (Pilbara)	Proposed						Project identified – current gap – High risk
Goldband snapper (Kimberley)	Complete						Sufficient for management
Rankin cod	Ongoing						Being revised
Bluespotted emperor (Pilbara)	Proposed						F-based assessment - High risk
Brownstripe snapper (Pilbara)	Proposed						F-based assessment - High risk
Rosy threadfin bream	Complete						Sufficient for management
Crimson snapper (Pilbara)	Proposed						Low priority
Saddletail snapper	Complete						Sufficient for management
Spangled emperor	Complete						Sufficient for management
Cod species (Kimberley)	Proposed						Project identified – High risk
Cod species (Pilbara)	Proposed						Project identified – High risk
Golden snapper	Proposed						Project identified – moderate risk
Ruby snapper	Proposed						F-based assessment – High risk
Eightbar grouper	Complete						Sufficient for management
1.2 Other Biology							
Stock structure – Red emperor/Rankin cod using stable isotopes	Complete						Sufficient for management
Stock structure – Goldband snapper stable isotopes	Complete						Sufficient for management
Genetics – goldband snapper	Complete						Sufficient for management
Genetics – red emperor	Complete						Sufficient for management
Stock structure – Ruby snapper using stable isotopes etc.	Proposed						Project identified – High risk
Genetics – Ruby snapper	Proposed						Project identified – High risk
Stock structure – Eightbar grouper using stable isotopes etc.	Proposed						Project identified – High risk
Genetics – Eightbar grouper	Proposed						Project identified – High risk
Stock structure – Brownstripe snapper, bluespotted emperor using stable isotopes etc.	Proposed						Project identified – High risk
Genetics – Brownstripe snapper, bluespotted emperor	Proposed						Project identified – High risk

North Coast Demersal Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1.3 Stock Assessment							
Annual catch and effort assessment	Ongoing	■	■	■	■	■	Ongoing
Age structured models (indicator species)	Ongoing	■					Periodic for indicator species
Fishing mortality assessments against benchmarks (indicator species)	Periodic					■	Periodic for indicator species
1.4 Fishery Monitoring							
Commercial catch and effort	Ongoing	■	■	■	■	■	Ongoing
VMS data	Ongoing	■	■	■	■	■	Ongoing
Age composition data for indicator species	Ongoing		■				Periodic
Commercial monitoring (vessel monitoring at sea)	Ongoing						Periodic
Recreational fishing surveys	Proposed						Periodic
Charter Boat Catch and Effort	Ongoing	■	■	■	■	■	Tour Operator Return Book
2. Habitat & Ecosystem							
2.1 Bycatch							
Monitoring and review (Pilbara)	Proposed						Joint Project proposal identified
Monitoring (Kimberley)	Ongoing						Periodic – low risk
2.2 Listed Species							
P: Dolphins (moderate risk), turtles (low risk). Syngnathids (low risk), sea snakes (low risk), sea horses (low risk). Sawfish (moderate risk)	Underway						Ongoing
P: Listed species mitigation - acoustic pingers	Complete						Acoustic pingers were ineffective
P: Selection grids	Complete						Dolphin catch has halved since 2005
K: Monitoring	Ongoing						Periodic – low risk
2.3 Habitat							
P: Survival of benthos	Complete						Work completed in the 1990s. part of joint proposal
K:	Not needed						Low risk
2.4 Ecosystem/Environment	Proposed						Part of joint proposal.
2.5 Oceanography							
Use of drifters to evaluate on-shelf oceanographic processes	Proposed						Project identified
2.6 Other impacts on fishery							
K: Effects of Indonesian impacts	Proposed						Project identified – low priority
3. Management Analysis							
3.1 Socio-economic							
Social assessment	Possible						May be needed for IFM
Economic analysis	Possible						May be needed for IFM
3.2 Resource Access (Shares)							
Detailed determination of access shares	Proposed						Needed for IFM
Monitoring of shares	Proposed						Needed for IFM
3.3 Compliance Research							
Validation of catch records	Proposed						Required for MSC assessment
3.4 Management Systems							
Management of recreational sector	Proposed						May be needed for IFM
Effort monitoring by VMS	Ongoing	■	■	■	■	■	Ongoing – gap for Pilbara line fishery

North Coast Demersal Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
4. Industry Development							
4.1 Production Technology							
4.2 Post Harvest							
Seafood quality enhancement	Proposed						Project identified
4.3 Marketing							
5. Stakeholder Consultation and Reviews							
Annual Management Meetings	Ongoing	■	■	■	■	■	
Pilbara	Periodic		■				Major assessment reports peer reviewed every five years
Kimberley	Periodic		■				Major assessment reports peer reviewed every five years
MSC	Complete	■					Pre-Assessment in 2014

North Coast – Northern Shark Fisheries

Description and Scope of Issues

The northern shark fisheries comprise the state-managed WA North Coast Shark Fishery (WANCSF) in the Pilbara and western Kimberley and the Joint Authority Northern Shark Fishery (JANSF) in the eastern Kimberley. Until July 2005, when new management arrangements were proposed for the two fisheries, the primary fishing method was demersal longlining in the WANCSF with only a small and intermittent amount of pelagic gillnetting in the JANSF. The intent of the proposed management revisions was to reduce the total effort capacity of the fisheries and re-target fishing towards more productive blacktip whaler stocks in the Kimberley.

Implementation of the proposed new management arrangements has been delayed by negotiations by the Joint Authority (comprising the WA and Commonwealth ministers), although there has been lower than anticipated effort in the fisheries since 2005. This is mainly due to the closure of the WANCSF since 2005 under a Section 43 order.

Recent analyses of data relating to the status of northern shark stocks have identified additional sustainability concerns for multiple shark stocks taken by the northern shark fisheries, including the intended target stocks of blacktip sharks. Concerns for blacktip shark stock sustainability relate to new genetic research that suggests the species composition of the “stock” (or at least catches) has changed dramatically over the last three decades; questionable assumptions in the assessment model and inaccurate time-series of CPUE data (on which previous assessments have been based). Nominal CPUE data from the WANCSF prior to July 2005 also suggest that several other long-lived shark stocks may have been significantly depleted by a combination of documented and undocumented catches by domestic target and non-target fisheries and illegal foreign fishing vessels. Other stakeholders

have also expressed concerns about mackerel stock sustainability and broader ecological impacts from increased pelagic gillnetting off the Kimberley and Pilbara coasts. In 2008 the JANSF's Wildlife Trade Operation (WTO) export approval was revoked by the Minister for the Environment, Water Heritage and the Arts. The WTO for the WANCSF expired in 2009.

Relevant Resource Assets and Risks from Fishery

Statewide North-West Sharks	High Risk
North Coast Listed Species	Low Risk
North Coast Habitat	Low Risk
North Coast Ecosystems	Low Risk

Summary of historical research completed

Research to monitor the status of northern shark stocks was initiated as an extension of the south and west coast shark research project. A three-year FRDC funded project, provided an age-structured demographic assessment of the fisheries' principal target species (sandbar shark) and an improved general understanding of the fisheries and the biology of northern shark stocks. Additional information from the WANCSF and other fisheries that are permitted to land sharks on the north coast was collected during a series of NHT and FRDC funded research projects that began in 1999. Results from those projects, which have been published in several project reports, have further improved our understanding of the various elasmobranch sustainability risks across the northern half of Australia.

Current Research Focus

Demonstrating the ecological sustainability of the northern shark fisheries is dependent on establishing robust estimates of sustainable harvest levels for target, byproduct and bycatch species. In particular, issues associated with blacktip shark, sandbar shark and mackerel catches, as well as Endangered, Threatened and Protected (ETP) species interactions require careful evaluation. Further research to estimate key biological parameters and fishing mortality rates for numerous species would therefore be required as a high priority if the proposed transition to pelagic gillnets was to proceed. To support these requirements and to facilitate the proposed fishery management arrangements, a new daily/trip catch and effort reporting system was introduced in 2006/07. The transition to this new reporting regime proved problematic for some fishers and discrepancies were identified in the logbook data reported for 2006/07, 2007/08 and 2008/09. New data validation procedures have been developed and catch and effort statistics for 2006/07 – 2008/09 have been recovered. All reporting issues have been addressed.

A new FRDC project commenced in late 2010 examining the spatial movement of commercially important shark species. It is due for completion in 2015.

Priority Setting Process

Priorities are reviewed on an annual basis through consultation between scientists of the Finfish Branch (Research Division) and fishery managers during the annual review of FishPlan. Additionally, research priorities may be identified by the Northern Science and Management Working Group, NAFM and through external processes (e.g. National Shark Recovery Group, EPBC approval, NPOA, etc.).

Review Timeline

Independent scientific reviews of the sandbar shark stock assessment were completed in 2005 (Professor Carl Walters) and 2007 (ICES Journal of Marine Science). A comprehensive review of Sharks and Rays (Chondrichthyans) in the North-west Marine Region was undertaken for the Department of the Environment, Water, Heritage and the Arts in 2007 (Heupel and McAuley 2007). Blacktip shark stocks (common and Australian) and the spot-tail shark stock were last assessed in 2013 by the Northern Territory (Grubert *et al.* 2013). The information from the Northern Territory Assessment, plus Western Australian fishery data and other data were independently reviewed in 2014 for the Department of Fisheries, WA. This fishery was last reviewed as part of the MSC pre-assessment in 2014.

Recent Publications

Grubert, M.A., Saunders, T.M., Martin, J.M., Lee, H.S., Walters, C.J. (2013). Stock Assessments of Selected Northern Territory Fishes. Northern Territory Government, Australia. Fishery Report No. 110.

Given the small amount of activity no matrix is provided.

North Coast – Northern Prawn Managed Fisheries

Description and Scope of Fisheries

There are a number of small prawn fisheries in the north coast region. The Onslow Prawn Managed Fishery (OPMF) and the Nickol Bay Prawn Managed Fishery (NBPMF) operate along the western part of the North-West Shelf. The OPMF targets western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus* spp.), whereas the NBPMF primarily targets banana prawns (*Penaeus merguensis*). The Broome Prawn Managed Fishery (BPMF) operates in a designated trawl zone off Broome and targets western king prawns and coral prawns (a combined category of small penaeid species). The Kimberley Prawn Managed Fishery (KPMF) operates off the north of the state between Koolan Island and Cape Londonderry. It predominantly targets banana prawns but also catches tiger prawns, endeavour prawns and western king prawns. All fishing is undertaken using low opening otter trawl systems.

Relevant Resource Assets and Risks from Fishery

North Coast Shelf Crustaceans	Moderate Risk
North Coast Listed Species	Low Risk
North Coast Habitat – Pilbara	Low Risk
North Coast Habitat – Kimberley	Low Risk
North Coast Ecosystems	Low Risk

Summary of historical research completed

The biology of western king and brown tiger prawns was completed in other fisheries within the state in the 1970s. Some research on the biology, including the distribution and life history of the banana prawn and endeavour prawn has been completed in northern Australia by CSIRO and QDPI.

The defined trawling area for the BPMF was surveyed by Department of Fisheries Research Division and industry divers prior to establishing the boundaries to ensure minimal impact on the adjacent pearl fishery habitats. The relationship between catch and moon phase was investigated during 1997/98 which resulted in modification of management arrangements to optimise fishing times (catch rates) over the new moons. Some opportunistic data has been collected on bycatch species (also in the NBPMF) and exploratory trawling outside the 'box' have been undertaken in recent years to determine if alternative trawl habitats are available to supplement low prawn stocks.

Between 2002 and 2005 bycatch reduction devices (BRDs) were implemented in these fisheries. An FRDC-funded project was finalised on the biodiversity of bycatch in trawled and untrawled areas within part of the Onslow fishery in 2007 (Kangas *et al.* 2007¹).

Current Research Focus

Research programs are focused to underpin the sustainable management of these small fisheries involves stock monitoring and assessment utilising information from daily logbooks catch unload data provided by industry and information from boat skippers. Preliminary biomass dynamic models were developed for the KPMF, ONPMF and NBPMG as part of the MSC pre-assessment process for these fisheries in 2013.

From the NBPMF and KPMF, annual rainfall records (December to March) are also used to update the rainfall-catch relationship for banana prawns and provides for an annual catch prediction.

For the BPMF, daily logbooks have been compulsory since its inception and a depletion analysis is usually undertaken which assists in the assessment of the western king prawn stocks within the permitted fishing area. In the last six years this has not been undertaken due to extremely low effort (and associated catch) in this fishery.

Proposed or Possible Research Initiatives

- Coral prawn biology – mainly for BPMF
- Bycatch monitoring

Priority Setting Process

Initial assessments were made through internal departmental meetings in 1998 discussing research undertaken, current research and research and development gaps and a plan was drafted for five years. Regular meetings (at least annually) have been held with the Research Division and industry to discuss research priorities and planning. The comprehensive EPBC assessment of each fishery has determined that performance should be reported annually against measures relating to the breeding stocks of target prawn species (banana, tiger, king

¹ Kangas, M.I., Morrison, S., Unsworth, P., Lai, E., Wright I., Thomson A. (2007). Development of biodiversity and habitat monitoring systems for key trawl fisheries in Western Australia. Final FRDC Report on Project No. 2002/038. Fisheries Research Report No 160. Department of Fisheries, Western Australia. 333 pp.

and coral). The most recent Industry, WAFIC, Departmental meeting was held in March 2014.

Review Timeline

Early research and publications on the biology and spawning stock stock recruitment and environment relationships have been peer reviewed.

The five-yearly re-assessment for export accreditation under the EPBC Act by the Commonwealth Department of the Environment has recently been completed for the NBPMF, OPMF, KPFM and BPFM and export approval has been granted until 20 August 2015 for all fisheries under the one approval.

The fisheries underwent MSC pre-assessment in 2013.

Recent Publications

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

Key to symbols in the summary matrix:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

Northern Prawn Managed Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
King prawn biology	Complete						Completed in the 1970-1980s
Coral prawn biology	Possible						Low risk - mainly for BPFM
Banana prawn biology	Minimal						Mainly for KPFM and NBPMF, occasionally caught in higher numbers in OPMF, opportunistic sampling in NBPMF
Brown tiger prawn biology	Complete						Completed in 1970-1990s
Endeavour prawn biology	Minimal						Low risk
1.2 Other Biology							
Biology of bugs	Complete						Desktop study done
1.3 Stock Assessment							
Catchability of king prawns - lunar phase	Ongoing	■	■	■	■	■	For BPFM
Depletion Analysis	Ongoing	■	■	■	■	■	When appropriate for BPFM
C&E stock assessment	Ongoing	■	■	■	■	■	All northern prawn fisheries
Environmental impacts on recruitment	Ongoing	■	■	■	■	■	All northern prawn fisheries
1.4 Fishery Monitoring							
Logbooks	Ongoing	■	■	■	■	■	All northern prawn fisheries
Processor returns	Ongoing	■	■	■	■	■	All northern prawn fisheries

Northern Prawn Managed Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Pre-season skipper briefings	Ongoing	■	■	■	■	■	When possible
Database maintenance	Ongoing	■	■	■	■	■	All northern prawn fisheries
Effort impact assessment (GIS)	Ongoing	■	■	■	■	■	EPBC requirement
2. Habitat & Ecosystem							
2.1 Bycatch							
BRD implementation (grids)	Complete						Completed in 2004
BRD implementation (secondary devices)	Complete						Further evaluation/trialling may take place
Bycatch monitoring	Periodic/ Possible						Limited-opportunistic, review every 5 years
2.2 Listed Species							
Listed species interactions - logbooks	Ongoing	■	■	■	■	■	EPBC requirement/MOU with DoE underway
2.3 Habitat							
Habitat/effort impacts	Ongoing	■	■	■	■	■	EPBC requirement
Habitat mapping outside 'box'	Complete						For BPMF, no significant areas identified in 2007.
2.4 Ecosystem/Environment							
Formal risk assessment	Periodic		■				EPBC requirement
2.5 Oceanography	Not needed						None identified
2.6 Other impacts on fishery	Not needed						None identified
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)							
Byproduct	Ongoing	■	■	■	■	■	For all northern prawn fisheries
Marine Park Planning	Ongoing	■	■	■	■	■	For all northern prawn fisheries - research advice on impacts to fisheries
Resource development	Ongoing	■	■	■	■	■	Research advice on impacts to fisheries by resource developments in northern regions
3.3 Compliance Research							
VMS	Ongoing	■	■	■	■	■	
3.4 Management Systems							
375 rule/unitisation	Underway						
Size Management Areas and Permanent Closures	Underway						Implemented in OPMF and KPMF, consultation with licensees required for the NBPMF.
Gear development/changes	Ongoing	■	■	■	■	■	For all northern prawn fisheries
Latent effort/effort trends	Underway						For the KPMF
4. Industry Development							
5. Stakeholder Consultation and Reviews							
Annual Management Meetings	Ongoing	■	■	■	■	■	
MSC	Complete						Pre-assessments 2013.
Other	Periodic		■				EPBC re-assessment is in 2015

North Coast – Crab Fisheries

Description and Scope of Fishery

The blue swimmer crab (*Portunus armatus*) is found along the entire WA coast in a wide range of inshore and continental shelf areas, from the inter-tidal zone to at least 50 metres in depth. In the North Coast Bioregion, crabbing for blue swimmer crabs along the Pilbara coast occurs as part of the Pilbara Developing Crab Fishery which spans the inshore waters from Onslow through to Port Hedland, with most commercial and recreational activity taking place in and around Nickol Bay.

The Pilbara Developing Crab Fishery was first developed in 2001 via the Developing New Fisheries process, with one exemption holder currently operating up to a maximum of 400 traps for catching blue swimmer crabs. The Onslow and Nickol Bay prawn trawl fisheries also retain blue swimmer crabs as by-product.

Two species of mud crab, the green mud crab (*Scylla serrata*) and brown mud crab (*Scylla olivacea*), occur in WA. The green mud crab is predominantly found in estuarine habitats in north-western Australia from the Northern Territory (NT) border to Shark Bay, whilst 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 Kimberley Developing Mud Crab Fishery is currently a small developing fishery that targets green and brown mud crabs using of crab traps between Broome and Cambridge Gulf near the WA/NT border. Fishing effort is concentrated around Cambridge Gulf, Admiralty Gulf, York Sound and King Sound. There are currently three commercial operators and two Aboriginal corporations holding exemptions to fish for mud crabs in WA.

Relevant Resource Assets and Risks from Fishery

North Coast Nearshore Crustaceans (Crabs)	Low Risk
North Coast Listed Species	Negligible Risk
North Coast Habitats	Negligible Risk
North Coast Ecosystems	Negligible Risk

Summary of historical research completed

Blue swimmer crabs: Some base-line information on the biology and ecology of blue swimmer crabs has been generated by a number of FRDC-funded projects conducted by the Department and Murdoch University over the past few decades.

Mud crabs: Relevant research information for mud crabs is sourced from two recent FRDC funded projects involving NT Fisheries investigating escape gap sizes of traps (Grubert and Lee 2012) and environmental correlations with mud crab catches in Australia (Meynecke *et al.* 2010). A third FRDC project has also been recently completed on equipping the mud crab industry with innovative skills through extension of best practice handling (Poole *et al.* 2012).

Current Research Focus

Data for assessing the blue swimmer crab and mud crab stocks in the North Coast Bioregion is obtained from trap fishers' compulsory monthly catch and effort returns and daily research

logbooks (and, in the case of blue swimmer crabs, trawl fishers' daily logbooks).

There is currently no research monitoring in the Pilbara Developing Crab Fishery, although limited commercial monitoring has been undertaken in the past in the Nickol Bay area. There is currently no research monitoring in the Kimberley Developing Mud Crab Fishery. Logbooks are required to be submitted in both fisheries as part of the Exemptions, although this data is not considered to be reliable. Statewide surveys of boat-based recreational fishing provide estimates on crab catches by boat-based recreational fishers in the North Coast Bioregion.

Priority Setting Process

Research priorities are set in consultation with management, and feedback obtained during meetings with industry groups and major stakeholders (WAFIC, Recfishwest) as required.

Both the Pilbara Developing Crab Fishery and the Kimberley Developing Mud Crab Fishery are transitioning to interim-managed fisheries in 2015.

Review Timeline

The Pilbara Developing Crab Fishery was formally (externally) reviewed in mid-2007 by the Developing Fisheries Assessment Committee (DFAC) as part of the 'Developing New Fisheries' process.

Both the Pilbara Developing Crab Fishery and the Kimberley Developing Mud Crab Fishery were more recently reviewed as part of the MSC pre-assessments of North Coast Bioregion fisheries in 2013.

Recent Publications

Grubert, M.A., Lee, H.-S. (2012). Improving gear selectivity in Australian mud crab fisheries. Northern Territory Department of Resources Fishery Report.

Poole, S., Mayze, J., Calogeras, C. (2012). Equipping the mud crab industry with innovative skills through extension of best practice handling. Report on FRDC Project 2010/302. 183 pp.

Meynecke, J-O., Lee, S-Y., Grubert, M., Brown, I., Montgomery, S., Gribble, N., Johnston, D., Gillson, D. (2010). Evaluating the environmental drivers of mud crab (*Scylla serrata*) catches in Australia. Report on FRDC Project No. 2002/012. Griffith University.

Given the small amount of activity no matrix is provided.

North Coast – Trochus Managed Fishery

Description and Scope of Issues

The North Coast Trochus Fishery officially began operating in 1980 and is located in State waters at One Arm Point on the Dampier Peninsula and Buccaneer Archipelago, north of Broome. Harvest of trochus is managed by a single entity, “Ardyaloon Incorporated”, which is the commercial arm of the Ardyaloon Aboriginal Community Council, located at One Arm Point, representing the Bardi Jawi and Mayala Native Title holders. The management arrangements for the Trochus Fishery include restrictions on the area from which trochus can be harvested, including two community-initiated area closures within the Native Title areas, seasonal closures from 1 June to 31 October each year, minimum and maximum size limits to protect juvenile and breeding stocks, an annual conservative quota of 15 tonnes, and biologically sustainable reference points, which include a catch limit of 72 tonnes, and a catch target of 37 tonnes. These management arrangements have been developed through a co-management approach between DoF and Ardyaloon Incorporated.

The Trochus Fishery is small and based on a single target species (*Tectus niloticus*). There are no by-product species retained within the fishery because all trochus are individually targeted and collected by hand.

Relevant Resource Assets and Risks from Fishery

North Coast Molluscs	Low Risk
North Coast Protected Species	Negligible Risk
North Coast Habitat	Negligible Risk
North Coast Ecosystems	Negligible Risk

Summary of historical research completed

Population biomass surveys and fishery assessments were undertaken between 1990 and 1994, and in 2007, and a significant review of the first 15 years of the fishery was undertaken in the mid-1990s. The daily catch and effort logbook gives full coverage of all fishing activities and there are occasional fishery independent surveys undertaken to estimate overall stock biomass and improve knowledge of the biology of trochus stocks.

Current Research Focus

The North Coast Trochus stocks are assessed each year using annual indices of catch and comparing these to the specified reference points. A biomass dynamics model is also applied to the catch and catch rate data to obtain an estimate of MSY.

Priority Setting Process

Meetings between the Department of Fisheries and industry

Review Timeline

The Fisheries Research Division reviews the fishery and stocks annually in January/February.

Key to symbols in the summary matrix:

- Indicates that the activity is funded and planned to occur.
- Indicates that the activity is part of a proposal but is not yet funded.

North Coast Trochus Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of indicator species (Growth, Reproduction, Diet, Natural mortality)							Life-history parameters have been well studied in this species
Growth	Completed						
Reproduction	Completed						
Size-at-maturity	Completed						
1.2 Other Biology							
Genetics	Completed						
1.3 Stock Assessment							
Baseline Fishery independent surveys	Completed						Population biomass surveys and fishery assessments were undertaken between 1990 and 1994, and in 2007
Sustainability of stocks	Ongoing	■	■	■	■	■	Catch rate, length-frequency monitoring, and stock status assessments carried out annually
Population survey	Planned			■	■		Periodic assessments of this stock since 1991
1.4 Fishery Monitoring							
Research logbook implementation	Ongoing	■	■	■	■	■	Daily logbook since 2008.
2. Habitat & Ecosystem							
2.1 Bycatch							Negligible Risk
2.2 Listed Species							Negligible Risk
2.3 Habitat							Negligible Risk
2.4 Ecosystem/Environment							Negligible risk
2.5 Oceanography							
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic	Not needed						Fishery is an indigenous fishery operating under a single license
3.2 Resource Access (Shares)	NA						
3.3 Compliance Research	NA						
3.4 Management Systems	Ongoing	■	■	■	■	■	Management focus will escalate if fishery attempts to attain MSC certification
4. Industry Development							Lack of appropriate markets for trochus shell currently an issue for industry
5. Stakeholder Consultation and Reviews							
Annual Management Meeting		■	■	■	■	■	
MSC	Complete						Pre-assessments 2014
Other							

South Coast Bioregion

South Coast – Biodiversity Issues

Description and Scope of Issues

The inshore marine habitats of the south coast are largely unaffected by human activities, the exceptions being some estuaries and marine embayments (e.g. Princess Royal Harbour and Wilson Inlet) where significant eutrophication associated with farming has occurred. There are few fishing operations in this region that directly impact on marine habitats with only one very small scallop trawl fishery focused in small localised areas along the coastline east of Albany to Israelite Bay. There are reef protected area closures that cover the *Sanko Harvest* wreck site, the end of the old Esperance Jetty and the HMAS *Perth* wreck site. This region has been the focus of a number of marine planning exercises from NRM, DPaW and most recently SEWPaC. The latter is in the process of determining potential closures as part of the Commonwealths' Marine Bioregional Planning processes.

Relevant Resource Assets and Risks from all Fishing Activities

South Coast Benthic Habitats - Nearshore & Estuaries	Low Risk
South Coast Benthic Habitats - Shelf	Negligible Risk
South Coast Protected species - Non-fish	Moderate Risk
South Coast Protected species - Mammals	Moderate Risk
South Coast Protected species - Fish	Negligible Risk
South Coast Ecosystem - Eucla	Negligible Risk
South Coast Ecosystem - Estuarine	Moderate Risk
South Coast Ecosystem - Marine	Low Risk

Summary of historical research completed

The Marine Futures project habitat mapping and biodiversity sampling was undertaken. Information regarding the status of introduced marine pest species (IMPs) on the south coast has been gathered at the ports of Albany and Esperance. The SEWPaC process generated some research summaries of the key ecological features in this region. A WAMSI project determined cumulative bycatch taken by various fisheries in this region in order to develop an appropriate long term monitoring scheme and better understand the level of impact of interactions between fisheries and bycatch species, particularly protected and endangered species.

Current Research Focus

- Input to SEWPaC's south-west Marine Bioregional planning.
- To develop and implement a monitoring program for Walpole and Nornalup Inlets Marine Park

Recent Publications

Molony, B.W., Newman, S.J., Joll, L., Lenanton, R.C.J. and Wise, B. (2011). Are West Australian waters the least productive waters for finfish across two oceans? A review with a focus on finfish resources in the Kimberley region and North Coast Bioregion. *Journal of the Royal Society of Western Australia* 94: 323-332.

Evans, R., Molony, B. (2010). Ranked Risk Assessment for bycatch in multiple fisheries: a Bioregional risk assessment method. Fisheries Research Report No 212. Department of Fisheries, Western Australia. 88 pp.

Priority Setting Process and Review Timeline

No formal process in place.

Given the small amount of activity no matrix is provided.

South Coast – Greenlip and Brownlip Abalone Fishery

Description and Scope of Issues

The commercial abalone fishery on the south coast of WA is a dive fishery operating in shallow coastal waters along WA's western and southern coasts and is divided into eight management areas. The fishery targets three species: greenlip abalone, brownlip abalone and to a lesser degree in this bioregion, Roe's abalone. This quota based fishery operates using a sophisticated suite of management arrangements. A number of predictive systems have resulted in the maintenance of abalone stocks and a profitable fishery.

Relevant Resource Assets and Risks from Fishery

South Coast Molluscs	Moderate Risk
South Coast Listed Species	Negligible Risk
South Coast Habitats	Negligible Risk
South Coast Ecosystems	Negligible Risk

Summary of historical research completed

An extensive amount of research on the biology and stock status of greenlip abalone has been undertaken to support the management of this fishery. The basic biology (growth, reproduction, maturity) and ecological studies (population densities, settlement and recruitment) have been completed by researchers from the WA Museum in the 1990s, and the Department of Fisheries in the 1990s and 2000s. Major relevant work has also been completed for greenlip abalone in South Australia.

Hatchery, nursery, and grow-out culture systems to support aquaculture of greenlip abalone have also been extensively researched by the Department of Fisheries during the early 2000s. An FRDC-funded disease survey of entire Australian abalone stocks was completed in 2006.

State-wide phone diary surveys were undertaken in 2004/05 and 2006/07 to provide estimates of the recreational catch of greenlip and brownlip abalone. For each survey, around 500 licence holders were randomly selected from the licensing database, with selection stratified by licence type (abalone or umbrella) and respondent location (country or Perth metropolitan area). The licence holders were sent a diary to record their fishing activity and were contacted every 3 months by telephone for the duration of the abalone season.

Using historical time series of daily catch information has enabled an annual standardized catch per unit effort (CPUE) model to be developed that accounts for variation in spatial and temporal fishing effects, as well as technological improvements that aid fishing efficiency for use in a decision-rule framework.

Current Research Focus

Current research is focused on stock assessment using catch and effort statistics, meat weight indices, length-frequency sampling, and stock surveys. Commercial abalone divers provide daily catch information on the weight and number of abalone collected, and effort in hours fished. The divers also supply a random selection of abalone shells from each fishing day, and these are measured and used to estimate fishing mortality. Fishery-independent surveys are undertaken by research staff who survey the main fishery areas (Cape Arid and Augusta regions) every year, and other areas every two years.

An annual CPUE model that takes into account diver, sub-area and month of fishing as well as technological improvements, is used to assess long term fishery trends. These trends are then applied in a harvest control rule to set annual TACCs (Total Allowable Commercial Catches). A new tag-recapture study of brownlip abalone (*Haliotis conicopora*) growth and mortality was initiated in 2009. Results will be used to assess stocks and estimate fishing mortality in this fishery.

The Department currently has two externally funded research projects:

- Seafood CRC 2009/710: Bioeconomic evaluation of commercial scale stock enhancement in abalone.
- FRDC 2012/016: Demographic performance of brownlip abalone: exploration of wild and cultured harvest potential.

The projects involve investigation into breeding and release of hatchery-reared juvenile abalone into the wild; determination of abalone growth and survival for the assessment of commercial scale stock recovery and stock enhancement. In addition, the use of hatchery-reared animals has become a routine assessment tool in WA's abalone fisheries, because of the high quality information that is obtained from enhancement experiments. For example, the release of animals of known age allows direct estimates of natural and fishing mortality, while the use of density experiments improves the understanding of key ecological limitations such as the carrying capacity of the natural ecosystem.

Proposed or Possible Research Initiatives

- Brownlip abalone growth and mortality
- Innovative approaches to enhancing productivity in abalone fisheries

Priority Setting Process

Annual meetings are held between the Department of Fisheries and the commercial abalone industry. Input on the recreational program has been obtained from the RFAC and the IFAAC groups.

Review Timeline

The fishery and stocks are reviewed annually, with quota decisions made each February. A mid-season research update is carried out during August - September. The research associated with this fishery was externally reviewed by SARDI (South Australian Research and Development Institute) in October 2010.

Recent Publications

Hart, A.M., Fabris, F.P., Brown, J., Caputi, N. (2013a). Biology, history, and assessment of Western Australian abalone fisheries. Fisheries Research Report No 241. Department of Fisheries, Western Australia, 90

Hart, A.M., Strain, L., Fabris, F., Brown, J., Davidson, M. (2013b). Stock enhancement of greenlip abalone: (1): Long-term growth and mortality. *Reviews in Fisheries Science* 21: 299-309

Hart, A.M., Fabris, F., Murphy, D., Brown, J., Strain, M., Davidson, M., (2013c). Stock enhancement of greenlip abalone: (2): Population and ecological effects. *Reviews in Fisheries Science* 21: 310-320.

Hart, A.M., Strain, L.W.S., Hesp, A. (2013d). Stock enhancement of greenlip abalone: (3): Bioeconomic evaluation. *Reviews in Fisheries Science* 21: 354-374.

Mayfield, S., Mundy, C., Gorfine, H., Hart, A.M., Worthington, D. (2012). Fifty years of sustained production from the Australian abalone fisheries. *Reviews in Fisheries Science* 24: 220-250.

Key to symbols in the summary matrix:

■ Indicates that the activity is funded and planned to occur.

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South Coast Abalone Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Roe's biology - growth etc.	Complete						Sufficient for management
Growth rate of greenlip abalone – spatial, juveniles (hatchery)	Complete						Growth recapture studies completed
Greenlip abalone reproduction/fecundity, spawning periodicity	Complete						Research by the Museum and Department of Fisheries completed in the 1990s

South Coast Abalone Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Disease survey/atlas	Complete						FRDC-funded survey of entire Australian abalone stocks completed in 2006
Greenlip abalone - early juvenile life history and habitat, natural mortality and predation	Ongoing	■	■	■	■	■	Large scale experiments on released animals underway
Brownlip abalone growth and mortality	Proposed						
1.2 Other Biology							
Environmental effects on recruitment	Ongoing	■	■	■	■	■	Long-term datasets on annual recruitment and relevant environmental factors are being developed
1.3 Stock Assessment							
Catch statistics (wildstock)	Ongoing	■	■	■	■	■	40 years of catch and effort statistics
Mapping of areas	Complete						FRDC funded project using GPS trackers, headed up by TAFI
Fishing efficiency	Ongoing	■	■	■	■	■	Environmental and technological factors continually monitored
Commercial length frequency monitoring	Ongoing	■	■	■	■	■	Catch sampling from industry used to estimate F
Population dynamics and harvest strategy assessment model	Ongoing	■	■	■	■	■	Model under development
Recreational impact	Ongoing	■	■	■	■	■	Annual monitoring of recreational catch
Yield and egg-per-recruit analysis for size limits	Complete						
1.4 Fishery Monitoring							
Research monitoring and recruitment sites	Ongoing	■	■	■	■	■	100 sites annually, 80-100 surveyed every two years
Industry video monitoring sites	Ongoing	■	■	■	■	■	50 to 70 sites surveyed annually
2. Habitat & Ecosystem							
2.1 Bycatch	Not needed						No Bycatch
2.2 Listed Species	Not needed						No interactions
2.3 Habitat	Not needed						Low risk
2.4 Ecosystem/Environment	Not needed						Low risk
Abalone Health - Contingency plan and monitoring and diagnosis	Ongoing	■	■	■	■	■	
2.5 Oceanography							
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)							
3.3 Compliance Research							
3.4 Management Systems							
Translocation/protocol	Ongoing	■	■	■	■	■	
4. Industry Development							
4.1 Production Technology							
Hatchery and grow out	Complete						Work in the 1990s
Stock enhancement	Underway	■	■				CRC project

South Coast Abalone Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
5. Stakeholder Consultation and Reviews							
Annual Management Meetings	Ongoing	■	■	■	■	■	
MSC	Complete	■					Pre-assessment in 2014
Other	Periodic						Externally reviewed in 2010. Major assessment reports peer reviewed.

South Coast – Crustacean Fisheries

Description and Scope of Issues

The south coast crustacean fisheries cover a series of pot-based fisheries, which operate from Windy Harbour to the South Australian border. They include Windy Harbour/Augusta Rock Lobster Managed Fishery, the Esperance Rock Lobster Managed Fishery (ERLF), the rock lobster pot fishery (a Regulation fishery) operating in the Albany and Great Australian Bight (GAB) sectors, and the deep-sea crab fishery (a Section 43 Order fishery). The fisheries are multi-species and take southern rock lobsters and western rock lobsters as well as deep sea crab species including giant crabs, crystal crabs and champagne crabs.

Relevant Resource Assets and Risks from Fishery

South Coast Crustaceans	Moderate Risk
South Coast Listed Species	Moderate Risk
South Coast Habitats	Negligible Risk
South Coast Ecosystems	Negligible Risk

Summary of historical research completed

Data on the biology of southern rock lobsters exists for South Australia, Victoria, Tasmania and New Zealand but little exists for WA. Biological data for these other areas need to be used with extreme caution because growth rates, L_{∞} , size at maturity and other variables are highly influenced by water temperature. A comprehensive study was undertaken on larval transport and recruitment processes of southern rock lobsters in Australia (Bruce *et al.* 2007¹). Modelling data produced by that study suggested that recruitment of southern rock lobsters in WA is largely supported by parent stock in this state and any contribution from the east is minimal.

Research has been undertaken on the biology of champagne crabs on the south coast (Smith *et al.* 2004²). Conditions on the south coast are not conducive for spawning by this species and females migrate from the south to lower west coast for spawning.

¹ Bruce, B., Griffin, D., Bradford, R. (2007). Larval transport and recruitment processes of southern rock lobster. FRDC Final Report on Project No. 2002/007. CSIRO, Hobart, Tasmania. 104 pp.

² Smith, K.D., Hall, N.G., Potter, I.C. (2004). Relative abundance and size composition of champagne crabs, *Hypothalassia acerba*, on two coasts and in difference water depths and

An evaluation of the crystal crab resources on the south coast has been undertaken (Chuwen and Stevens 2006¹). That report suggested potentially sustainable long term landings of 20 – 108 t depending on assumptions. The Department produced a different estimate of ~12 t, also with caveats attached (Melville-Smith and Thomson unpub. data).

Comparatively good data are available on the biology of giant crab in WA and in other areas of that species' distributional range (Levings *et al.* 2001²).

Current Research Focus

Only compulsory commercial catch and effort returns and a few voluntary catch log books are obtained from these fisheries. Given the downturn in southern rock lobster landings (which are the mainstay of the fishery) in recent years, there is a need for basic biological research to be undertaken, as well as for a regular length frequency monitoring program to be established.

Priority Setting Process

Internal Departmental Risk Assessment.

Review Timeline

The fishery has been reviewed as part of undergoing MSC pre-assessment in 2014.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

South Coast Crustacean Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Crystal crab biology	Preliminary						Information on growth, movement patterns, size at maturity, are available for stocks on the west coast (probably similar on south coast)
Reproduction champagne crabs	Complete						
Movement champagne crabs	Complete						Only some data
Movement giant crabs	Complete						
Reproduction giant crabs	Complete						
Growth data giant crabs	Complete						
Western rock lobster	Complete						
Southern rock lobster genetic stock structure	Ongoing	■	■	■			Supplying samples to a PhD student at UTas

seasons. Marine and Freshwater Research 55: 653-661.

1 Chuwen, B.M., Stevens, R. (2006). Evaluation of crystal crab (*Chaceon bicolor*) resources on the south coast of Western Australia. FRDC Final Report on Project No. 2003/077. 60 pp.

2 Levings, A., Mitchell, B.D., McGarvey, R., Mathews, J., Laurenson, L., Austin, C., Heeren, T., Murphy, N., Miller, A., Rowsell, M., Jones, P. (2001). Fisheries biology of the giant crab *Pseudocarcinus gigas*. Final Report to the FRDC for Projects 93/220 and 97/132. School of Ecology and Environment, Deakin University, Warrnambool. 388 pp.

South Coast Crustacean Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Southern rock lobster biology							Information is needed on size at maturity, growth rates, movement patterns
1.2 Other Biology	Nil						
1.3 Stock Assessment							
Annual assessment (all species)	Developing	■	■	■	■	■	Rudimentary
Crystal crabs	Preliminary						One-off survey funded by FRDC
1.4 Fishery Monitoring							
Commercial catch and effort	Ongoing	■	■	■	■	■	Only CAES; trip form to be developed for new management plan
Processor returns	Nil						
Commercial length frequency monitoring	Nil						At least some sampling is desirable for future monitoring of stocks
2. Habitat & Ecosystem							
2.1 Bycatch							
Finfish and sharks	Nil						Negligible risk
Octopus	Nil						Negligible risk
Spider crabs, hermit crabs, seastars	Nil						Negligible risk
Cuttlefish	Nil						Negligible risk
2.2 Listed Species							
Monitoring of seal and sea lion interactions	Ongoing	■	■	■	■	■	Low risk - SLEDs to be implemented as part of the new management plan
Monitoring of whale and dolphin interactions	Ongoing	■	■	■	■	■	Moderate risk - is being done as part of reducing whale entanglements in WA pot and line fisheries
2.3 Habitat	Nil						
2.4 Ecosystem/Environment							
Debris	Not needed						Negligible risk
2.5 Oceanography							
2.6 Other impacts on fishery	Nil						
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)							
3.3 Compliance Research							
3.4 Management Systems							
4. Industry Development							
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete	■	■	■	■	■	Pre-assessment in 2014
Internal risk assessment	Ongoing	■	■	■	■	■	

South Coast – Nearshore and Estuarine Finfish Resources

Description and Scope of Fishery

Estuaries: The finfish resources in South Coast estuaries are multi-sector (commercial, recreational and non-harvest) and multi-species. South Coast estuarine fisheries are small-scale and have relatively low commercial value but have high social, recreational and historical values. Most south coast estuaries are intermittently open to the sea. Therefore, recruitment by marine-spawned fish is determined by sand bar openings and water levels within each estuary, independent of estuarine fishing pressure. Cobbler (*Cnidoglanis macrocephalus*) and black bream (*Acanthopagrus butcheri*) are the only true estuarine species with discrete stocks in each estuary.

The South Coast Estuarine Managed Fishery (SCEMF) has 13 estuaries and inlets open to commercial fishing, with Wilson Inlet being the most important. The fishery captures cobbler, bream, sea mullet (*Mugil cephalus*), Australian herring (*Arripis georgianus*), King George whiting (*Sillaginodes punctata*), flathead (Platycephalidae), leatherjackets (Monacanthidae) and many other species. Recreational fishing occurs in each of the 25 major estuaries on the south coast, including those commercially fished. The recreational catch includes the same species as in the commercial catch (except cobbler which is rarely taken recreationally).

Nearshore: The Australian herring trap net fishery and the South Coast Salmon Managed Fishery (SCSMF) are the two main commercial fisheries operating in nearshore waters in the South Coast Bioregion. These commercial fishers mainly operate on beaches in the western portion of the Bioregion. The salmon and herring fisheries have historically been relatively large but the commercial catch and catch rates of both species on the South Coast have been declining since 2002 and have reached historically low levels in recent years. Recreational fishers in nearshore waters on the South Coast capture Australian herring, Australian salmon, trevally (*Pseudocaranx* spp.), King George whiting, southern school whiting (*Sillago bassensis*) tarwhine (*Rhabdosargus sarba*) and many other species.

Relevant Resource Assets and Risks from Fishery

South Coast Nearshore Finfish	High Risk
South Coast Estuarine Finfish	Moderate Risk
South Coast Listed Species	Negligible Risk
South Coast Habitats	Negligible Risk
South Coast Ecosystems	Negligible Risk

Summary of historical research completed

Estuaries: Since the 1970s, many biological research projects have been conducted in estuaries by universities (particularly Murdoch University) and the Department, which has provided a good understanding of the basic biology for all key fisheries species. The most recent estimates of recreational catches are from a on-site survey conducted by the Department in 17 estuaries/inlets in 2002/03.

Nearshore: The commercial fisheries for salmon and herring were established on the South Coast in the 1930s and 1940s, respectively. There is a substantial level of historical biological

and catch data available on these fisheries, including factory sampling and salmon logbook* information since the 1970s (*voluntary salmon logbooks discontinued due to low catch and effort in recent years). An FRDC project in the 1990s examined aspects of herring age, growth, reproduction and stock structure from which a stock assessment model for herring was developed but which still needs to be validated. Another FRDC project in the 1990s developed a method to monitor juvenile recruitment for Australian herring, salmon, mullet and whiting. Recruitment indices are used to predict fishery landings. A state-NRM funded project in 2009-2012 developed an annual sampling regime for herring to determine age structure of the breeding stock, from which the rate of fishing mortality (F) could be estimated. The sampling regime was adopted and F-based stock assessments for herring are now ongoing. The most recent estimates of shore-based recreational catches in nearshore waters are from the National Recreational and Indigenous Fishing Survey conducted in 2000/01.

Current Research Focus

Indicator species were selected for these resources using a risk assessment process. Indicators for estuaries are black bream (various estuaries) and cobbler (Wilson Inlet, Oyster Harbour) and sea mullet. Indicators for the nearshore suite are Australian salmon and Australian herring.

The status of nearshore and estuarine finfish stocks in the South Coast Bioregion are assessed using CAES data, voluntary recreational logbook (Research Angler Program) and fishery-independent surveys of annual recruitment for some species. Fishery data is limited for most south coast estuaries, especially in recreational-only estuaries. Trends in commercial catch and catch rates, where available, form the basis of estuarine assessments. Annual fishery-independent monitoring of cobbler recruitment in Wilson Inlet commenced in 2007/08. Sampling of the age structure of the Wilson Inlet cobbler catch commenced in 2009/10. The status of Australian herring is assessed from the level of fishing mortality relative to reference points, in conjunction with trends in recruitment and catch rate.

Murdoch University regularly undertakes ecological projects relating to fish in South Coast estuaries.

Proposed or Possible Research Initiatives

- Sea mullet – Examine stock structure, age structure & current biological parameters (growth rate, etc.) in WA
- Salmon – Examine age structure & current biological parameters; Develop new value-added products, low price for raw product; Develop new markets. Address negative public perception
- Benthic habitat quality – Environmental variation possible cause of cobbler stock fluctuations in Wilson Inlet
- Climate change, river flows & eutrophication
- Black bream – Stock enhancement
- Adaptive management – Responding to fluctuating stock levels due to recruitment, fish kills, bar openings, mainly bream
- Trial of commercial crab traps in some South Coast estuaries

Priority Setting Process

Priorities are reviewed on an annual basis through consultation between scientists of the Finfish Branch (Research Division) and fishery managers during the annual review of FishPlan. Discussions are also held between the Department of Fisheries, industry members and peak bodies (WAFIC, Recfishwest).

Review Timeline

An internal risk assessment of nearshore and estuarine finfish resources in the South Coast Bioregion was completed in 2009. The commercial fisheries were reviewed as part of the MSC pre-assessments in 2014.

Recent Publications

Brown, J., Dowling, C., Hesp, A., Smith, K., Molony, B. (2013). Status of nearshore finfish stocks in south-western Western Australia. Part 3: Whiting (Sillaginidae). Final NRM Report - Project No. 09003. Fisheries Research Report No. 248. Department of Fisheries, Western Australia.

Smith, K., Brown, J., Lewis, P., Dowling, C., Howard, A., Lenanton, R., Molony, B. (2013). Status of nearshore finfish stocks in south-western Western Australia. Part 1: Australian herring. Final NRM Report - Project No. 09003. Fisheries Research Report No. 246. Department of Fisheries, Western Australia.

Key to symbols in the summary matrix:

■ Indicates that the activity is funded and planned to occur.

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South Coast Estuarine and Inshore Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Australian herring	Complete	■	■	■	■	■	Adequate for management
Australian salmon	Complete	■	■	■	■	■	Adequate for management
Black bream	Complete	■	■	■	■	■	Adequate for management
Cobbler	Complete	■	■	■	■	■	Adequate for management
Sea mullet	Complete	■	■	■	■	■	Adequate for management
1.2 Other Biology							
Sea mullet	Proposed	○	○	○			Examine stock structure, age structure & current biological parameters (growth rate, etc.) in WA
Salmon	Proposed	○	○	○			Examine age structure & current biological parameters
1.3 Stock Assessment							
Annual trends in catch and CPUE	Ongoing	■	■	■	■	■	CAES data. Insufficient data to estimate recreational catch
Annual trends in juvenile recruitment	Ongoing	■	■	■	■	■	Fishery-independent annual trapping & beach seining programs

South Coast Estuarine and Inshore Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Age-based assessment using 'weight-of-evidence' approach (herring)	Ongoing	■	■	■	■	■	Otoliths collected (west & south coasts). NRM-funded project completed 2012
1.4 Fishery Monitoring							
Commercial catch & effort	Ongoing	■	■	■	■	■	CAES compulsory monthly catch & effort returns
State-wide survey of boat-based recreational fishing	Periodic		■		■		Biennial phone-diary survey
Voluntary recreational logbook	Ongoing	○	○	○	○	○	Research Angler Program (RAP). Not fully funded
Juvenile recruitment surveys	Ongoing	■	■	■	■	■	Annual trapping (cobbler) & beach seining (salmon, herring, mullet, others) programs
Observer program (salmon)	Underway						ESD requirement. Intermittent. Logistically difficult due to low & infrequent fishing operations & catches
Age structure monitoring	Ongoing	■	■	■	■	■	Herring (W & S coasts) & cobbler (Wilson Inlet)
2. Habitat & Ecosystem							
2.1 Bycatch	Not needed						Low risk
2.2 Listed Species	Not needed						Low risk
2.3 Habitat							
Benthic habitat quality	Possible						Environmental variation possible cause of cobbler stock fluctuations in Wilson Inlet
2.4 Ecosystem/Environment							
Climate change, river flows & eutrophication	Possible						Ecological flow requirements for estuaries are unclear. Flow effects on bream reproduction & early life history may be major determinant of recruitment success.
Fish Kills	Occasional						Respond to reports and investigate cause of fish kills. Opportunistic sampling, logistically difficult, limited resources available
2.5 Oceanography							
Leeuwin current monitoring	Ongoing	■	■	■	■	■	Influence on larval dispersal & recruitment
2.6 Other impacts on fishery	Not needed						Low risk
3. Management Analysis							
3.1 Socio-economic	Not needed						
3.2 Resource Access (Shares)	Not needed						
3.3 Compliance Research	Not needed						
3.4 Management Systems							
Stock enhancement	Possible						Black bream
Adaptive management	Possible						Mainly bream. Responding to fluctuating stock levels due to recruitment, fish kills, bar openings

South Coast Estuarine and Inshore Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
4. Industry Development							
4.1 Production Technology							
Trial of commercial crab traps in some South Coast estuaries	Proposed	O	O				For blue swimmer crabs
4.2 Post Harvest							
Salmon	Possible						Develop new value-added products. Low price for raw product
4.3 Marketing							
Salmon	Possible						Develop new markets. Address negative public perception
5. Stakeholder Consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Complete	■					Pre-assessment in 2014
Other	Periodic						

South Coast – Purse Seine Fishery

Description and Scope of Issues

The South Coast Purse Seine Managed Fishery is based on the capture of pilchards (*Sardinops sagax*) by purse seine nets. The fishery is divided into three primary management zones – Albany, Bremer Bay and Esperance. The management plan also covers the take of yellowtail scad (*Trachurus novaezelandiae*), Australian anchovy (*Engraulis australis*) and maray (*Etrumeus teres*). This fishery was the largest tonnage fishery during the late 1980s and early 1990s, until a pilchard virus hit in 1995 and 1998 which decimated stocks. The fishery is yet to fully recover.

Relevant Resource Assets and Risks from Fishery

South Coast Pelagic

Low Risk

Summary of historical research completed

An extensive set of studies were completed into the biology and stock assessment of pilchards for this fishery in the 1980s and 1990s. This included growth, ageing, plankton studies, stock assessment by age-structured modeling and daily egg production techniques. Monitoring of catches from each region was undertaken monthly to provide age-composition data, from which relative recruitment strengths could be inferred. Estimates from biomass surveys and age-composition data were integrated via an age-structured model to provide a robust estimate of pilchard biomass in each of the three management regions. The model outputs, along with analyses of catches, allowed the annual review of stocks in each major zone.

Following the mortality events in 1995/98, the Fish Health Unit assessed the identification and spread of the herpes virus (Jones 2006¹). Another project examined the recovery of the pilchard stocks using egg production methods to estimate biomass (Gaughan *et al.* 2008²).

Murdoch University and SeaNet examined the interaction between the fishery and Listed species, focusing on seabirds. The project examined the extent of interactions with wildlife (pinnipeds, cetaceans and seabirds) and potential mitigation methods to reduce these interactions. This project resulted in reductions in significant interactions via changes in fishery operations.

Current Research Focus

Current catches of all zones are currently below the TACs and the risk to the stocks is low. As a result, annual age-sampling and assessment of the stocks ceased in 2007 with the fishery monitored by statutory catch and effort data submitted by fishers.

Priority Setting Process

Priorities are reviewed on an annual basis through consultation between scientists of the Finfish Branch (Research Division) and fishery managers during the annual review of FishPlan.

Review Timeline

The science underpinning this fishery was extensively studied during the 1990s and 2000s. This fishery was last reviewed as part of the MSC pre-assessment in 2014.

Given the small amount of activity no matrix is provided.

South Coast – Temperate Demersal Gillnet and Demersal Longline Fisheries

Description and Scope of Issues

The Temperate Demersal Gillnet and Demersal Longline Fisheries (TDGDLF) comprise the state-managed West Coast Demersal Gillnet and Demersal Longline (interim managed) Fishery (WCDGDLF) and the Joint Authority Southern Demersal Gillnet and Demersal Longline Fishery (JASDGDLF), which is co-managed by the State and Commonwealth governments. Both fisheries are managed via limited entry, unitised input (effort) controls and gear-specification restrictions with most fishing by demersal gillnets. Catch limits are also being developed for catches of demersal fishes by the sector of this fishery that operates in the West Coast Bioregion.

¹ Jones, B., Crockford, M., Whittington, R., Crane, M., Wilcox, G. (2006). Aquatic animal health subprogram: pilchard herpesvirus infection in wild pilchards. FRDC Final Report on Project No. 2002/044. Department of Fisheries, Western Australia. 54 pp.

² Gaughan, D. J., Craine, M., Stephenson, P., Leary, T., Lewis, P. (2008). Regrowth of pilchard (*Sardinops sagax*) stocks off southern WA following the mass mortality event of 1989/99. FRDC Final Report on Project No. 2000/135. Fisheries Research Report No. 176. Department of Fisheries, Western Australia. 82 pp.

The main shark species targeted in the TDGDLF are gummy shark (*Mustelus antarcticus*), dusky shark (*Carcharhinus obscurus*), whiskery shark (*Furgaleus macki*) and sandbar shark (*Carcharhinus plumbeus*). On the south coast, operators primarily target gummy and dusky sharks, while dusky and sandbar sharks are targeted on the west coast. Whiskery sharks are an important component of the catch for both fisheries. These fisheries also capture a range of scalefish (teleosts) which accounting for 10 - 20% of total fishery landings.

Relevant Resource Assets and Risks from Fishery

Statewide South West Sharks	High Risk
South Coast Demersal Finfish	Moderate Risk
South Coast Listed Species	Negligible-low Risk
South Coast Habitats	Negligible Risk
South Coast Ecosystems	Negligible-low Risk

Summary of historical research completed

Major FRDC-funded studies to assess the biology and status of targeted shark stocks on the south and west coasts of Western Australia were undertaken over the period 1993–2004. These studies have provided a detailed basis for managing the fishery and the extensive biological and fishery information gained from these studies has been reported in three FRDC final reports and numerous international journal articles. These data have been used to develop stock assessment models for the fisheries' key target stocks and to determine their likely responses to current levels of exploitation and to test alternative harvest regimes. A database of DNA profiles from Listed and commercially important shark species and forensic sampling protocols have been developed for evidentiary purposes and NHT-funded studies of grey nurse shark movement and ecology have been undertaken.

Current Research Focus

Current research involves monitoring and analyses of fishing returns data and data from previous sampling of commercial catches. To support significant recent changes to fishery management arrangements, improve assessments of key stocks and to facilitate the more detailed reporting requirements of the fisheries' export accreditation under the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act, a new daily/trip catch and effort reporting system was introduced in 2006/07. After rectifying some initial problems this exercise generally improved reporting standards and has provided the basis for development and implementation of new catch and effort data validation protocols.

Tactical research is also completed on bycatch issues with TEP species. Two National Heritage Trust funded projects investigated movements and aggregation locations of grey nurse sharks (*Carcharias taurus*) and a recent FRDC-funded project examined the relative spatial risks of Australian sea lion (*Neophoca cinerea*) interactions with demersal gillnets. A further FRDC-funded study to estimate quantitative rates of Australian sea lion encounters with demersal gillnets was undertaken in 2010–11. WA Government-funded research into white shark (*Carcharodon carcharias*) movements around the south-west of Western Australia may also yield information on the ecology and population structure of this Listed species.

A four year FRDC-funded study of movements of the four indicator shark stocks commenced in 2011. Results from this study will be used to help in the reassessment of the status of the target species stocks enabling greater reference to their spatial and temporal dynamics. Therefore, several improvements will be undertaken over the coming years. The main outcomes of this project will be:

- Species-specific limit, threshold and target reference points
- New series of standardised CPUE series
- Quantification of movement rates among management areas
- Redevelopment of assessment models for the integration of the newly available information

Proposed or Possible Research Initiatives

- Wobbegongs – age & growth
- Pencil shark – age & growth
- Mercury and other contamination

Priority Setting Process

Priorities are reviewed on an annual basis through consultation between Scientists of the Finfish Branch (Research Division) and Fishery Managers during the annual review of FishPlan.

Review Timeline

A review of the assessment models and the performance of the fisheries is scheduled in 2014/2015. This fishery was last reviewed in as part of the Marine Stewardship Council (MSC) pre-assessment in 2014.

Recent Publications

Santana-Garcon, J., Braccini, M., Langlois, T. J., Newman, S. J., McAuley, R. B. & Harvey, E. S. (2014), Calibration of pelagic stereo-BRUVs and scientific longline surveys for sampling sharks. *Methods in Ecology and Evolution*, 5: 824–833.

O'Shea, O., Braccini, J.M., McAuley, R., Speed, C. & Meekan, M. (2013). Growth of tropical dasyatid rays estimated using a multi-analytical approach. *PLoS ONE* 8(10): e77194.

Key to symbols in the matrix/summary tables:

- Indicates that the activity is funded and planned to occur.
- Indicates that the activity is part of a proposal but is not yet funded.

South Coast Temperate Demersal Gillnet and Longline Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of indicator species (Growth, Reproduction, Diet, Natural mortality)							
Gummy shark	Completed						Reproduction complete, age & growth incomplete
Whiskery shark	Completed						There may be a need for the collection of new growth coefficient estimates
Dusky shark	Completed						
Sandbar shark	Completed						
1.2 Other Biology							
Wobbegongs	Proposed						Reproduction and diet complete; age & growth uncertain
Pencil shark	Proposed						Reproduction and diet complete; age & growth incomplete
Other spp. Biology	Ongoing						Further data collected opportunistically
Grey nurse ecology	Completed						
1.3 Stock Assessment							
Commercial catch and effort analysis	Ongoing	■	■	■	■	■	FRDC funded project 2010/003.
Biological reference points	Ongoing	■					FRDC funded project 2010/003.
Gummy	Ongoing	■	■				FRDC funded project 2010/003. Due for completion in mid 2015
Whiskery	Ongoing	■	■				FRDC funded project 2010/003. Due for completion in mid 2015
Dusky	Ongoing	■	■				FRDC funded project 2010/003. Due for completion in mid 2015
Sandbar	Ongoing	■	■				FRDC funded project 2010/003. Due for completion in mid 2015.
1.4 Fishery Monitoring							
Daily logbook development & analysis	Ongoing	■	■	■	■	■	
VMS	Ongoing	■	■				All vessels (>6.5m) are now fitted with ALCs. VMS is used to monitor and acquit entitlement
2. Habitat & Ecosystem							
2.1 Bycatch							
Finfish & Elasmobranchs	Completed						WAMSI cumulative risk assessment completed
2.2 Listed Species							
Pinnipeds	Completed						Murdoch University led FRDC project finalised.
Australian sea lion	Ongoing	■					ASLWG established ,working with DotE in regard to WTO conditions
Other: Dolphins, Turtles, Grey nurse shark, White shark	Completed						WAMSI cumulative risk assessment completed
White shark	Ongoing	■	■				Government-funded initiatives underway including the collection of movement data via tagging.
2.3 Habitat							Low Risk
2.4 Ecosystem/Environment							Low Risk
2.5 Oceanography							

South Coast Temperate Demersal Gillnet and Longline Fisheries Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
2.6 Other impacts on fishery							
Catch in Commonwealth Fisheries, including retained catches and bycatch	Ongoing						Via involvement in Commonwealth Shark Resource Assessment Group. Monitor level of effort of the Commonwealth Trawl fisheries in the South-west as potential risk to dusky and sandbar breeding stocks.
Statewide survey of boat-based recreational fishing	Ongoing		■		■		Biennial phone-diary survey
3. Management Analysis							
3.1 Socio-economic							
Mercury and other contamination	Proposed						
3.2 Resource Access (Shares)							
Detailed determination of access shares	Proposed						Needed for IFM
Monitoring of shares	Proposed						Needed for IFM
3.3 Compliance Research							
3.4 Management Systems							
Catch and effort triggers	Ongoing	■	■	■			FRDC funded project 2010/003.
National Plan of Action (NPOA) for the conservation and management of sharks	Ongoing						Input as required. Includes input to Protected Species Recovery Plans and
EPBC Act export approval assessments	Ongoing	■					Current WTO
4. Industry Development							
5. Stakeholder consultation and Reviews							
Annual Management Meeting	Ongoing	■	■	■	■	■	
MSC	Completed	■					Pre-assessment in 2014.
Other	Periodic	■					Review of the assessment models and the performance of the fisheries

South Coast – Demersal Scalefish Fishery

Description and Scope of Issues

Commercial

This fishery includes wetline fishers using handlines and droplines from vessels up to about 15 m in length in oceanic waters of the South Coast Bioregion. It targets mainly demersal scalefish species, including snapper (*Chrysophrys auratus*), Bight redfish (*Centroberyx gerrardi*) and hapuku (*Polyprion oxygeneios*). A small component of the catch is taken by net and fish trap. It excludes the Temperate Demersal Gillnet and Demersal Longline Fishery

operating in the South Coast Bioregion (see Demersal Gillnet and Longline Fisheries Status Report).

Recreational

Recreational fishers, mostly using line-based fishing methods from boats, also target demersal scalefish in the South Coast Bioregion. Statewide surveys of boat-based recreational fishing were undertaken in 2011/12.

Relevant Resource Assets and Risks from Fishery

South Coast Demersal Scalefish	Moderate Risk
South Coast Listed Species	Negligible Risk
South Coast Habitats	Negligible Risk
South Coast Ecosystems	Negligible Risk

Summary of historical research completed

Research on the growth, age composition and reproductive biology of snapper and hapuku in the South Coast Bioregion has been completed. The biology of other retained species, such as western blue groper (*Achoerodus gouldii*), blue morwong (*Nemadactylus valenciennesi*) and Samson fish (*Serriola hippos*), has also been studied.

Current Research Focus

Age structure data collected from the commercial and recreational catches of snapper and Bight redfish in 2013 and 2014 will result in the publication of a stock assessment in 2015. The stock structure of Bight redfish is being investigated through a simultaneous study of the otolith chemistry and genetics of this species.

Priority Setting Process

Priorities are reviewed on an annual basis via internal consultation between Scientists of the Finfish Branch (Research Division) and Fishery Managers as part of regular review of FishPlan. Priority settings are also discussed with Stakeholders.

Review Timeline

A MSC pre-assessment of this fishery was undertaken in 2014. Stock assessments for the key target species and an investigation on stock structure of Bight redfish will be completed in late 2015. A review of management of the South Coast wetline fishery is currently underway.

Recent Publications

- Coulson, P., Hesp, S., Potter, I., Hall, N. (2010). *Life cycle characteristics of the blue morwong Nemadactylus valenciennesi, compared with those of other species of Cheilodactylidae*. Marine and Freshwater Research 61: 104-118.
- Wakefield, C.B., Newman, S.J., Molony, B.W. (2010). Age-based demography and reproduction of hapuku, *Polyprion oxygeneios*, from the south coast of Western Australia: implications for management. ICES Journal of Marine Science 67: 1164-1174.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

South Coast Demersal Scalefish Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Identification of indicator species	Complete						See RAF ¹
Snapper	Underway	■					Report due in 2015
Bight redfish	Underway	■					Report due in 2015
Hapuku	Complete						Wakefield <i>et al.</i> 2010
Western blue groper	Complete						Murdoch University study
Blue morwong (Queen snapper)	Complete						Murdoch University study
Samson fish	Complete						Murdoch University study
1.2 Other Biology							
Stock structure of indicator species (genetics, microchemistry)	Underway	■					Report (Bight redfish) due in 2015
1.3 Stock Assessment							
Annual catch and effort assessment	NA						Catch and effort levels monitored annually
1.4 Fishery Monitoring							
Commercial catch and effort	Ongoing	■	■	■	■	■	Logbooks
Charter boat catch and effort	Ongoing	■	■	■	■	■	Tour Operator Return Book
State-wide survey of boat-based recreational fishing	Periodic		■		■		Biennial phone-diary survey
Age-structure monitoring	Underway	■					Report due in 2015
2. Habitat & Ecosystem							
2.1 Bycatch							
2.2 Listed Species							
2.3 Habitat							
2.4 Ecosystem/Environment							
2.5 Oceanography							
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access (Shares)	Underway	■					Wetline review by management
3.3 Compliance Research							
3.4 Management Systems							

¹ DoF. (2011). Resource Assessment Framework (RAF) for finfish resources in Western Australia. Fisheries Occasional Publication No. 85. Department of Fisheries, Western Australia. 28 pp.

South Coast Demersal Scalefish Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
4. Industry Development							
5. Stakeholder Consultation and Reviews							
Annual Management Meetings	Planned	■	■	■	■	■	Meetings with Department and Stakeholders will occur 2015 onwards when results of NRM project are available
MSC	Complete	■					Pre-assessment in 2014
Other	Periodic						

Northern Inland Bioregion

Northern Inland – Lake Argyle Silver Cobbler Fishery

Description and Scope of Issues

The only commercial freshwater fishery in Western Australia is contained in the impounded waters of the Ord River at Lake Argyle in the north-eastern Kimberley. This gillnet fishery specifically targets the silver cobbler.

Summary of historical research completed

Given the nature and priority of this fishery the Lake Argyle Silver Cobbler Fishery is only assessed by compilation of catch and effort data from the fishery in the form of the statutory monthly catch and effort returns. Little data is available on the biology of the Silver Cobbler.

Relevant Resource Assets and Risks from Fishing

Finfish- Native	Moderate Risk
Listed Species (Crocodiles)	Low Risk

Current Research Focus

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 assessing this fishery.

The catch and effort data provided by industry are used to develop stock assessment models for the fishery. However the modelling approach used in the assessment of the fishery requires a number of assumptions, which creates a high degree of uncertainty around the results generated from the models. To reduce this uncertainty an understanding of some key characteristics of both the fishery and the biology of the species would be needed.

Priority Setting Process and Review Timeline

Initial assessments were made through internal departmental meetings and forums discussing the history of research in the fishery, research activities that have been completed, current research as well as research and development gaps. Research issues are discussed at industry consultation meetings as required.

Given the small amount of activity no matrix is provided.

Southern Inland Bioregion

Southern Inland – Biodiversity Issues

Description and Scope of Issues

This region contains the state'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 the significant native forest areas. Some of the rivers are more saline in their upper reaches owing to the effects of agricultural clearing of native vegetation in more inland areas.

The southwest region of Western Australia is recognised by Conservation International as one of 34 global biodiversity hotspots. The rivers of the southwest have the largest percentage of native endemic fish species (80%) and crustacean species (100%) in Australia. As result they have been recognised by WWF as one of the Earth's 53 most biologically outstanding freshwater habitats. Significantly, the southwest rivers and streams in Australia are also one of 28 freshwater habitats identified by WWF as a Global Ecoregion that is considered to have a conservation status of critical or endangered.

The conservation of the 13 species of freshwater native fish which exist in the southwest region of Western Australia is a growing issue for the Department of Fisheries. Some of these species are endemic to Western Australia, and therefore their survival depends on proper environmental management. Most of these fish are under pressure because of deteriorating environmental conditions. Therefore the Department of Fisheries is working with other agencies and institutions to undertake research on the distribution and life history of these animals to obtain the information required to protect them. In 2015 the Department came under pressure to significantly reduce its program of native fish captive breeding and research activity. This resulted in the end of a collaborative research program with the University of Western Australia based around its metropolitan-based Aquaculture and Native Fish Breeding Laboratory. Where possible, future Departmental activity in this space will be conducted through its Pemberton Freshwater Research Centre (PFRC) and/or opportunistically in partnership with the research sector via collaborative research grants. The Department of fisheries will continue to maintain its focus on freshwater biosecurity and the management of non-native fish species which remain one of a number of significant factors threatening our native freshwater fish biodiversity.

Relevant Resource Assets and Risks from all Activities

Southern Inland Finfish - Native	Severe Risk (non-fishing)
Southern Inland Protected species	Severe Risk (non-fishing)
Southern Inland Ecosystem	High Risk (non-fishing)
Southern Inland Introduced Pests & Diseases	Moderate Risk

Summary of historical research completed

The Department of Fisheries has conducted small scale holding of south-west native fish at the PFRC since the early 1990's. Between 2008 and 2014 the Department of Fisheries

established a captive breeding program at PFRC to 1) Breed the critically endangered Margaret River marron for restocking, and 2) Develop production techniques for fish species native to the south-west of WA. These fish species also offer potential for stocking wetlands and lakes for mosquito control and restocking rehabilitated water bodies. Between 2012-2014 at the metropolitan-based Aquaculture and Native Fish Breeding Laboratory the Department, in collaboration with UWA, developed hatchery and rearing techniques to successfully close the lifecycle of three native fish species, the critically endangered *G. truttaceus*, *G. occidentalis* and *N. vittata*.

The Department has also developed the expertise to remove, produce and maintain native fish and crayfish stocks during refurbishment of water reservoirs to preserve genetic lines for restocking after completion of dam remedial works (Water Corp funded).

Current Research Focus

In 2015 the Department of Fisheries significantly reduced their captive breeding program aimed at reducing the risk of extinction of native species and conserving biodiversity by restocking waterbodies. The key species in this program were the critically endangered Western trout minnow (*Galaxias truttaceus hesperius*), Margaret river hairy marron (*Cherax tenuimanus*) and Balston's pygmy perch (*Nannatherina balstoni*) which is listed as vulnerable to extinction. In addition several species such as Mud minnow (*Galaxiella munda*) and Black-stripe minnow (*Galaxiella nigrostriata*) offered potential for restocking waterways as although not yet listed as critically endangered they have severely restricted and fragmented distributions due to widespread habitat degradation.

The identification of the 'hairy' marron in the Margaret River catchment as a separate species or sub-species has focused attention on Southern Inland biodiversity issues through the decline of this critically endangered species. Specific management actions that are underway to recover this unique stock involve 1) Removing competing 'smooth' marron species from the catchment, 2) Chairing the Margaret River marron recovery team and 3) development of a captive species breeding population.

In 2009, the Department developed an online Native Freshwater Fish Database. The database contains most historical records of native freshwater fish distribution in WA. The database is linked to the scientific exemption process administered by the Department that permits university researchers to collect native fish. This enables the Department to capture all native fish distribution data collected by universities and other agencies in WA. It provides a valuable tool for researchers and managers to identify both changes in native fish biodiversity and introductions of feral species.

Priority Setting Process

Research priorities for this program are developed through consultation with freshwater fisheries managers, university research groups and natural resource managers.

Review Timeline

The most recent review of Southern Inland freshwater biodiversity research was around 2008. The next review is due around 2015.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

○ Indicates that the activity is part of a proposal but is not yet funded.

Southern Inland Biodiversity Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Stock Assessment							
Native fish distribution stock assessment	Complete	■					Stock status of species of conservation concern
Native Fish Database	Ongoing	■	■	■	■	■	Management of Native Fish database for monitoring native fish distribution & decline
Reproduction (Margaret River marron)	Ongoing 2015	■	■	■	■	■	Margaret river marron Captive breeding program for restocking & recollection & testing of broodstock
2. Habitat & Ecosystem							
2.1 Bycatch							
2.2 Listed Species							
Limited maintenance of critically endangered species at PFRC	Ongoing	■	■	■	■	■	Maintenance of critically endangered fish species pending future development of funded collaborative projects
Margaret river marron	Ongoing	■	■	■	■	■	Captive Breeding program for recovery of Margaret river marron
2.3 Habitat							
Water Corp Dam biological remediation	Complete						Provide advice to Water Corp on removal, transport, breeding and maintaining native fish and crayfish during draining & refurbishment of water reservoirs to 1) prevent major fish kills and 2) preserve genetic lines for restocking after completion of dam remedial works (Water Corp funded)
Water Corp advice	Ongoing	■	■	■	■	■	Provide scientific and technical advice to Water Corp
2.4 Ecosystem/Environment							
Environmental monitoring	Complete	■					Investigation of environmental factors affecting decline in native fish stocks
Impacts of introduced species	Proposed	○	○	○			Quantify the impacts of trout & redfin perch on native fish species
Fish Kills	Ongoing	■	■	■	■	■	Respond to reports and investigate cause of fish kills coordinated through Fisheries Research (Fish Health)
2.5 Oceanography							
2.6 Other impacts							
3. Management Analysis							
3.1 Socio-economic							
Social assessment	Proposed	○	○				Involving community & school groups in native fish conservation and restocking programs

Southern Inland Biodiversity Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
3.2 Resource Access (Shares)							
3.3 Compliance Research							
3.4 Management Systems							
Native Fish Strategy	Underway	■	■	■	■	■	Management of database using research permits to record distribution of native & feral freshwater fish
4. Stakeholder Consultation and Reviews							
NRM Stakeholder	Ongoing	■	■	■	■	■	
Science review	Proposed		○				

Southern Inland – Freshwater Aquaculture

Description and Scope of Issues

The Southern Inland Bioregion contains suitable land, water and climate conditions to farm a range of species including marron (*Cherax canii*), silver perch (*Bidyanus bidyanus*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), yabbies (*Cherax d.albidus*) and a variety of ornamental fish species. Farming occurs in tanks, earthen ponds and farm dams located between Esperance to Hutt River, north of Geraldton, however the bulk of farms are concentrated in the higher-rainfall south-west coastal areas. Potential exists to expand aquaculture production in the Southern Inland Bioregion, particularly on the south-west coastal plain, by using irrigation dam water for aquaculture, prior to reuse on agricultural farms. In addition, some farmers located in salt-affected regions have constructed ponds to trial trout production in saline groundwater.

There are around 180 licensed marron farms in the Southwest Bioregion and they currently represent the majority of aquaculture licences in WA. There are around 12 licensed silver perch farms in WA. Silver perch production has increased rapidly over the past few years, mainly due to improved hatchery supply of juveniles. There are around 10 licensed trout farms in WA. There are around 15 licensed yabbie processors in WA, who receive animals harvested from around 4000 farm dams. To protect endemic marron populations in the southwest of the state, yabbie farming is restricted to east of the Albany Highway. There are around 25 licensed ornamental fish farms in WA. A wide range of both native and non-native ornamental fish species are produced in WA.

Summary of historical research completed

Marron: The marron farming industry developed from research commenced by the Department in the 1970s that developed techniques to breed, feed and grow marron at PFRC (Pemberton Freshwater Research Centre) and transferred this technology to industry in the late 1980s. More recently, from 2000-05 Department researchers used selective breeding to

increase the growth rate of marron and developed improvements in husbandry and farm management strategies.

Silver Perch: Techniques for breeding, feeding and farming silver perch were developed by researchers in New South Wales in the late 1980s. In the early 1990s, Department researchers in Western Australia developed extension material to facilitate the adoption of this technology by local farmers. However, farmers in WA were unable to achieve similar spawning success as those in NSW. In the early 2000's, Department researchers worked with industry to improve spawning success of silver perch in WA.

Trout: Trout farming is well established internationally and as a consequence considerable research on breeding, feeding and rearing these species has been conducted overseas. Since trout were introduced to WA in the late 1800s the Department strain at PFRC has evolved to tolerate warmer water temperatures than those farmed overseas. Selective breeding to increase this temperature tolerance could result in WA becoming a major supplier of fertilised trout eggs to the northern hemisphere. In 2013/14 a valuable collaboration was established with the University of Columbia (Canada). This resulted in a PhD student completing a series of experiments in Pemberton on PFRC trout temperature tolerance and physiology. This research will be published in 2014/15.

Yabbies: Research conducted by the Department from 1994-2000 resulted in improved methods for stocking, feeding, harvesting, managing and farming yabbies. It also developed a hybrid yabby that grows twice as fast as the most commonly farmed species.

Ornamental fish: Techniques for farming non-native ornamentals, such as goldfish and koi, are well established overseas. A pilot program was run by UWA to develop improved stocks of koi for export based upon selective breeding of local genetic lines. In addition the department provides technical support to producers of high value ornamental species. The Department, with cooperation from AQIS, has been monitoring the disease status of ornamental fish entering Australia through Perth and which die in quarantine. This is part of the Departments ongoing biosecurity surveillance activity.

Current Research Focus

Marron: No current research.

Silver Perch: No current research.

Trout:

- Selective breeding to increase temperature tolerance and growth of PFRC trout population.
- The cause of a 60% decline in egg viability of brown trout needs to be identified.
- Improved production of triploids by pressure shock.
- Control of inbreeding in PFRC population.
- Production of trout fingerlings for both aquaculture and freshwater angling

Yabbies: No current research but development of eradication techniques for feral yabby populations within the marron region warrants attention.

Ornamental Fish: Provision of disease surveillance on imported fish.

Priority Setting Process and Review Timeline

Research priorities for this program are developed through consultation with industry

associations and key producers and involve a strategic approach to address industry problems as they arise.

The most recent review of Freshwater Aquaculture research was around 2007/08.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded and planned to occur.

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Southern Inland Freshwater Aquaculture Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Marron biology	Complete						Completed in WA in 1980s – 1990s
Yabby biology	Complete						Completed in WA in 1990s
Silver perch biology	Complete						Completed in NSW
Trout biology	Complete						Completed in WA
Temperature tolerance & climate change of trout	Complete	■	■				Trout in WA appear to have a higher temperature tolerance than stocks elsewhere in the world
1.2 Other Biology							
Disease diagnostic service	Ongoing	■	■	■	■	■	Ongoing surveillance and monitoring
Brown trout reproduction	Underway	■	■				The cause of a decline in egg viability from 70% - 10% is being identified
Triploid production	Underway	■	■	■			Improved production of triploids
1.3 Stock Assessment							
1.4 Fishery Monitoring							
2. Habitat & Ecosystem							
2.1 Listed Species							
2.2 Habitat							
2.3 Ecosystem/Environment							
2.4 Other impacts							
Fish kills	Ongoing	■	■	■	■	■	
3. Management Analysis							
3.1 Socio-economic							
3.2 Compliance Research							
3.3 Management Systems							
4. Industry Development							
4.1 Production Technology							
Production technology marron	Complete						Developed in 1980's, validated in 2000-05

Southern Inland Freshwater Aquaculture Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Hatchery production (trout)	Ongoing	■	■	■	■	■	Production of trout fingerlings & yearlings for aquaculture & recreational stocking
4.2 Post Harvest							
4.3 Marketing	Not needed						
5. Stakeholder Consultation and Reviews							
ACWA	Ongoing	■	■	■	■	■	

Southern Inland – Recreational Marron Fishery

Description and Scope of Issues

Marron are endemic to Western Australia and are the third largest crayfish in the world. Recreational fishing occurs in freshwater dams and rivers throughout the southern part of the State extending from as far north as Geraldton to Esperance in the east. This fishery is managed through input controls of licences, closed seasons and gear restrictions, and the output controls of size and bag limits.

The main external factors which affect the marron fishery are illegal fishing activities, degradation of freshwater habitat, winter rainfall, access to dams, and introduced species. Degradation of freshwater habitat (mainly salinisation in the upper reaches of catchments) has significantly reduced the natural range of marron. Winter rainfall plays a major role in marron reproduction, growth and survival. Another major issue in this fishery is access to irrigation dams. Introduced species that impact on the marron fishery either through predation or competition for similar resource are redfin perch (*Perca fluviatilis*), trout (*Oncorhynchus mykiss* and *Salmo trutta*) and yabbies (*Cherax d. albidus*).

Relevant Resource Assets and Risks

Crustaceans Native (marron)

High Risk (non-fishing)

Summary of historical research completed

The marron recreational fishery has historical data from the 1970s.

Additional research on improving habitat in artificial impoundments (water reservoirs) showed that rock wall can provide an important refuge for juvenile marron.

Current Research Focus

- Annual stock assessment.
- Improve logbook survey.
- Remove, produce and maintain marron stocks during refurbishment of water reservoirs

to preserve genetic lines for restocking after completion of dam remedial works (Water Corp funded).

Priority Setting Process and Timeline Review

Marron research priorities are developed in consultation with the Recreational Freshwater Fisheries Stakeholder sub-committee.

Key to symbols in the matrix/summary tables:

■ Indicates that the activity is funded

○ Indicates that the activity is part of a proposal but is not yet funded.

Southern Inland Recreational Marron Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural Mortality)							
Biology	Complete						Data collected as part of FRDC 2003/027
1.2 Other Biology							
Disease diagnostic service	Ongoing	■	■	■	■	■	Provided as part of surveillance and monitoring of state disease status
1.3 Stock Assessment							
Annual assessment	Ongoing	■	■	■	■	■	2006 introduced new sampling program using traps
Methods			○	○	○	○	A more accurate alternative needs to be calibrated against existing box traps, previous techniques and known population size
1.4 Fishery Monitoring							
Phone-recall survey	Ongoing	■	■	■	■	■	
Logbook survey	Ongoing	■	■	■	■		Continuation with RAP program requires increased number of returns. Annual survey of recreational catch by license holders
Field monitoring				○	○	○	A field based recreational angler survey could provide more accurate information on the status of the fishery.
2. Habitat & Ecosystem							
2.1 Bycatch							
2.2 Listed species							

Southern Inland Recreational Marron Fishery Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
2.3 Habitat							
Water Corp Dam biological remediation	Ongoing	■	■	■	■		Provide advice to Water Corp on how to remove, transport to PFRC, breed and maintain native fish and crayfish during draining & refurbishment of water reservoirs to 1) prevent major fish kills and 2) preserve genetic lines for restocking after completion of dam remedial works (Water Corp funded)
Fishing enhancement structures	Ongoing		○	○	○	○	Investigate purpose built fishing enhancement structures for use in dams where recreational marron fishing occurs
2.4 Ecosystem/Environment							
2.5 Hydrography							
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic							
3.2 Resource Access							
3.3 Compliance Research							
3.4 Management systems							
4. Industry Development							See Aquaculture
5. Stakeholder Consultation and Reviews							
RecFishWest	Ongoing	■	■	■	■	■	
Other							

Southern Inland – Recreational Freshwater Angling

Description and Scope of Issues

The south-west recreational freshwater fishery is focused primarily on angling for rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*), which are the subject of an annual controlled stocking program by the Department. In addition, anglers take the native freshwater cobbler (*Tandanus bostocki*) and an exotic species redfin perch (*Perca fluviatilis*). Redfin perch were previously released in the south-west and now occurs as self-breeding populations in most water bodies. Licensed anglers may only use a single rod, reel and line or single handline when targeting these species. Access to this fishery is controlled by license, seasonal closures, minimum sizes, and bag limits. People under 16 years of age are not required to hold a license to go freshwater angling.

The extent and success of the freshwater angling fishery in the south-west is dependent

mainly upon availability of high-quality fresh waters for stocking. The degraded nature (e.g. increased salinity) of many freshwater streams and rivers coupled with the effect of deforestation and climate change (e.g. reduced flow and water levels) has a strong negative effect on the future of recreational fishing. The availability of water is dependent on rainfall and access to irrigation dams. Thus low rainfall and reduced access to permanent water bodies are having a negative influence on the freshwater angling fishery.

Relevant Resource Assets and Risks from Fishing

Finfish – Exotic (trout)

Moderate Risk

Finfish – Native

High Risk

Summary of historical research completed

The Department has records of trout stocking locations and numbers, but there has been limited research into the impacts of stocking or the establishment of self-sustaining populations.

Current Research Focus

Integration of logbooks into the RAP program.

Priority Setting Process and Review Timeline

Freshwater Angling research priorities are developed in consultation with the Recreational Freshwater Fisheries Stakeholder sub-committee.

A review was completed in the late 1990s.

Key to symbols in the matrix/summary tables:

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Southern Inland Recreational Freshwater Angling Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
1. Retained Species Stock Analysis							
1.1 Basic Biology of Indicator Species (Growth, Reproduction, Diet, Natural mortality)							
Trout: Growth, Mortality	Proposed		○	○			Limited information of wild stock growth & survival. A tagging program is required
Trout: Reproduction	Proposed		○	○	○		Determine location and success of self-sustaining populations
Trout: diet	Complete						Data collected as part of FRDC 2003/027; co-operation with Murdoch University
Redfin (growth, diet, mortality)	Complete						Several publications available; additional data collected as part of FRDC 2003/027

Southern Inland Recreational Freshwater Angling Research Projects	Research Status	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Freshwater Cobbler (growth, diet, mortality)	Complete						Several publications available; additional data collected as part of FRDC 2003/027; focus of several research projects by MU
1.2 Other biology							
1.3 Stock Assessment							
Annual Assessment	Ongoing	■	■	■	■	■	Catches and catch rates only
1.4 Fishery Monitoring							
Phone-recall survey	Ongoing	■	■	■	■	■	Annual survey of recreational catch by license holders
2. Habitat & Ecosystem							
2.1 Bycatch							
2.2 Listed Species							
Impact of trout & redfin on listed species	Proposed			○	○		Urgent need to determine interaction between stocked trout and (protected) native fish species
2.3 Habitat							
Potential for trout stocking in artificial impoundments	Proposed	○	○	○	○	○	Evaluation of stocking trout in artificial impoundments as an alternative to streams
Artificial reef habitats to enhance fishery	Proposed	○	○	○	○	○	Install and monitor artificial reefs in impoundments to improve fishery
2.4 Ecosystem/Environment							
Impact of trout on native species	Proposed	○	■	○	○		Urgent need to determine interaction between stocked trout and native fish species
Impact of redfin on native species	Proposed	○	■	■	○		Urgent need to determine interaction of redfin on native fish species
2.5 Hydrography							
2.6 Other impacts on fishery							
3. Management Analysis							
3.1 Socio-economic							
Social assessment	Complete						Demographic and Social value of trout angling has been completed
Economic Analysis	Complete						Socio-economic value of trout angling has been completed
3.2 Resource Access (Shares)							Not needed
3.3 Compliance Research							
Poaching	Proposed	○	○	○	○		Concerns about unlicensed fishing and illegal gear used to target stocked broodstock trout
3.4 Management Systems							
4. Industry Development							
5. Stakeholder Consultation and Reviews							
Recreational Freshwater Fisheries Stakeholder sub-committee	Ongoing	■	■	■	■	■	

